Prostate Cancer

- Incidence rate ~ 1 in 6 men in U.S. will be diagnosed
- Estimated deaths in U.S. in 2008: 28,860
- Median age diagnosis: 72 yrs
  - prevalence likely increases with age
  - 64% cases in men ≥ 65 yrs
- Present with urination symptoms
- Risk factors include age, ethnicity, family history, diet & obesity
**Prostate Cancer**

- Most common noncutaneous cancer in men
- Usually adenocarcinoma (>90%)
  - ~4% transitional cell, thought arise urothelial lining
- Multifocal
  - 70% peripheral zone
  - ejaculatory ducts & SV
  - 15-20% central zone
  - 10-15% transitional zone
  - spread bladder neck

- **Rate of tumor growth**
  - Very slow to moderately rapid
  - Early-stage doubling time ~ 2-4 yrs

<table>
<thead>
<tr>
<th>Relative survival rates (1996-2003)</th>
<th>All stages (5 yr)</th>
<th>Local &amp; Regional (5 yr)</th>
<th>Distant (5 yr)</th>
<th>All stages (10 yr)</th>
<th>All stages (15 yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prostate</td>
<td>98.4</td>
<td>100.0</td>
<td>31.9</td>
<td>91</td>
<td>76</td>
</tr>
</tbody>
</table>

**Prostate Anatomy**

**Prognostic Factors**

- Organ-confined - (Low; Intermediate; High) risk
- Locally-advanced (outside prostate)
- Node positive
- Metastatic (bone, liver, lung)
Diagnosis
- DRE
- PSA
- Gleason score
- Other imaging
  - CT – Lymph nodal involvement
  - MRI – SV involvement
  - Bone scan – bone metastasis

Digital Rectal Exam (DRE)

Prostate Specific Antigen (PSA)
- Antigen released by normal prostate tissue and tumor cells arising from the prostate
  - PSA normal range ≤ 4 ng/mL (≤ 2.5 ng/mL ≤ 60 yrs)
  - Normal prostatic growth: 0.04ng/mL increase per year
- PSA elevation may indicate the presence of prostatic disease

<table>
<thead>
<tr>
<th>Approximate chance of having prostate cancer on biopsy:</th>
<th>Below 4 ng/mL</th>
<th>Between 4-10 ng/mL</th>
<th>Greater than 10 ng/mL</th>
</tr>
</thead>
<tbody>
<tr>
<td>2%</td>
<td>25%</td>
<td>50% to 67%</td>
<td></td>
</tr>
</tbody>
</table>

Gleason Score
- Gleason grade (1-5)
  - Histologic variation – 5 patterns
  - Based on degree of glandular differentiation and overall pattern of tumor growth at low microscopic magnification
- Primary grade (>50%) and secondary grade (5-50%) characteristics

- Gleason score (2-10) = sum of Gleason grades
  - Low 2-4, Mid 5-7, High 8-10
  - E.g. Gleason 3+4 = 7
Prostate cancer first progresses locally and invades the local lymphatics in an orderly fashion:
- periprostatic and obturator nodes
- external iliac
- hypogastric
- common iliac
- periaortic

As nodal involvement increases, prognosis decreases.

**Prognosis**

- **Favorable**
- **Unfavorable**

2002 American Joint Committee on Cancer (AJCC) Staging

- **T1** Clinically inapparent tumor
  - T1a,b Found incidentally during TURP*
  - T1c Needle biopsy due elevated PSA
- **T2a,b,c** Palpable (one or both lobes)
- **T3a,b** Extracapsular extension, Seminal vesicle involvement
- **T4** Invasion other structures

*TURP – Transurethral resection of the prostate

### Risk Stratification

#### Table 1. Risk scoring schemes

<table>
<thead>
<tr>
<th>Scenario Risk Group</th>
<th>Ms Stage Risk Group</th>
<th>Mr Advance Risk Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>PSA ≤10 ng/ml</td>
<td>PSA ≤10 ng/ml</td>
</tr>
<tr>
<td>Intermediate</td>
<td>PSA &gt;10 ng/ml or GLEason Score 2-4</td>
<td>PSA = 10.1-150 ng/ml or Gleason Score 5-7 and/or Stage T2b</td>
</tr>
<tr>
<td>High</td>
<td>2 or 3 of intermediate risk factors</td>
<td>PSA &gt;150 ng/ml or Gleason Score 8-10 and/or Stage T3d</td>
</tr>
</tbody>
</table>

**Abbreviation:** PSA = serum prostate specific antigen

**MDACC**

### Organ Confined Disease

<table>
<thead>
<tr>
<th>Radiation Dose</th>
<th>Radiation Target</th>
<th>Hormones</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low-risk</strong></td>
<td>78 Gy in 39 fractions</td>
<td>Prostate alone</td>
</tr>
<tr>
<td><strong>Intermediate</strong></td>
<td>78 Gy in 39 fractions</td>
<td>Prostate and proximal SV</td>
</tr>
<tr>
<td><strong>High-risk</strong></td>
<td>78 Gy in 39 fractions (SV 45-54 Gy)</td>
<td>Prostate and SV as dose constraints allow</td>
</tr>
</tbody>
</table>
Post-Operative EBRT

- Adjuvant treatment – 60-70 Gy
  - Adverse pathology post RRP
    - + margins (>10mm or ≥3 sites), ECE, SV involvement
    - + lymph nodes
  - Used after surgical recuperation
  - Detectable PSA (≤1.5 ng/mL)
- Salvage – 70 Gy
  - Biochemical recurrence/progression post RRP (-margins)
    - PSA not fall to undetectable
    - Detectable PSA increase 2 consecutive times
  - Post RT
    - Rising PSA ≥ 2 ng/mL above nadir PSA after EBRT ± ADT
    - Positive DRE

Alternatives to Standard EBRT

- Brachytherapy Seed Implantation
  - I-125 or Pd-103
  - **ABS Rx doses**
    - | Isotope | No EB (Gy) | EB (40-50Gy) |
      |-------|------------|-------------|
      | I-125 | 144        | 100-110 Gy  |
      | Pd-103 | 115-120    | 80-90 Gy    |
    - 100 Gy + 45 Gy = 145 Gy
    - 80 Gy + 45 Gy = 125 Gy
- Hormonal Therapy

Hypofractionation

- Alpha/beta values debate
- Prostate may have low α/β
  - Therapeutic ratio may be enhanced by delivering fewer, larger fractions
  - Maintain normal tissue toxicities
  - May benefit intermediate risk patients
- SBRT
  - 32-38 Gy in 4 – 5 fractions; (~7-8 Gy per fraction)
- Results inconclusive

CT Simulation: External Immobilization

- Empty rectum (Fleet’s enema 1 hour before sim)
- “Semi-full” bladder (18-24 oz 30 mins before sim)
- Supine, pillow under head, arms across chest
- Legs in immobilization device (indexed)
  - Patient’s pelvis straight!
  - Relaxed muscles
CT Simulation: Scan Process

- Inferior border of the treatment field set at the bottom of the ischial tuberosities
- Longitudinal axis should split symphysis pubis
- 2.5mm slices, 2.5mm spacing
- Mini-scan – bladder fullness, sigmoid & small bowel
- Select isocenter (prostate)
- Look at skin contours
- Full scan

CT Simulation: Internal Immobilization

- Water or air filling
- Immobilization of the prostate
  - Bony alignment for prostate treatment – protons
- Displacement of sigmoid/small bowel away from prostate / sv

Target Structures

- Prostate
  - Inf border/apex defined using sagittal imaging on treatment planning CT (1 slice above GU diaphragm)
- Seminal Vesicles
  - “Proximal SV” ~ 1.5cm (6 slices)
  - Distal SV – remainder
- Involved Lymph Nodes

Critical Avoidance Structures

- Rectum
  - Inf border at bottom of ischial tuberosities
  - Sup border at the rectosigmoid junction (~11 cm)
- Bladder
- Sigmoid & Small Bowel
- Femoral Heads
Contouring

Margins for PTV
- PTV = CTV plus margin
- Setup uncertainty – aka localization
- Organ motion
  - Interfraction motion
  - Intrafraction motion
- 5mm posterior, 7mm for the rest

MDACC EBRT
- 4-Field Box
  - < 1995
  - Conventional 4-Field Box + 4-Field Boost (70 Gy)
- 3D Conformal Radiation Therapy (3D-CRT)
  - 1995
  - 4-Field Box + 6-Field 3D-CRT Boost (78 Gy)

3D-CRT: 78 Gy to Isocenter
MDACC IMRT

- Intact prostate cases
  - 1998
    - 4-Field Box + IMRT Boost (75.6 Gy)
    - MIMiC (Dec 1998 - 2001)
  - May 2000 - Present
    - Prostate (75.6 Gy / 76 Gy / 78 Gy mean); SV (45 – 54 Gy)
    - Step-and-Shoot MLC (sMLC)

- Prostatectomy cases
  - 2005?
    - Prostatic fossa (70 Gy); SV fossa (57.75 Gy)
    - sMLC

IMRT: 80 Gy to Isocenter

IMRT Beam Angles

Old IEC Scale
Occasionally 180° post-op

IMRT Dose Objectives
**IMRT Dose Volume Histogram**

- **Prostate:**
  - >98%V@78Gy

- **SV:**
  - >95%V@78Gy

- **Rectum:**
  - <20%V@70Gy
  - <40%V@60Gy
  - <60%V@40Gy

- **Bladder:**
  - <20%V@70Gy
  - <35%V@60Gy

- **Femoral Heads:**
  - <10%V@50Gy

**IMRT Evaluation**

- Peripheral dose < 50 Gy
- Plan Total MUs < 700
- Rectum
  - 45 Gy should always split the rectum
  - 30 Gy not cover entire posterior wall but conformal
- Sigmoid
  - Distance from sigmoid to 76 Gy ≥ 1 cm
  - 54 Gy spots, 50 Gy entirety ok
  - May need two IMRT plans to get SV coverage
- Small bowel at 45-54 Gy

**VMAT**

- **Volumetric Modulated Arc Therapy**

  - Three parameters are modulated simultaneously:
    - Gantry rotation
    - Dose rate
    - Leaf speed

**VMAT**

- Arc optimization
  - MLC leaf positions & dose per degree are calculated for a # of cp in an arc field
  - Resulting MLC leaf positions & dose per degree are stored in a # of cp in the field
  - Treatment machine control system determines how the dose rate & gantry speed need to be modulated in order to deliver the cp sequence in the plan
**MDACC VMAT**

**VMAT (Eclipse)**
- 2 arcs
  - 225 – 135 CW
  - 135 – 225 CCW
- Total MU = 1119
  - (562 + 557)
- Total control points = 354
- Dose rate ~ 600MU/min
- Treatment time ~ 3min (75 sec per arc)

**IMRT (Pinnacle)**
- 8 step-and-shoot fields
  - 225, 260, 295, 330, 30, 65, 100, 135
- Total MU = 706
- Total control points = 49
- Dose rate = 400MU/min
- Treatment time ~ 4.5min

*NB: Pinnacle SmartArc recently commissioned but not delivered for prostate treatments. MUs lower than Eclipse plans*

---

**DVH**

**VMAT**
- Bladder, rectum 8% volume @ 70Gy

**IMRT**
- Bladder 10% volume @ 70Gy
- Rectum 15% volume @ 70Gy

---

**Proton Radiation Therapy**

**3-D Conformal Proton Therapy**
- Reduces damage to surrounding tissues
- Greatly reduces side effects
- Treatment of choice for lesions close to sensitive areas of the body

Trofimov et al., *IJROBP*, 2007, 69 (2), pp 444-453
MDACC Proton Therapy

- Protons 2-Field – Passive Scattering Beams
  - May 4, 2006

MDACC Proton Therapy

- Protons 2-Field – Scanning Beam
  - May 5, 2008

Imaging for Setup, Localization, & Re-planning*
Image-Guided Radiation Therapy (IGRT)

- Setup / Localization
  - Organ motion
    - Interfraction & intrafraction
    - Bladder volumes and rectal filling
  - Re-planning
    - Prostate setup confirmation – e.g. rectal balloon, sigmoid/small bowel toxicities

Dancing Prostate

25 treatment CTs
Acquired during a course of 42 fx treatment

Target Localization

- Ultrasound guidance
  - Soft tissue alignment
  - No dose (NOMOS B-Mode Acquisition and Targeting System)
- Implanted fiducials (kV)
  - Soft tissue alignment
- Bony anatomy (kV)
  - Prostate moves relative to bone
- Cone beam CT (CBCT)
  - Image quality needs to improve
  - Spot-check endorectal balloon placement

Ultrasound Guidance

Before alignment
Couch Left 1.84 cm
Couch Down 0.36 cm
Couch Out 0.13 cm
After alignment
Fiducial Markers

Bony Alignment

Differences from CT Prostate Registration

Imaging

- CBCT
  - Image quality can be an issue
  - Can be used for positioning
  - Critical organ localization
  - Can visualize changes to consider re-planning
Introduction

- Gynecological Cancer
  - Introduction

- Cervical Cancer for Intact and Post-operative Cases
  - Diagnosis, Evaluation, History
  - Anatomy and disease progression
  - Staging
  - Treatment Planning, simulation and QA
  - Examples

Gynecological Epidemiology - US

- ~80,000 new cases of gynecological cancer annually
  - Cervical – 11,070
  - Endometrial – 40,100
  - Ovarian – 21,650
  - Other (vulvar, vaginal)

- 27,000 deaths account for 10% of overall cancer mortality
  - Cervical – 2%
  - Endometrial – 18.6%
  - Ovarian – leading cause of cancer death in gynecological malignancies,

Cervical Cancer Epidemiology

- Cervical intraepithelial neoplasia prevalent in younger women
- Invasive cervical cancer rates appear at a later age (50-60)
  - Squamous cell carcinoma – 75%
  - Adenocarcinoma (seen in increasing numbers of women <40)
- Cervical cancer is on the decline in the US
  - Cytologic Screening
- Black women, Hispanic and Vietnamese women
  - Recent immigration, sexual activity history
  - Birth control - adenocarcinoma
- Epidemiologic studies and molecular studies have shown that HPV plays a causative role but there is evidence – multi-factorial

Clinical Presentation

- Asymptomatic
- Detected during routine cytologic screening
- Discharge and bleeding most common symptoms – dependent on tumor
  - Exophytic
  - Endophytic and endocervical
- Urinary frequency, constipation, heaviness
- Advanced stages – abdominal swelling and pain and nausea but…
- Pain is rare
  - Note: Currently no blood test for detection except for ovarian (Ca-125)

Radiation Therapy Text, Cox and Ang, 2010
Cervix Anatomy and Tumor Progression

- 2.5 cm long, projects into anterior vaginal wall
- Divided into the supravaginal and vaginal regions
- Most cervical carcinomas arise between endocervix (EO) and exocervix (EO)
- Invasion into the muscular stroma may still remain confined to the cervix

Anatomy and Tumor Progression

- Exterior to the smooth muscle of the uterus and cervix is a layer of visceral pelvic fascia - parametrium and paracervix
- The uterine fundus is covered by the peritoneum which covers the upper cervix and vaginal fornices to anterior rectal wall
- Large tumors may grow into this area but rarely invade the rectum
- Anteriorly the peritoneum reflects from the fundus to bladder but in only 5% of cases with large invasive tumors will the bladder be involved. (by cystoscopy)

Anatomy and Tumor Progression

- The uterus is connected to surrounding structures by a number of peritoneal folds and ligaments and are continuous with the paracervix tissue.
- These serve as conduits for direct extension of cancer of the cervix
- Tumors that invade the paracervical fascia can involve broad ligaments or rectouterine space and gain access to these regions by lymphatic extension

Tumor Progression Synopsis

- Squamous cell – arises in epithilium and spread laterally
- Adenocarcinoma’s – arise in endocervical canal and are exophytic in nature
- Local extension of cervical tumors are common
  - Involving the uterus, vagina ad pelvic ligaments
  - Disease progresses into the lymphatic system
    - Late Spread will involve nerves, pelvic bones, peritoneal cavity, vulva and then other organs
Pelvis Lymphatics

- Lymphatic's of the cervix drain to internal, external and common iliac nodes
- Uterus drain laterally to external iliac nodes
- Fundus drain with those from the ovary to para-aortic nodes
- Drainage from the external genitalia goes to the inguinal nodes

Original Staging Workup

- Cervical cancer traditionally has been staged clinically
- Physical examination
- Imaging
  - Originally limited role – film
  - Advances lymphangiography, ultrasonography, CT, MRI, PET, and lymphatic mapping

Current Staging Workup

- Physical examination
- Imaging Modalities
  - lymphangiography, ultrasonography, and lymphatic mapping
- CT is very useful but has limits, failure to detect small metastases
- MRI – soft tissue evaluation but also has limits in detection of positive nodes
- PET CT – lymph node identification and tumor size
- Biopsies for lymph nodes >1.0-1.5 cm

FIGO Cervical Staging

- FIGO (International Federation of Gynecology and Obstetrics) system
- Stage I – Cancer confined to the cervix
  - Stage IA – IA2 – Microinvasion disease, 3->7mm stromal invasion
  - Stage IB – Lesions greater than 7mm in horizontal spread
- Stage II – Involvement beyond cervix, including vagina except for the lowest third, or infiltration of parametrium but not extending to pelvic sidewall
- Stage III – Involvement of the lowest third of the vagina or pelvic sidewall
- Stage IV – Cancer extends beyond reproductive tract
Prognostic Factors

- Tumor size
- Lymph Node involvement
- Histologic Type and Tumor grade
- Patient related Factors

Disease-Specific Survival

<table>
<thead>
<tr>
<th>Tumor Size (cm)</th>
<th>Number of Patients</th>
<th>Central Tumor Control Rate (%)</th>
<th>Pelvic Tumor Control Rate (%)</th>
<th>Disease-Specific Survival Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5</td>
<td>701</td>
<td>99</td>
<td>98</td>
<td>90</td>
</tr>
<tr>
<td>5–5.9</td>
<td>200</td>
<td>93</td>
<td>85</td>
<td>69</td>
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<tr>
<td>6–6.9</td>
<td>95</td>
<td>92</td>
<td>79</td>
<td>69</td>
</tr>
<tr>
<td>7–7.9</td>
<td>55</td>
<td>90</td>
<td>81</td>
<td>58</td>
</tr>
<tr>
<td>≥8</td>
<td>48</td>
<td>69</td>
<td>57</td>
<td>40</td>
</tr>
</tbody>
</table>

Treatment Options

- Based on the staging
  - Surgery alone or Radiation therapy alone
  - Lesion size >3 cm and vaginal involvement – RT (recommended)
  - With 6 cm or "barrel" shaped tumors - RT – either alone or before hysterectomy
  - Definitive RT: EBRT and intracavitary implants

TB/RT: EBRT for the Cervix

Intact Cervix
- Conventional 2-Field AP-PA
- 3D Conformal Radiation Therapy (3D-CRT)
  - 4-Field Box

Post-operative cervix
- IMRT
- IMRT/IGRT

EBRT for the Cervix

CT Simulation

Standard Pelvis Setup
- Supine
- Regular head holder or pillow
- Arms high on chest holding A-bar, with or without vacloc
- Legs
  - Relaxed in lower vacloc cradle
  - Med-Tec leg device
CT Simulation

- All Gyn patients will need an anal verge marker (small metal BB) for the CT scan which will mark the inferior extent of the disease
- Full bladder
- The isocenter is usually placed midline, mid-depth and 2 cm above the femoral heads unless otherwise specified
- Scan from either T12 or L2 down through mid-femur
- 2.5 - 3mm slices
- Mini-scan
- Select isocenter

CT Simulation

- Patients with large extension into the vagina may also be treated frog legged.
- Using the frog legged position:
  - Prevents the skin from too much dose
  - Provides adequate dose to the vagina

Role of EBRT for Intact Cervix

- Shrink tumor to improve geometry
  - Endocervical
  - Exophytic
- Sterilize disease beyond the high dose rate ICBT region
  - Paracervical
  - Nodal

AP/PA
Pelvic RT for Intact Cervix

- Post-op for locoregional advanced disease
- Problem – treatment of normal tissue to provide adequate tumor control
- Must cover common, external and iliac nodes
- Superior border - L4-L5
- Inferior border cover the upper portion of the vagina
- Laterally the fields must cover the iliac nodes > 15 cm wide

45 Gy in 25 FX
Block the femoral heads but should not compromise the pelvic ligaments

- Care must be taken covering the posterior border so that the uterosacral ligaments are covered
- And finally anteriorly—there is adequate coverage of the external iliac nodes

Pelvic RT for Intact Cervix

- Fields are limited to the pelvis 45 Gy in 25 fractions
  - If with chemotherapy, then 40 Gy in 20 fractions
- In all cases the external beam should be completed in 5 weeks
  - Compliance issue
- If LDR ICBT is being done the total treatment time should not extend beyond 7-8 weeks

Localization

- MV imaging weekly
- AP/PA
- SSD’s should be verified as well
- All patient marks should be assessed and improved if necessary

4 Field Technique

- This technique will reduce the dose to the anterior small bowel or rectum
- Upper borders L4-L5 or at least be two vertebral bodies above known disease
- Inferior border: superior edge of pubic ramus
- Lateral borders: ~2 cm lateral to bony pelvic, in order to cover lymph nodes
- If the tumor is bulky the and lateral fields are used relatively little pelvis can be spared
Contouring Intact Cervix

- Nodes
- Bladder
- Rectum
- Bowel
- Uterus, cervix, vagina

DVH Intact Cervix

Post operative Radiation Therapy

- Planning similar to intact
- More consideration of small bowel
- Bladder fill is important

Conventional Radiation Therapy in the Post-operative Setting

- Laterals shield very little small bowel
- Small Bowel complications limit whole pelvis dose –
  - 10 – 12% Grade 3-4
  - Higher Grade 1-2
- High–risk post-op CX patients 45–50 Gy
  - prevents only 50–70% of pelvic recurrences
Conformality by MLC

Localization

- These patients should have imaging weekly – kV or MV
- AP/PA and RT/LT Lat
- Bladder fill should be assessed ± 10 - 20%

IMRT for Post Operative Cervix

ConsenSUS GUIDELINES FOR DELINEATION OF CLINICAL TARGET VOLUME FOR INTENSITY-MODULATED PELVIC RADIOThERAPY


- **Common iliac** lymph nodes - From 7 mm below L4-L5 interspace to level of bifurcation of common iliac arteries into external and internal iliac arteries
- **External iliac** lymph nodes - From level of bifurcation of common iliac artery into external artery to level of superior aspect of femoral head where it becomes femoral artery
- **Internal iliac** lymph nodes - From level of bifurcation of common iliac artery into internal artery, along its branches (obturator/hypogastric) terminating in paravaginal tissues at level of vaginal cuff
- **Upper vagina** - Vaginal cuff and 3 cm of vagina inferior to cuff
- **Parametrium/paravaginal tissue** - From vaginal cuff to medial edge of internal obturator muscle/ischal ramus on each side
- **Presacral lymph nodes** - Lymph node region anterior to S1 and S2 region
CTV Delineation

Critical Structure Doses

- Spinal Cord – 45 Gy (extended field L3 and above)
- Kidney – V 20 < 30%
- Pelvis Bones - > 60 Gy necrosis
- Duodenum – V60< 2cc
- Rectum – V45 < 60%
- Bladder – V40 < 35%, Bladder > 50 Gy fibrosis-hematuria
- Femoral Heads – V30 < 15%
- Small Bowel – 20-25 Gy enteritis, > 45Gy increases probability of injury

IMRT comparison with 4 Field

DVH IMRT vs. 4 Field

Dashed – 4 FLD, Solid - IMRT
Comparative Studies: Instensity-modulated Pelvic RT vs. Conventional Pelvic RT  
(Kochanski et al, Clin Adv Hematol Oncol, May 2006)

<table>
<thead>
<tr>
<th>Authors</th>
<th>↓ Volume Receiving Prescription Dose</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Small Bowel</td>
</tr>
<tr>
<td>Roeske et al</td>
<td>↓50%</td>
</tr>
<tr>
<td>Heron et al</td>
<td>↓51%</td>
</tr>
<tr>
<td>Chen et al</td>
<td>↓70%</td>
</tr>
<tr>
<td>Ahamad et al</td>
<td>↓40-63%</td>
</tr>
<tr>
<td>Wong et al</td>
<td>↓95%</td>
</tr>
</tbody>
</table>

Bone Marrow Sparing – Lujan et al. 2003, Int. J Radiation Oncology Biol Phys

IMRT – Intact Cervix

- IMRT for cervical cancer may be beneficial however need to account for:
  - Organ motion – both bladder and rectal filling
  - Accurate knowledge of the areas of risk
  - Tumor regression when there is gross disease
Organ Motion - Bladder

CT-on Rails – Yu, H, 2011

Bladder volume increased from 204 cc to 331 cc, a 62% increase!
Organ Motion

VAGINAL MOTION AND BLADDER AND RECTAL VOLUMES DURING PELVIC INTENSITY-MODULATED RADIATION THERAPY AFTER HYSTERECTOMY

Anelia Jeneidi, M.D.,* Mohammad Salehpour, Ph.D.,* Marianne Sall, B.S.,* Larry LeY, M.S.,* and Patrick J. Ebbe, M.D.*

Departments of *Radiation Oncology and Radiation Physics, The University of Texas M. D. Anderson Cancer Center, Houston, TX.


Internal Pelvic Organ Motion – Beyond Bladder

- More complex
- Tumor response
  - Shifts in position of critical structures
- Internal motion
  - Bladder filling
  - Rectal filling
- Contour changes

Treatment Response Variation

Beadle et al

- 16 pts - weekly serial ct scans and one with implant
  - Mean start cervical volume - 97 cc (range 37-302 cc)
  - Mean end cervical volume - 32 cc (range 11.8-83.3)
  - Reduction of 62% no matter what stage
  - Median change in 20 days

Tumor Regression & Re-plan

Yu, Henry, 2011, MDACC

Ref

Fx07

- Recent Volume Change
IMRT Considerations

- Need Daily imaging due to organ motion/tumor response
  - Rectal filling
  - Bladder filling
  - Movement of the fundus

- No clear definition on what should be included
  - Should the entire fundus be included in ctv
  - When to include para-rectal nodes
  - When should all the sacral nodes be treated

- How often should you replan?
  - Should be done only in a protocol setting
Conclusions

- Treats less small bowel
- Results in lower acute bowel toxicity as well as chronic bowel toxicity
- Results in less bone marrow treated – may lead to better tolerance of concurrent chemotherapy
- May be able to dose-escalation without increase bowel toxicity leading to better local control
- Needs larger studies

Quality Assurance

TPS
- Quality assurance for clinical radiotherapy treatment planning (AAPM TG 53)
- Patient-specific treatment plan
  - Prescription, dose constraints, & plan parameters
  - Verification of monitor unit calculations for non-IMRT clinical radiotherapy (AAPM TG 114)
  - IMRT commissioning: Multiple institution planning and dosimetry comparisons (AAPM TG 119)

R&V
- Quality assurance of external beam radiotherapy data transfer (AAPM Task Group 201)

Machine-Specific QA

CT Simulator
- Quality assurance for computed-tomography simulators and the computed-tomography-simulation process: (AAPM TG 66)
- “Classic” Accelerator
  - AAPM Code of Practice for Radiotherapy Accelerators (AAPM TG 45)
  - Comprehensive QA for Radiation Oncology (AAPM TG 40)
  - Quality assurance of medical accelerators (AAPM TG 142)
  - Protocol for clinical reference dosimetry of high-energy photon and electron beams (AAPM TG 51)
Machine-Specific QA

- IAEA Code of Practice for proton beams
- Basic Applications of Multileaf Collimators (AAPM TG 50)

- Modality-specific
  - Guidance document on delivery, treatment planning, and clinical implementation of IMRT: Report of the IMRT Subcommittee of the AAPM Radiation Therapy Committee
  - VMAT (e.g., dynalog files)

Patient-Specific QA

- IMRT, VMAT, Protons
- Ion chamber measured dose is ±5% than calculated dose
- 2D measurement
  - Results are in qualitative agreement with calculated dose distribution
    - Passes for 5% relative dose/3mm criteria

Dynalog Results

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<tr>
<th>Bin No.</th>
<th>Error (cm)</th>
<th>Mean %</th>
<th>Std Dev %</th>
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</table>

Dynalog Results

- Field A
  - 225 CW
- Field B
  - 135 CC

Imaging QA

- Localization
  - ACR-ASTRO PRACTICE GUIDELINE FOR IMAGE-GUIDED RADIATION THERAPY (IGRT)
  - ACR TECHNICAL STANDARD FOR MEDICAL PHYSICS PERFORMANCE MONITORING OF IMAGE-GUIDED EXTERNAL BEAM RADIATION THERAPY (IGRT)
  - Quality assurance of U.S.-guided external beam radiotherapy for prostate cancer (AAPM TG 154)
  - The Role of In-Room kV X-Ray Imaging for Patient Setup and Target Localization (AAPM TG 104)
  - Clinical use of electronic portal imaging: (AAPM TG 58)

Quality Assurance

- Imaging dose
  - The management of imaging dose during image-guided radiotherapy (AAPM TG 75)

- Practice QA
  - AAPM Task Group 103 report on peer review in clinical radiation oncology physics
  - ACR/ASTRO Accreditation

I keep hitting "escape," but I'm still here.