Target & OAR Volume Delineation

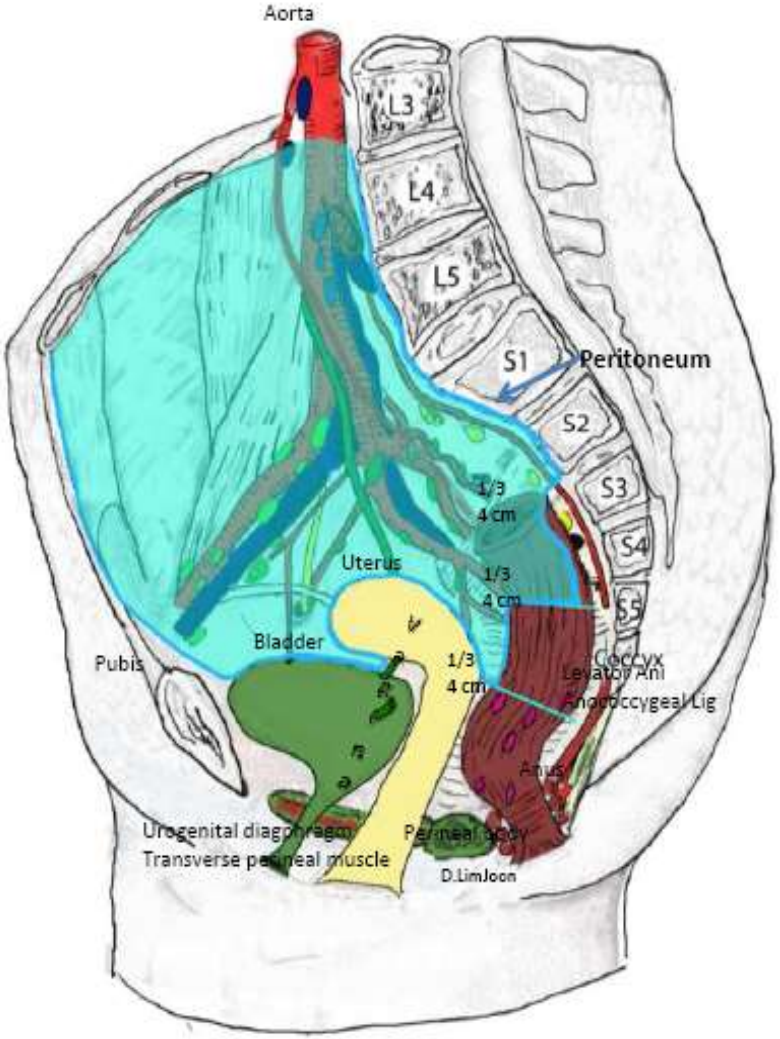
Rectal Cancer

Curs postuniversitar, SRROM 2015, Sibiu

Rectal Cancer - Standard of Care
Diagnosis

- Complete history & physical examination
- Digital rectal examination → DRAW, DATE & SIGN
- Endoscopy (< 15 cm from anal margin)
- Biopsy → HP confirmation! (SCC, melanoma, GIST……)
- Blood(…., + CEA)
- CT chest (or chest X-ray) + abdo*
- Pelvis MRI / + abdo* (or US, including endo-rectal)

Anatomy: Rectum



- Continuation of sigmoid colon
- Follows sacrum hollow & deviates to left

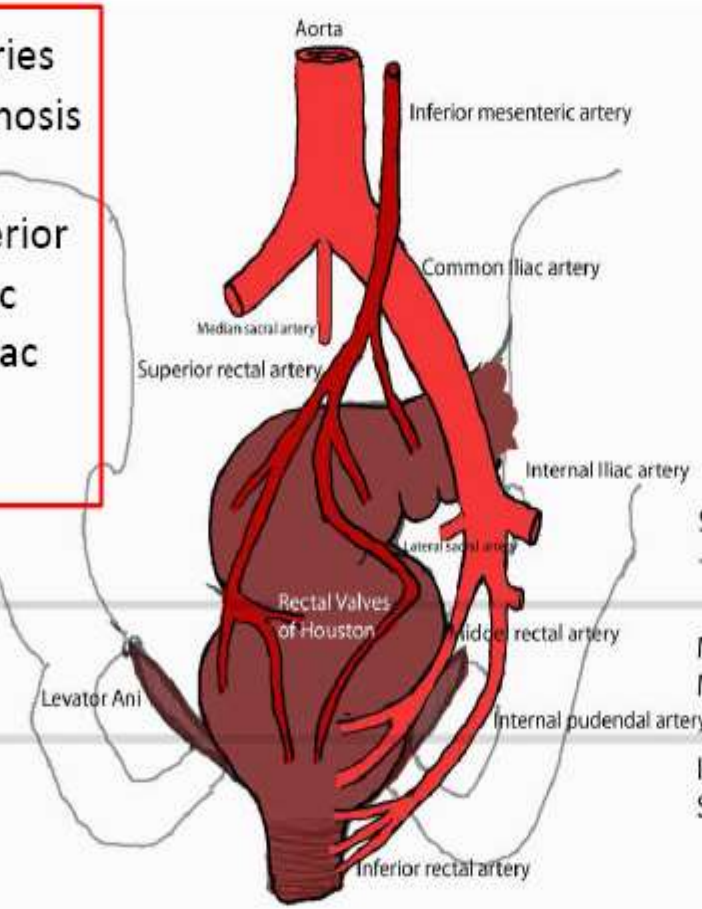
- 12 (8-15) cm long
- S3 to coccyx

- Pierces pelvic diaphragm – continuous with anal canal
- Anorectal junction – levator ani forms a sling & produces anorectal angle
- the anal canal 3 cm long (2.5 to 3.8 cm)

Anatomy: Lymphatic Drainage

- Follows arteries
- Rich anastomosis

1. Superior rectal/Inferior mesenteric
2. Internal Iliac
3. Presacral
4. Inguinal

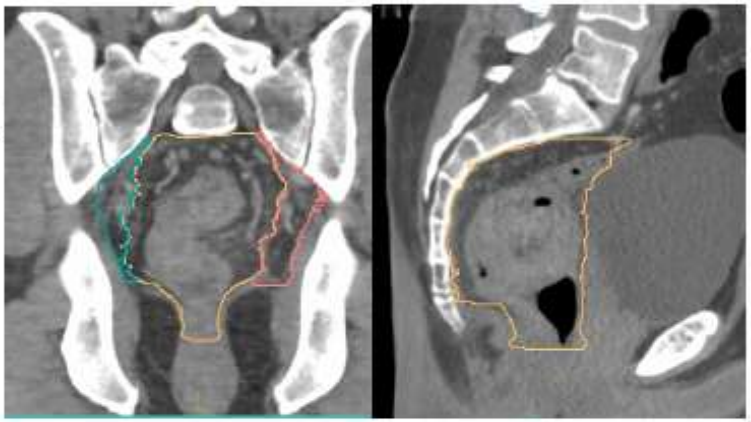


Lymphatic Drainage

Upper	Superior rectal -> Inferior mesenteric -> aortic
Middle	Middle rectal & Internal pudendal -> Internal Iliac Median (promontorial) and lateral sacral
Lower	Inferior rectal -> internal pudendal -> Internal iliac Superficial inguinal

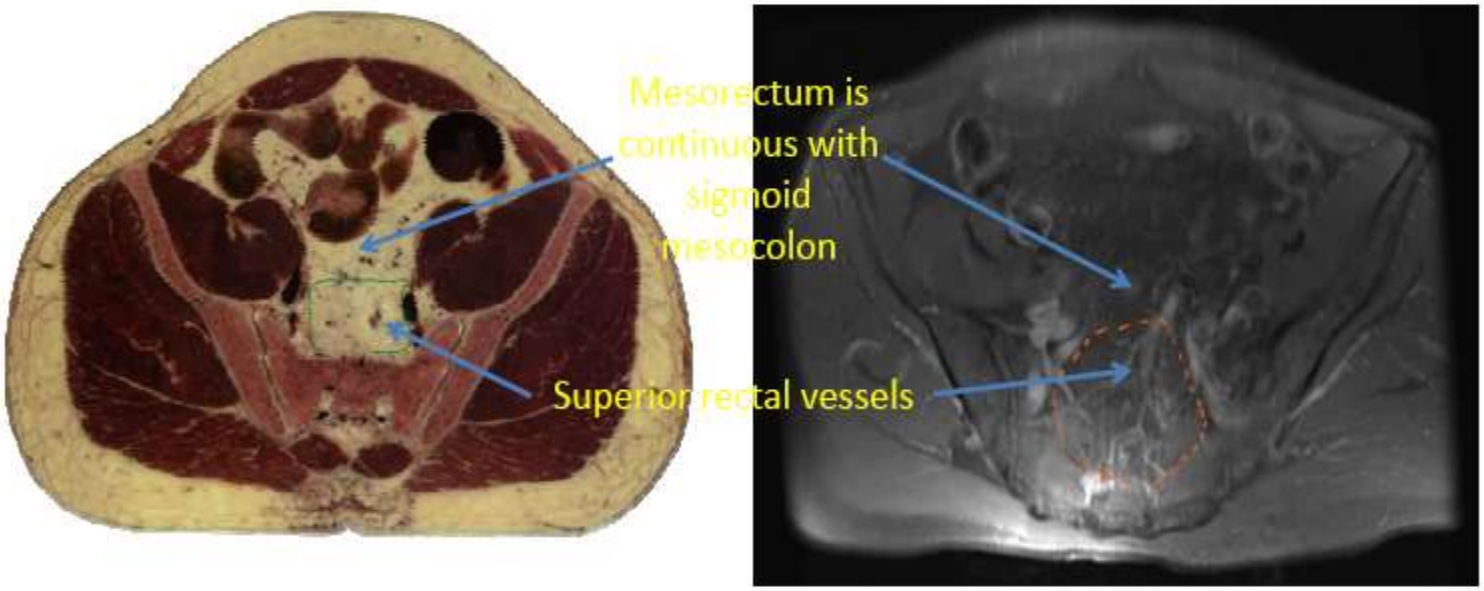
Anatomy: Mesorectum Relationships

- Superior
  - Bifurcation of superior rectal artery –S3
  - sigmoid mesocolon
- Posterior
  - Presacral space/presacral fascia (of Waldeyer)
  - Sacral veins/plexus
  - Sacrum and Coccyx
- Anterior
  - Denonvilliers fascia
  - Urogenital structures
    - (Ureters/Bladder); Vagina; SV and prostate perineal body

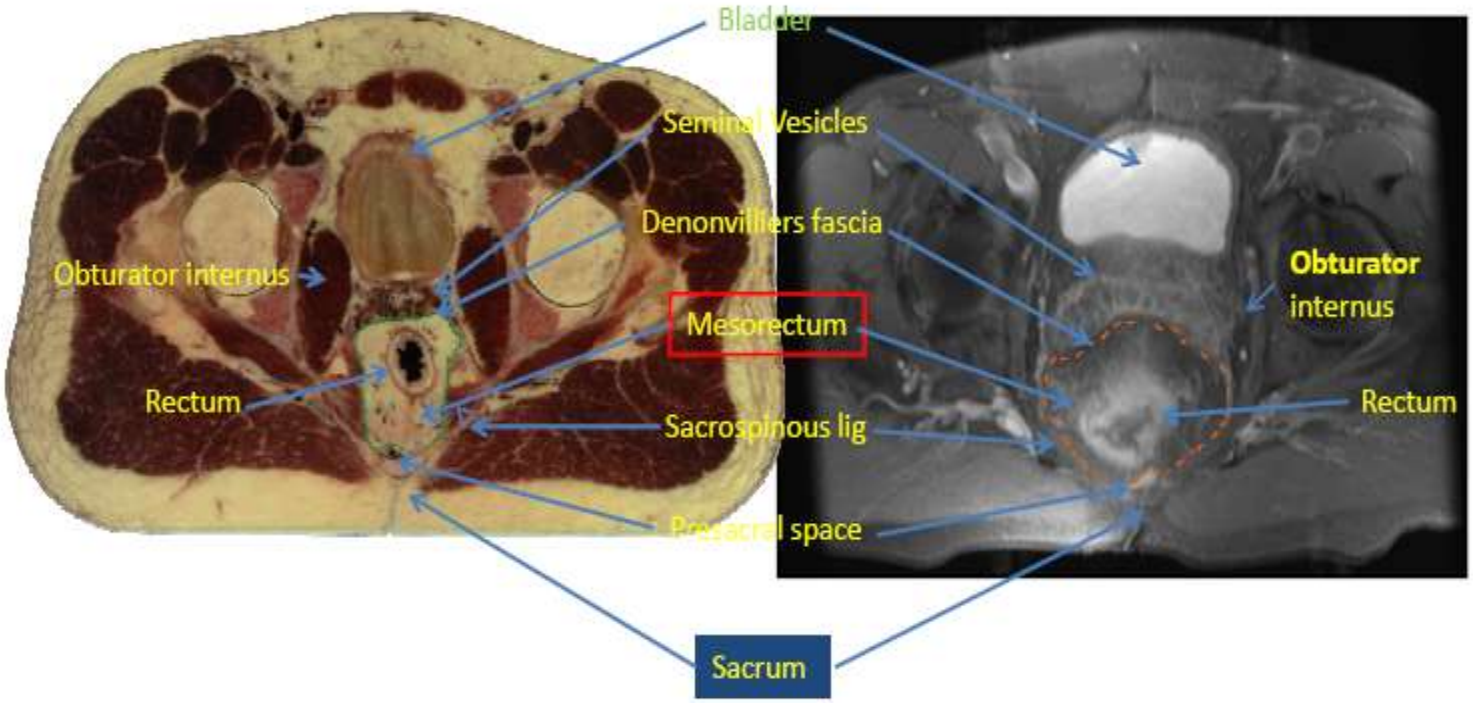


- Lateral
  - –parietal fascia/obturator internus
  - –left and right hypogastric nerves/ pelvic plexuses
  - –internal iliac region
- Inferior
  - Levator ani

Anatomy: Mesorectum
Superior ~ S3



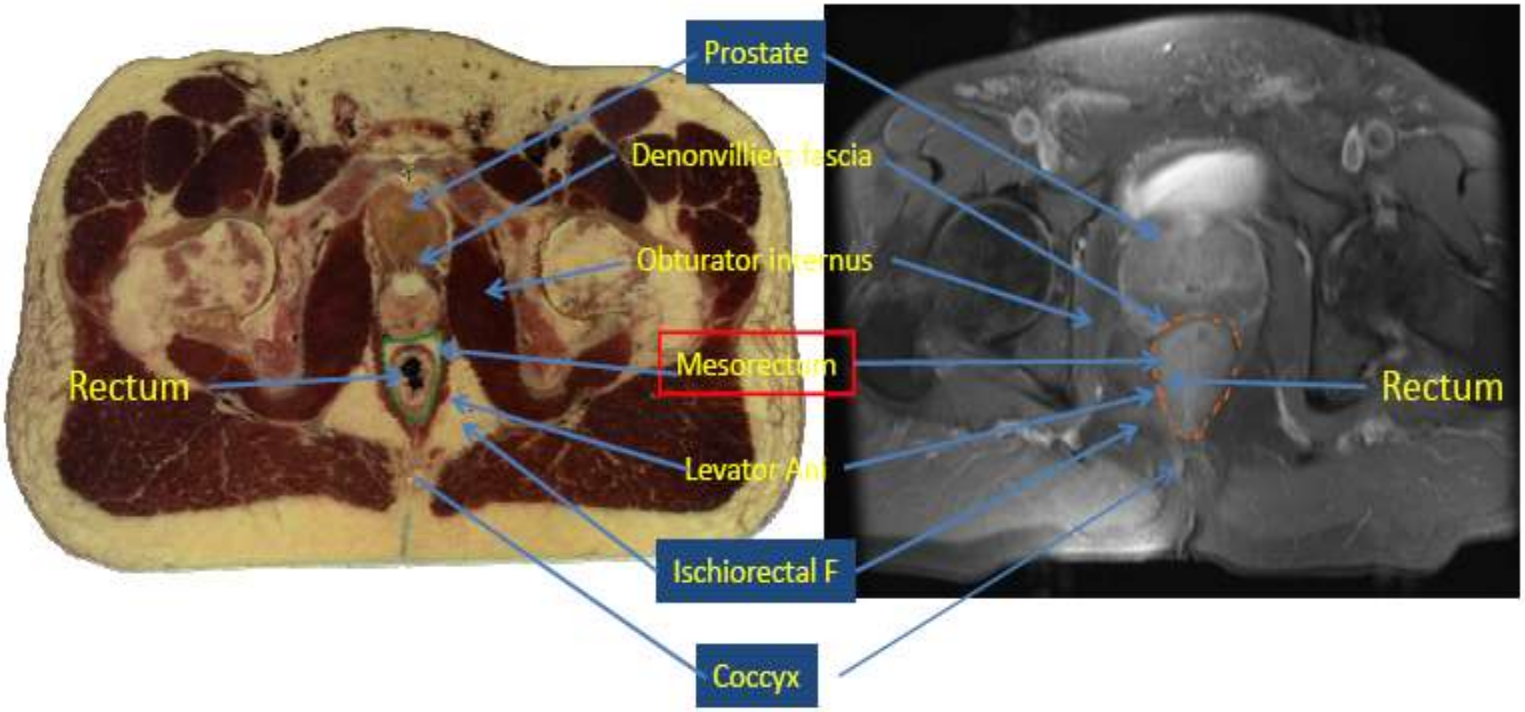
Anatomy: Mesorectum
Middle ~S4 S5



Mesorectal fascia -low-signal-intensity linear structure surrounding the mesorectum

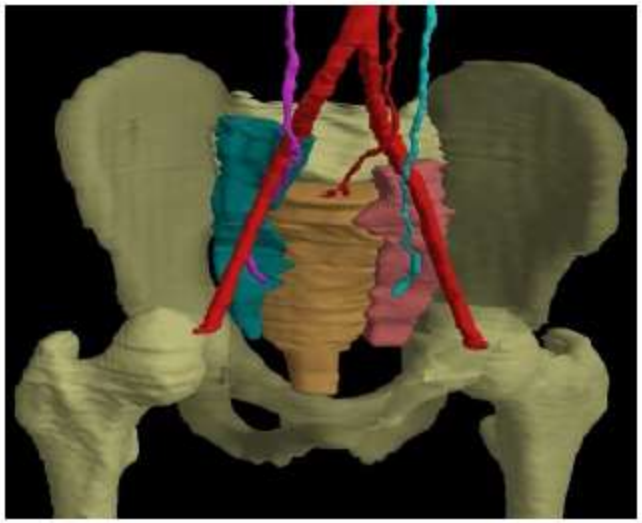
Mesorectum high-signal-intensity (~fat) package surrounding the rectum, containing vessels and lymphatic tissue on MR T2

Anatomy: Mesorectum
Inferior ~Coccyx



INTERNAL ILIAC LYMPHATIC REGION

- Triangular in shape
- Centered on internal iliac artery
- Enlarges caudally -visceral branches
- Anterior: pelvic part of ureter (EIR)
- Posterior: lateral edge of sacrum & SIJ
- Inferior: base of triangle: lower free edge of levator ani downwards to Apex of the coccyx dorsally.
- Lateral wall: superiorly ischium, then medial surface of piriformis and caudally levator ani
- Medial wall: extends towards the plane of the sacrorectogenitopubic septum/ Mesorectum



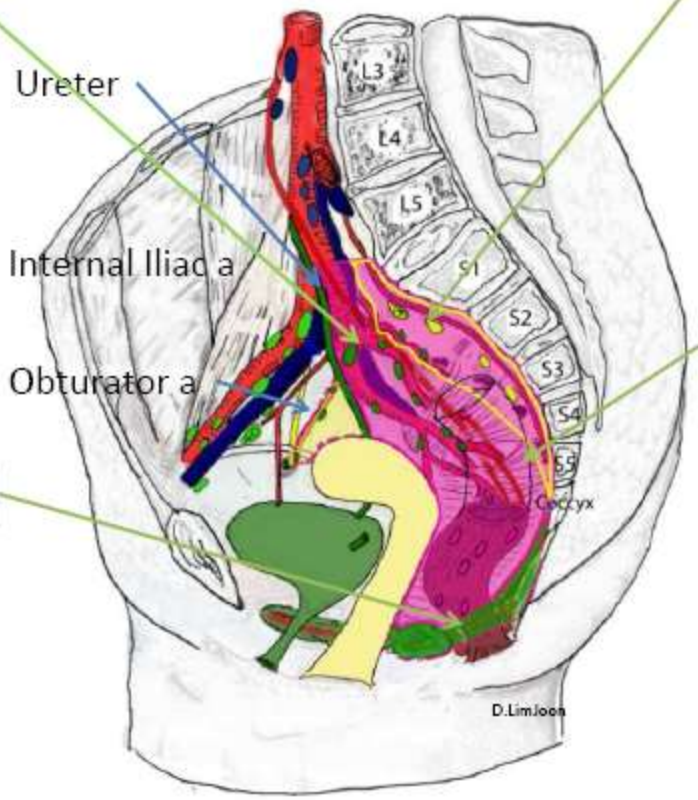
Rectum: CTV Anatomical Regions & Defining Landmarks

Internal Iliac region

S:CIA Bifurcation
A: Ureter
EIA region
P: Sacrum
L: Sacrum
Piriformis;
Ob internus
M: Urogenital
I: Levator ani

Internal pudenal region

Ischiorectal fossa
•Gl maximus
• Sacrotuberous lig
•Ob internus
•Levator ani



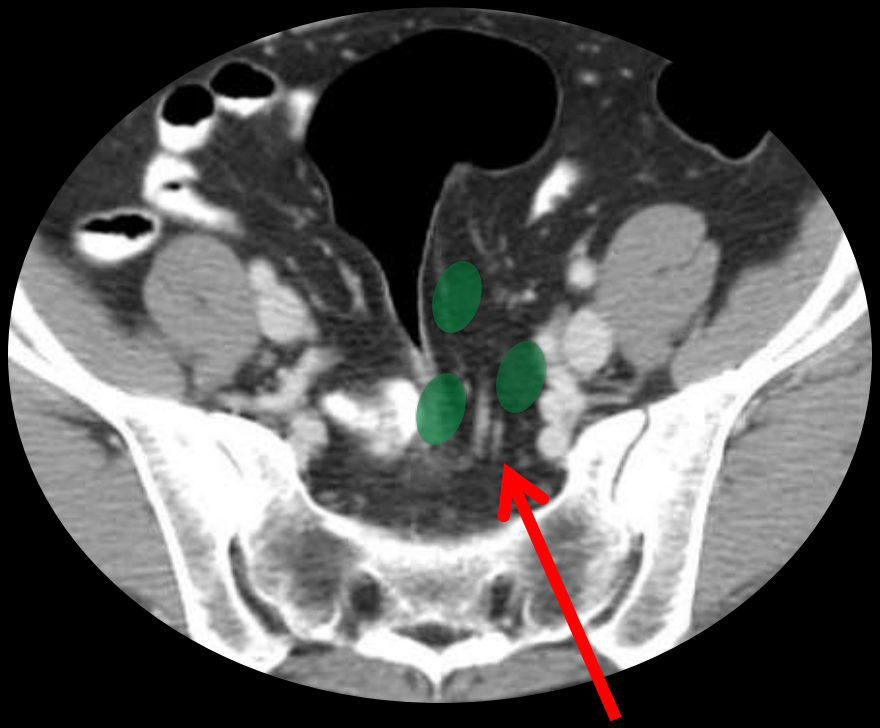
Presacral region

S: S1 promontory
A: MR
P: Sacrum
L: Sacrum
I:Coccyx

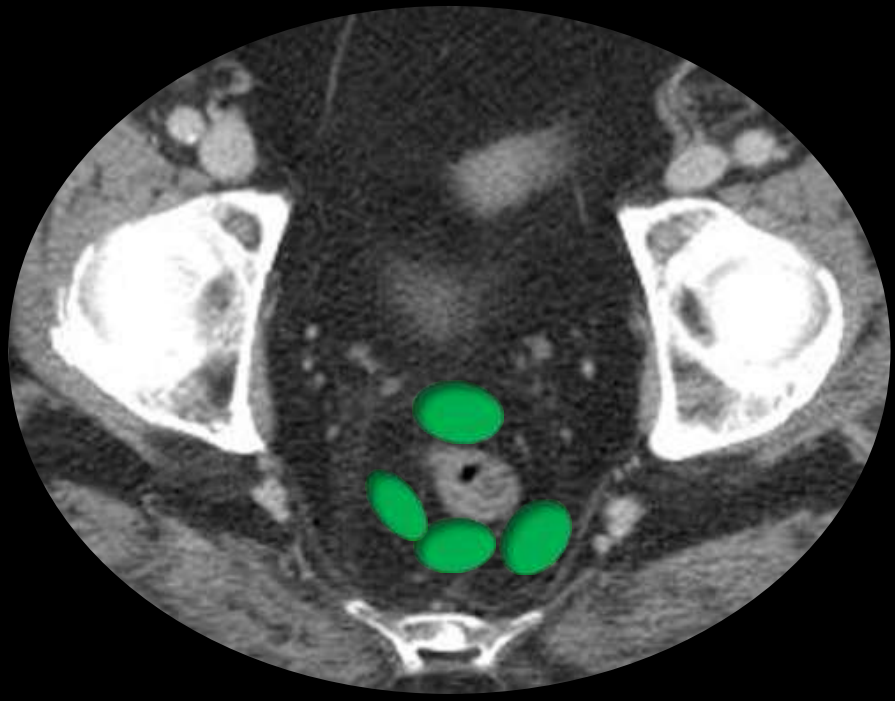
Mesorectal region

S: SRA/S3
A: Denonvilliers F
Urogenital
P: Presacral space
L: Ob internus
IIA region
I: Levator ani

Pelvic Nodal Anatomy



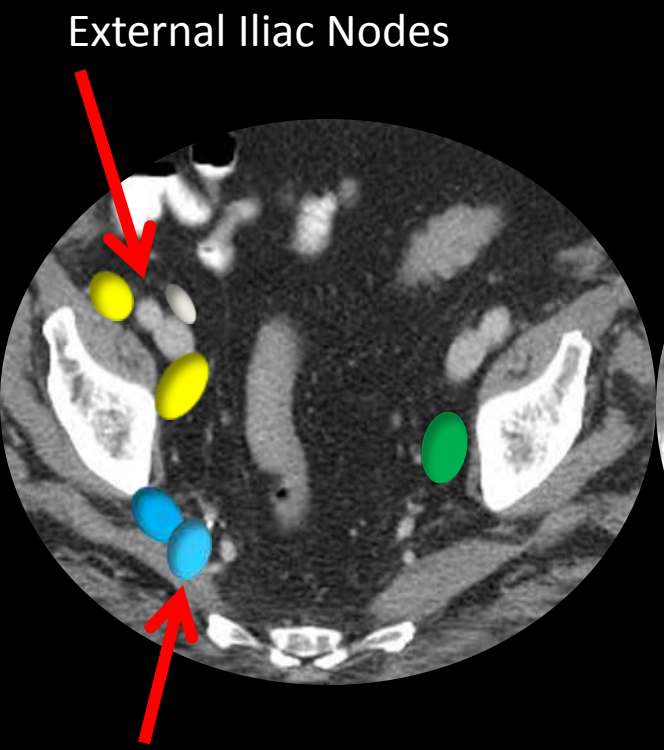
Superior Hemorrhoidal Vessels

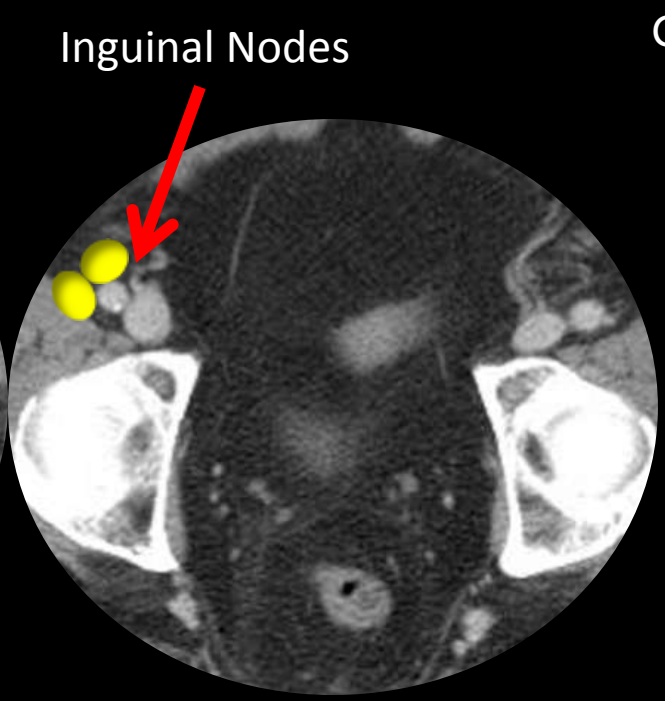


Mesorectal Nodes

Courtesy of Corinne Winston, MD

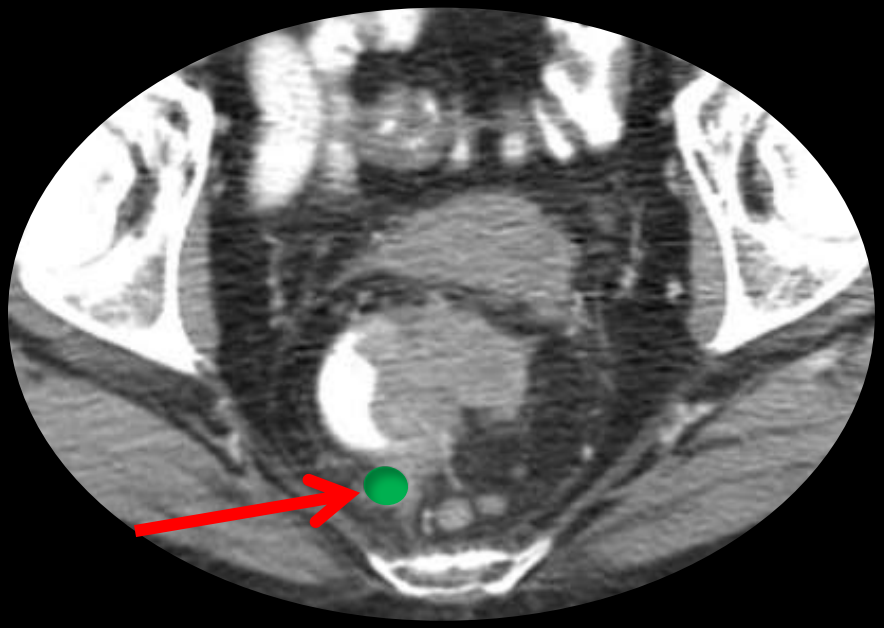
Pelvic Nodal Anatomy



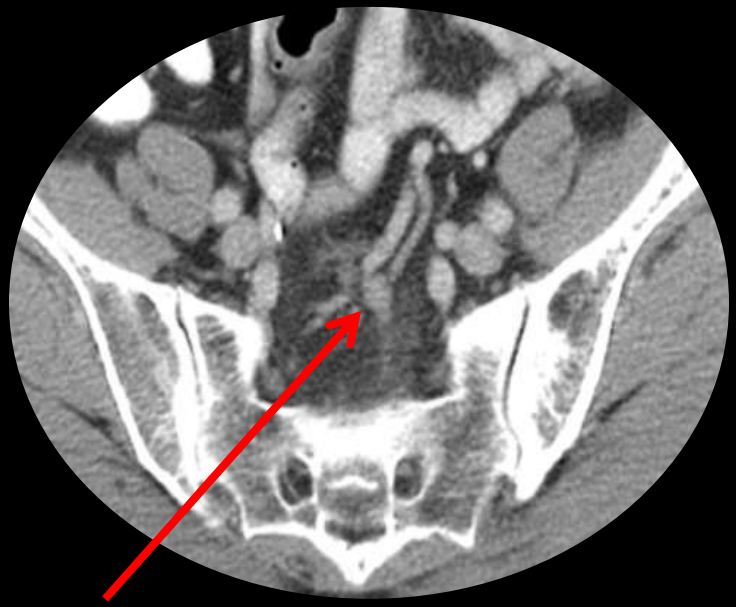


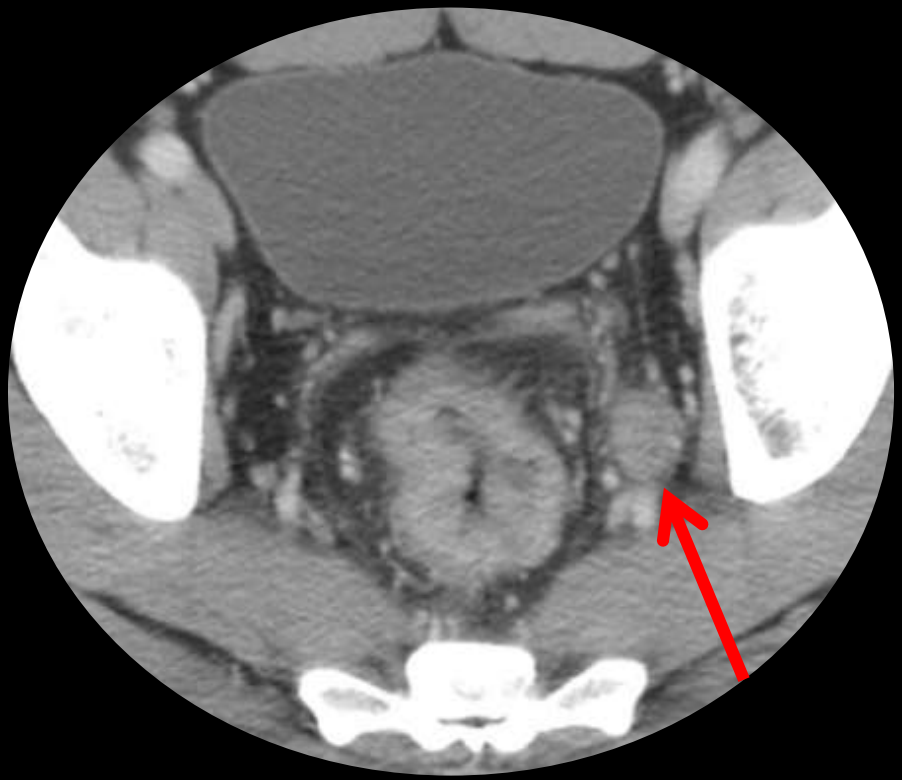
Courtesy of Corinne Winston, MD

Pelvic Nodal Anatomy



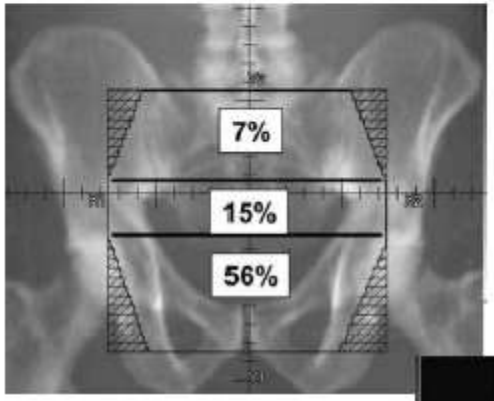
Pelvic Nodal Anatomy

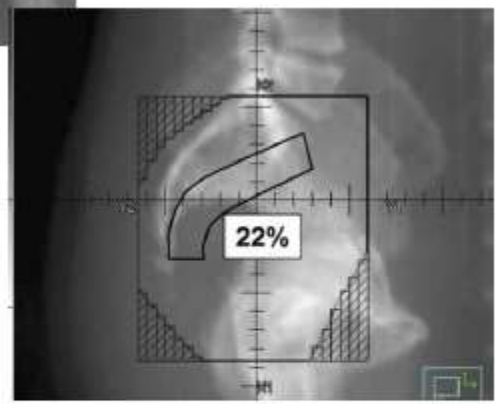




PATTERNS OF LOCOREGIONAL RECURRENCE AFTER SURGERYAND RADIOTHERAPY OR CHEMORADIATION FOR RECTAL CANCER MDACC 2008

- 36 or 554 patients with CT defined locoregional recurrence
- Preop 85% and Post op 15%
- Infield recurrences
  - 28/36 (65%)
  - 12 (56%) low pelvis
  - 6 (22%) presacral
  - 4 (15%) mid pelvis
  - 1 (7%) high pelvis
  - 1 extended across multiple areas





~80% in field recurrences occurred in low pelvic and presacral regions

Yu TK, et al. *Int J Radiat Oncol Biol Phys* 2008.

Recurrence Patterns: Summary

- "Rectal & Mesorectal Bed" – S3 to Coccyx; particularly presacral region
- Anterior into urogenital structures (anterior mesorectum)
- Lymph node metastases and recurrences occur in the regions of the mesorectum and internal iliac system

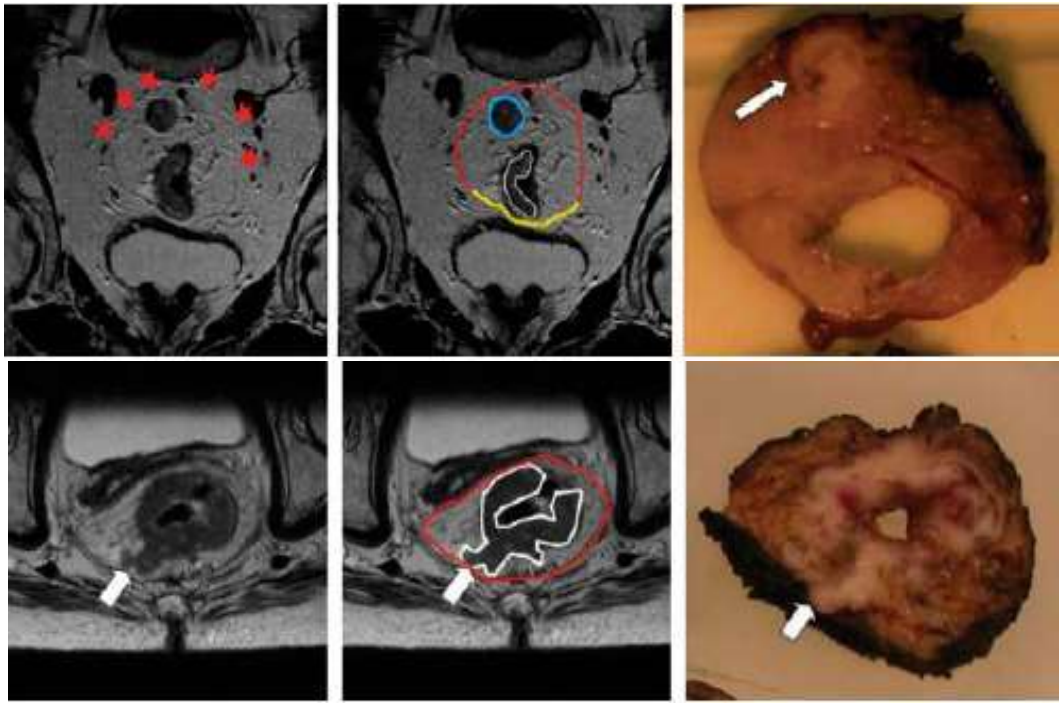
CONSISTENT WITH ANATOMICAL AND PATHOLOGICAL PREDICTIONS

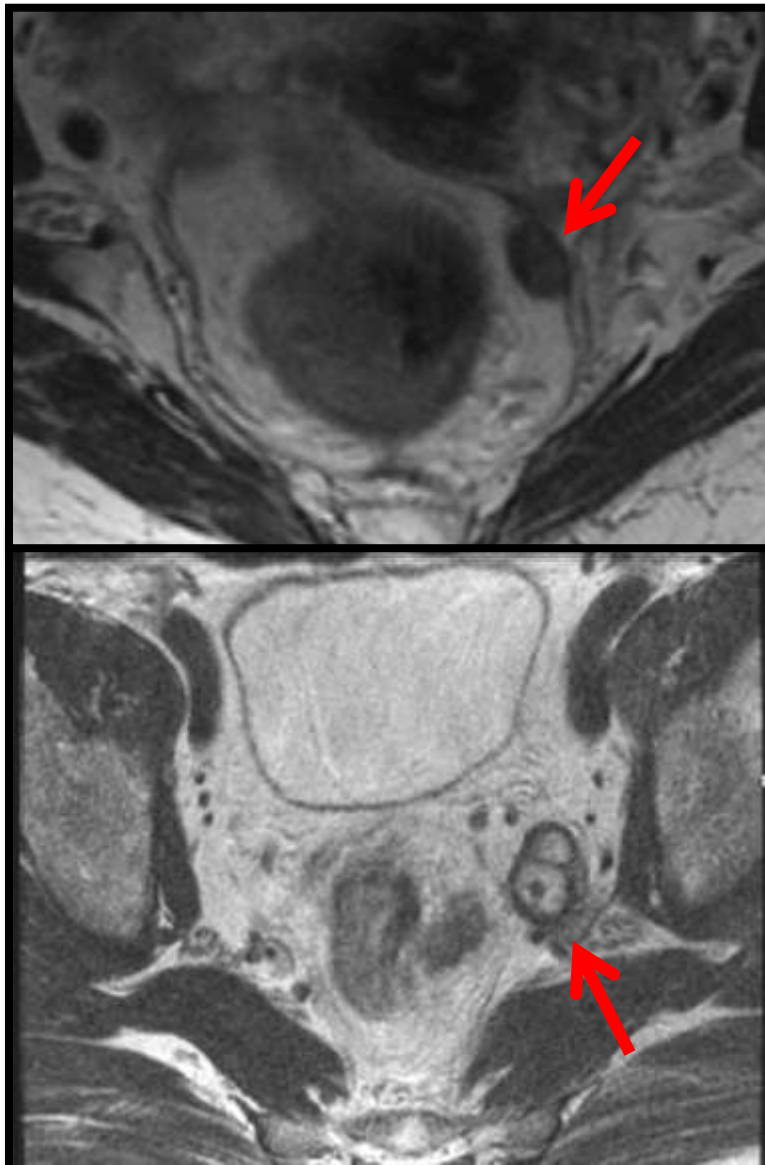
Roels et al 2006; Hocht et al 2004; Yu et al 2008

MRI to Risk Stratify Rectal Cancer

Determine extent of extramural tumor [1]

Identify risk of CRM positivity [2]





1- Mercury Study group, Radiology, 2007

2- Mercury Study group, British Medical Journal, 2006

T3 Staging of Rectal Carcinoma

Majority (80%) of rectal cancers present as T3 tumors

The degree of extension beyond the muscularis propria is important prognostically and potentially to the Rx chosen

T3a <1mm

T3b 1-5mm

T3c >5-15mm

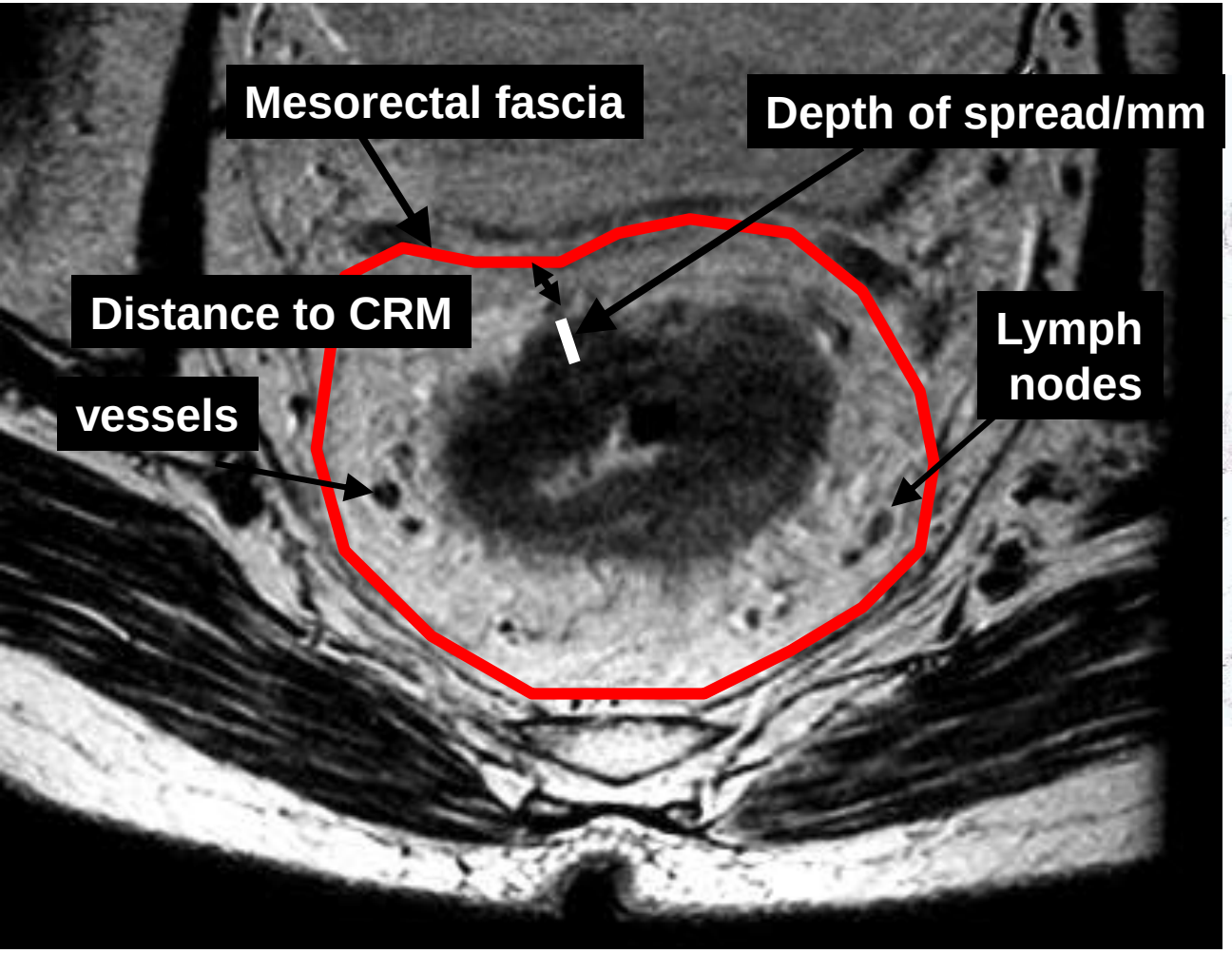
T3d >15mm

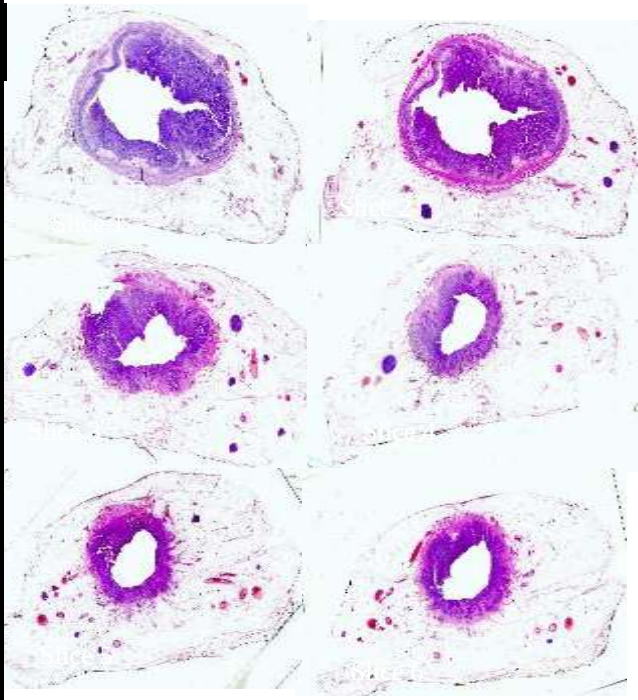
Early stage T3 (<5mm) 85% 5yr cancer specific survival

Advanced stage T3 (>5mm) 54% 5yr cancer specific survival

(Merkel et al. Int J Colorectal Dis 2001; 16: 298-304.)

The mesorectal fascia forms the potential CRM in TME surgery





Rectal Cancer – Target Definition

– GTV T & GTV N:

= Primary tumor + involved nodes (≥ 3 mm mezoR, ≥ 10 mm short axis iliac)

– As defined on physical exam, ERUS, MRI, CT, and/or PET

– GTV T = Include tumor + entire rectal circumference at that level

→"CTV T "(+10mm */ chiar daca CC va fi tot rectul sau/si + 20 mm cranial/ caudal de limita GTV)

→& CTV N = "CTV T&N"

Contouring Guidelines for CTV LN

RTOG Atlas

CTV A includes:

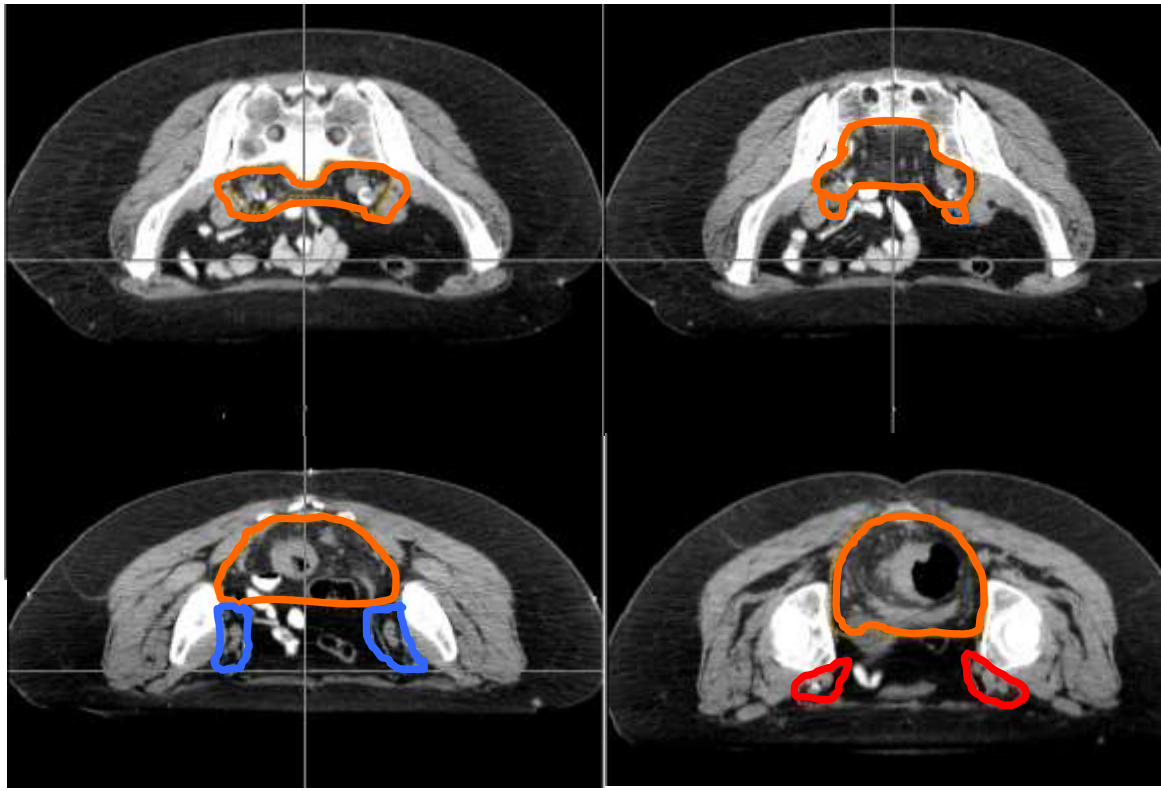
- Mesorectal nodes
  - Perirectal
  - "Presacral"
- Internal iliac nodes

CTV B includes:

- External iliac nodes

CTV C includes:

- Inguinal nodes



RTOG anorectal atlas:
www.rtog.org/CoreLab/ContouringAtlases/Anorectal.aspx

CTV- N: Elective nodal regions

*__Standard__: Mezorectal, internal iliac, and superior rectal **(CTV A)**

For **T4 tumors (P/ VS/ cervix/ vagina..):

- include external iliac **(CTV A + B)**

***For tumors invading **anal canal:**

- include inguinal and external iliac **(CTV A+B+C)**

GTV delineation (T & N)

CT Caveats : Poor contrast

- Tumor and faeces
- Tumor and anal sphincters/levator ani
- Partial volume effect through valves of Houston
- Imaging horizontal sigmoid

MRI: Better contrast

- Better contrast : tumor, rectal wall and faeces
- Improved visualization of longitudinal & circumferential spread into mesorectum
- Better define infiltration into adjacent organs (bladder, prostate or seminal vesicles in men and vagina and uterus in women)
- Co-registered with CT

RTOG Consensus: Rectum- CTVA

- Lower pelvis
  - 2cm caudal of GTV
  - Mesorectum to pelvic floor
  - Few mm below levator ani
- Mid pelvis
  - Rectum & mesorectum
  - Internal iliac region
  - Pelvic sidewall muscle/bone
  - 1 cm posterior bladder (day to day variation)

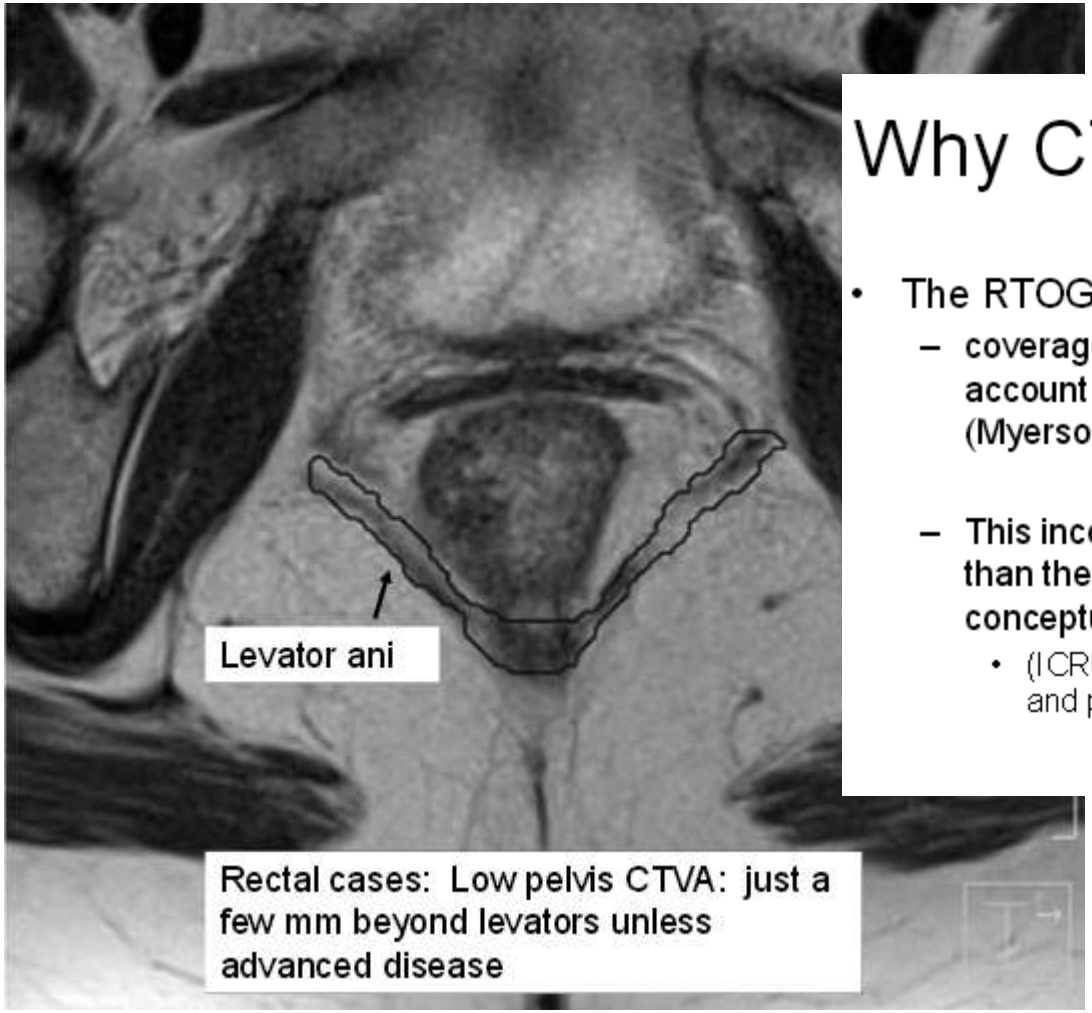
I.e. Rectum + Mesorectum + Internal iliac region
= Rectosigmoid to levator + IIA from CIA bifurcation and to pelvic sidewalls

Myerson et al IJROBP 2008

RTOG Consensus: Rectum- CTVA

- Upper pelvis
  - Rectosigmoid or 2cm proximal to GTV
  - CIA bifurcation
  - 1cm anterior to sacrum in midline
- Other
  - Exclude uninvolved pelvic bone & muscle
  - Include levators

Myerson et al IJROBP 2008



Why CTVA 1cm into bladder?

- The RTOG anorectal contouring guidelines
  - coverage extending CTVA 1cm into the posterior bladder to account for day to day variation in bladder position (Myerson RJ, IJROBP 2008;74: 824-830).
  - This incorporation of motion into CTV generation, rather than the planning target volume expansion, represents a conceptual break with ICRU 62.
    - (ICRU 50 and 62: PTV only takes into account organ motion and patient positioning)

CTVA (peri-rectal, pre-sacral, internal iliac regions) Lower Pelvis

- caudal extent of this ECTV (elective clinical target volume) should be a minimum of 2 cm caudal to GTV

- In addition → coverage of the entire mesorectum to the pelvic floor even for upper rectal cancers

CTVA (peri-rectal, pre-sacral, internal iliac regions)
Lower Pelvis

- advanced rectal cancers extending through the mesorectum or the levators, the panel recommend: add ~1–2 cm margin up to bone, wherever the cancer extends beyond the usual compartments

- if the tumor is invading a neighboring organ (T4 disease) CTVA should include a 1–2 cm margin around the identified areas of invasion
- MRI and/or PET/CT scan is strongly recommended

CTVA (peri-rectal, pre-sacral, internal iliac regions). Mid pelvis

- *CTVA* includes rectum and its mesentery, the internal iliac region + margin for bladder variability
- posterior & lateral margins of *CTVA* should extend to pelvic sidewall musculature or, where absent, bone
- Anterior: extend *CTVA* ~1 cm into the posterior bladder, to account for day-to-day variation in bladder position
- including at least the posterior portion of the internal obturator vessels (which lie between the external and internal iliacs in the mid pelvis) with *CTVA*.

CTVA (peri-rectal, pre-sacral, internal iliac regions). Mid pelvis

- The recommended superior extent of the peri-rectal component of *CTVA* was whichever is more cranial: the rectosigmoid junction or at least 2 cm proximal to the superior extent of macroscopic disease in the rectum/peri-rectal nodes

- The full length of the rectum should always be in *CTVA*, but more of the large bowel should be incorporated, if the 2 cm proximal margin requires that.

CTVA (peri-rectal, pre-sacral, internal iliac regions). Upper pelvis

- The most cranial extent of *CTVA* will be higher than the rectum, to cover the internal iliac and pre-sacral regions.

- The most cranial aspect of *CTVA* should be where the common iliac vessels bifurcate into external/internal iliacs (approximate boney landmark: sacral promontory)

- midline- CTVA should extend at least 1cm anterior to the sacrum for proper coverage of the pre-sacral region

CTVA (peri-rectal, pre-sacral, internal iliac regions). Upper pelvis

- For all areas of *CTVA*, care should be taken to avoid contouring into uninvolved bone
- In general the CTVA contour does not extend into uninvolved pelvic sidewall muscles but does include the levators
- when small bowel fell into the region normally taken by rectal mesentery the panel opted to keep it in the elective target volume CTVA—since the location of small bowel could vary from day to day !

CTVA (peri-rectal, pre-sacral, internal iliac regions). Upper pelvis

- In principle, the day-to-day variation of adjacent organs like the bladder and bowel should be incorporated in the PTV margin

- It is more practical, however, to assign a uniform PTV margin and account for physiologic variability by adjusting the CTV.

CTVB (external iliac) and *CTVC* (inguinal region)

Indications for elective irradiation

- The consensus group felt that elective coverage of the inguinal and external iliac regions should be routine for anal carcinoma
- For rectal carcinomas extending into GYN or GU structures (the most common manifestation of T4 disease), the panel agreed that the external iliac region should be added (elective nodal coverage = *CTVA* + *CTVB* for these cases)

Indications for elective irradiation

Caudal extent of elective target volumes

- The consensus panel recommended that the caudal extent of the inguinal region (*CTVC*) should be 2 cm caudal to the saphenous/femoral junction
- The transition between inguinal and external iliac regions (*CTVC* to *CTVB*) is somewhat arbitrary
- the group recommended that this should be at the level of the caudal extent of the internal obturator vessels (approximate : upper edge of the superior pubic rami)

Margin around blood vessels

- The group recommended at least a 7–8 mm margin in soft tissue around the iliac vessels, but one should consider a larger, 10+ mm, margin anterolaterally—especially if small vessels or nodes are identified in this area
- The inguinal/femoral region should be contoured as a compartment with any identified nodes (especially in the lateral inguinal region) included
- If using automated expansions, the CTVs should be trimmed off uninvolved bone and muscle

Rectum: CTV Anatomical Regions & Defining Landmarks

Internal Iliac region

S:CIA Bifurcation
A: Ureter
EIA region
P: Sacrum
L: Sacrum
Piriformis;
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Internal pudenal region

Ischiorectal fossa
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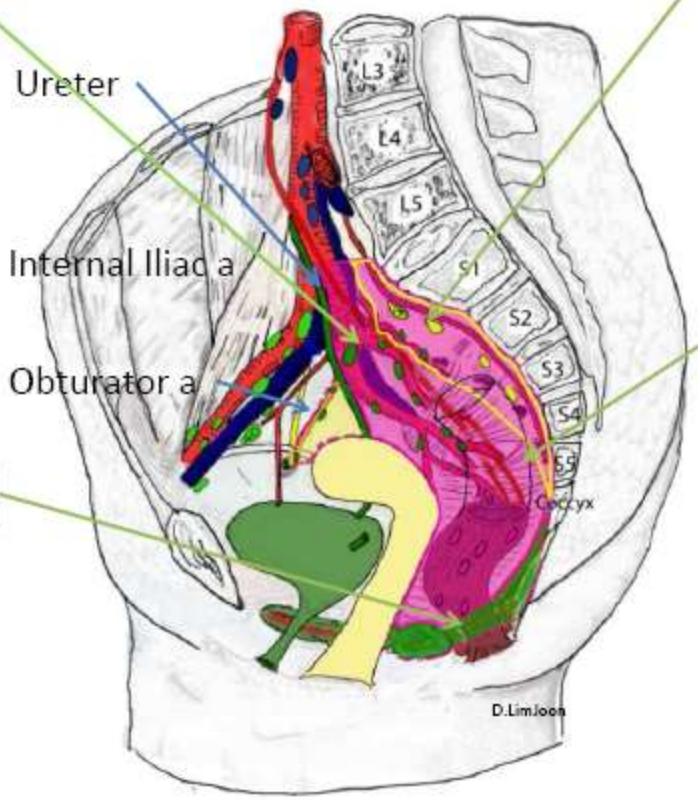

Presacral region

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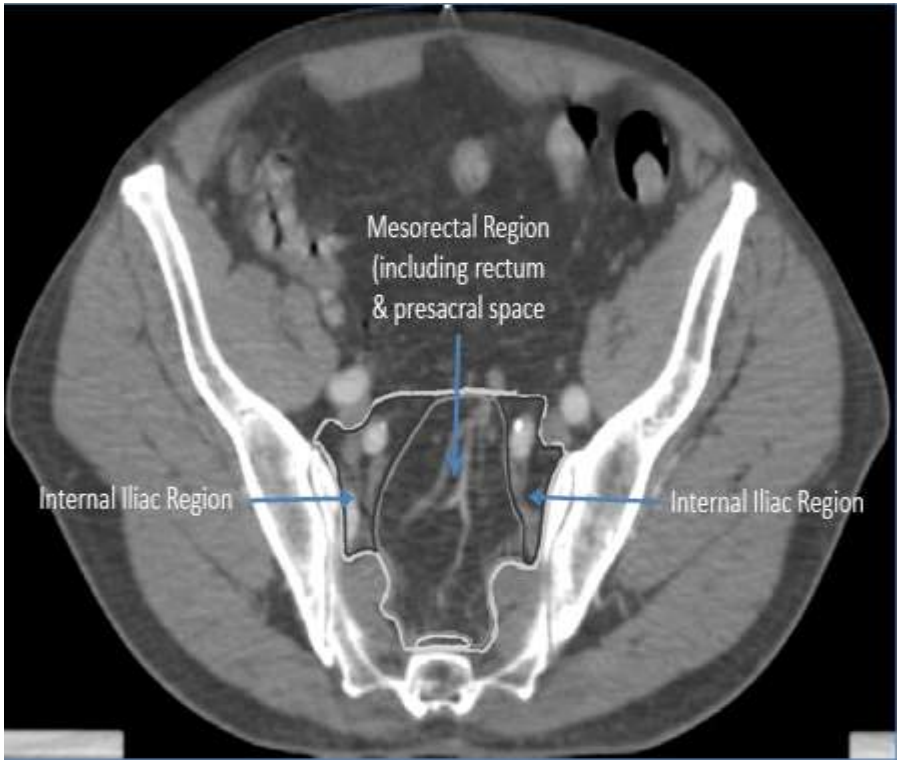
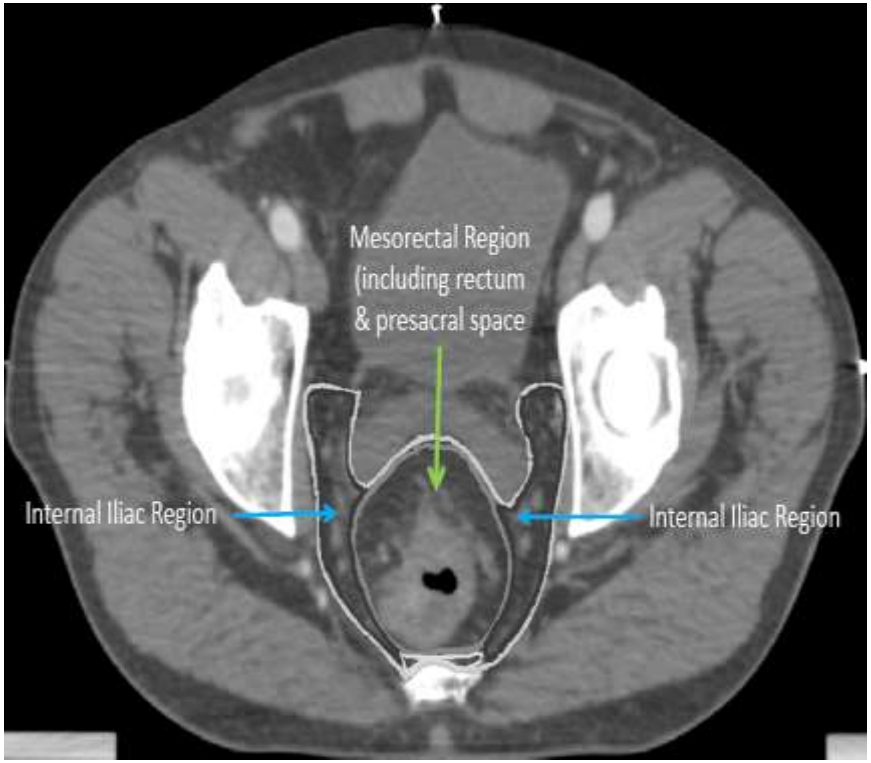

Mesorectal Region
(including rectum
& presacral space
Internal Iliac Region
Internal Iliac Region


Mesorectal Region
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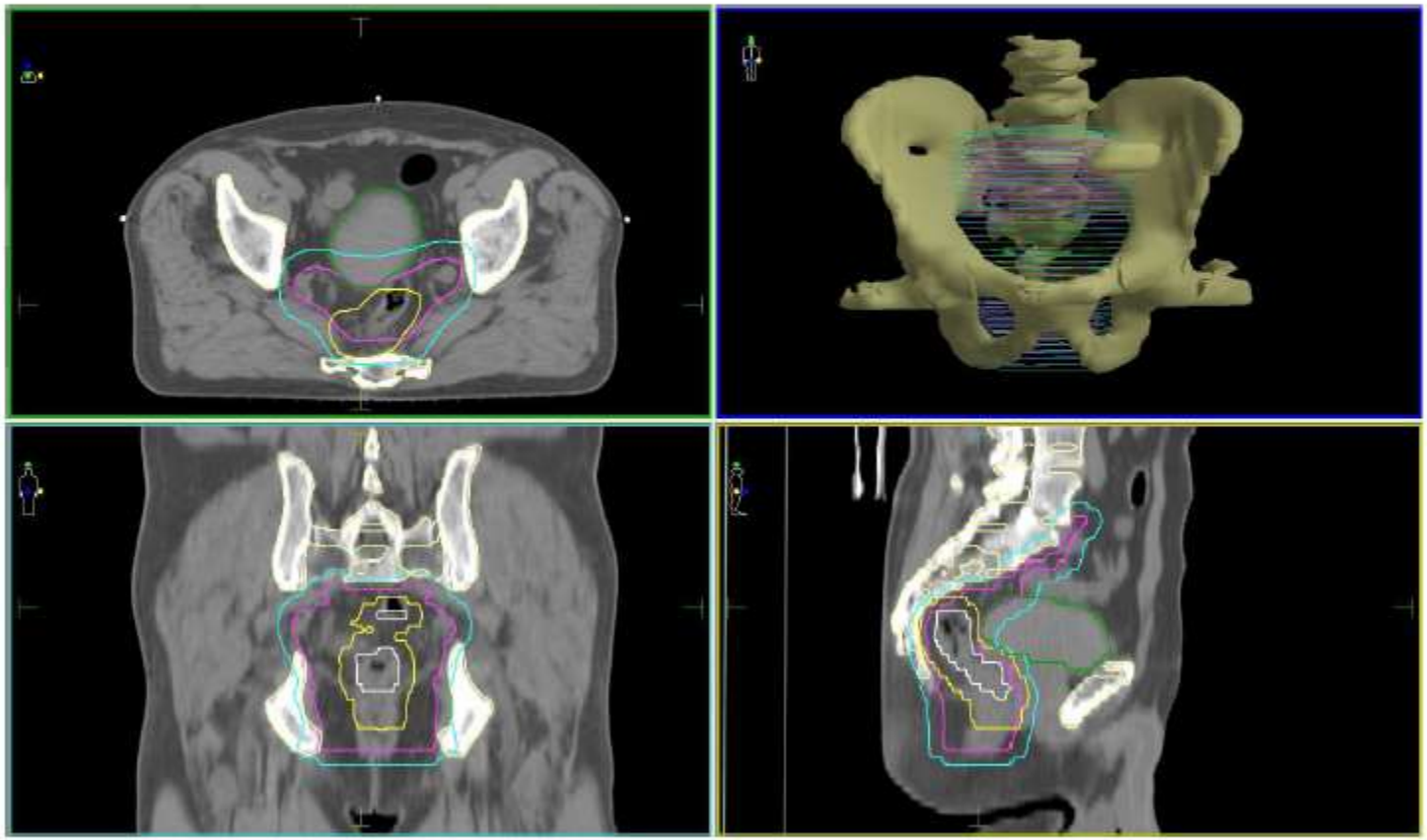
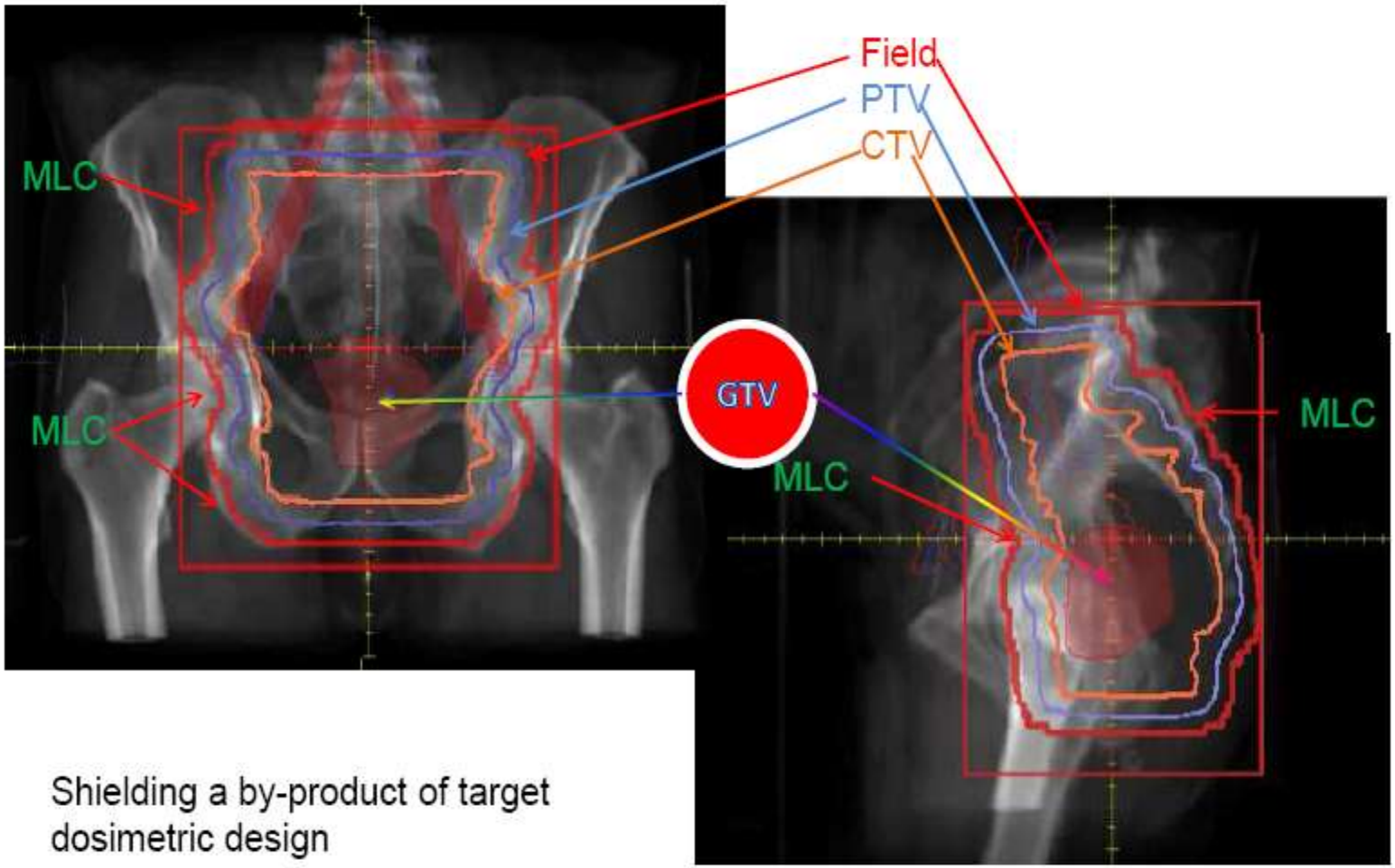
Internal Iliac Region
Internal Iliac Region

Completed Contouring



Typical Fields

(product of CTV dosimetric design)



Shielding a by-product of target dosimetric design

Boost Volumes and Planning Target Volumes

- any **boost CTV** extend to the entire mesorectum and pre-sacral region at involved levels, including:

~1–2 cm cranial & caudal in the mesorectum and

~2 cm on gross tumor within the anorectum

Planning target volumes (PTVs).

- PTV – symmetrical 5 mm expansion around the CTV
- If PTV extend outside of the skin surface, manually trim the PTV contours to be 3-5 mm inside the outer skin (unless there is direct skin involvment)

Organs at risk (OAR)

Femoral head and neck

- The entire femoral head and neck should be contured
- The inferior extent is the cranial edge of the lesser trochanter

Urinary bladder

- The entire external outline of the bladder wall should be contoured

Organs at risk (OAR)

Bowel

- small & large bowel should be delineated from 15 mm superior to the cranial aspects of the PTV, extending inferiorly→ recto-sigmoid junction

Organs at risk (OAR)

External genitalia and perineum

- males: penis, scrotum, skin and fat anterior to pubic symphisis
- Females: clitoris, labia majora, minora, skin & fat anterior to pubic symphisis

Bone marrow

- Iliac crests used to define “bone marrow”
- Cranially: top of the iliac crest
- Caudally: superior part of acetabulum
- Left and right iliac crests combined into one volume

Conclusions

- Improve the individual dosimetric coverage of the target compared to traditional fields
- Improve inter and intra-observer variation (base anatomical planes – distinct edge/contrast gradient)
- Allows for the collection of 3D dose response data
  - Map recurrence with respect to dosimetry

Present & Perspectives

- Induction chemotherapy - NCCN 2015
- Preop CRT remains standard of care in advanced LR rectum adenocarcinoma
- IMRT can reduce toxicity of pelvic RT

→ Restaging after induction chemotherapy & CRT

→ " wait and see" or definitive CRT

….. Molecular biomarkers, functional imaging