Contouring Guidelines in Rectal Malignancies: Target volumes and strategies for reduction of toxicities

Dr Kanika Sharma Sood
Dharamshila Narayana Superspeciality Hospital
Delhi

Narayana Health

ROADMAP

- Prerequisites for RT Planning
- Intent of therapy
- Steps of Simulation
- OAR Delineation
- CTV Delineation
- Tips for reducing toxicity
- Conclusion

Intent of Therapy

Neoadjuvant
Adjuvant
Radical
Palliative

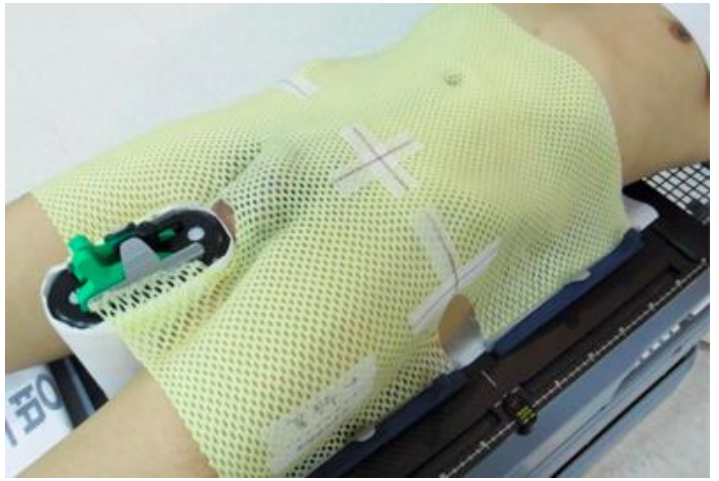
Means to reduce toxicity

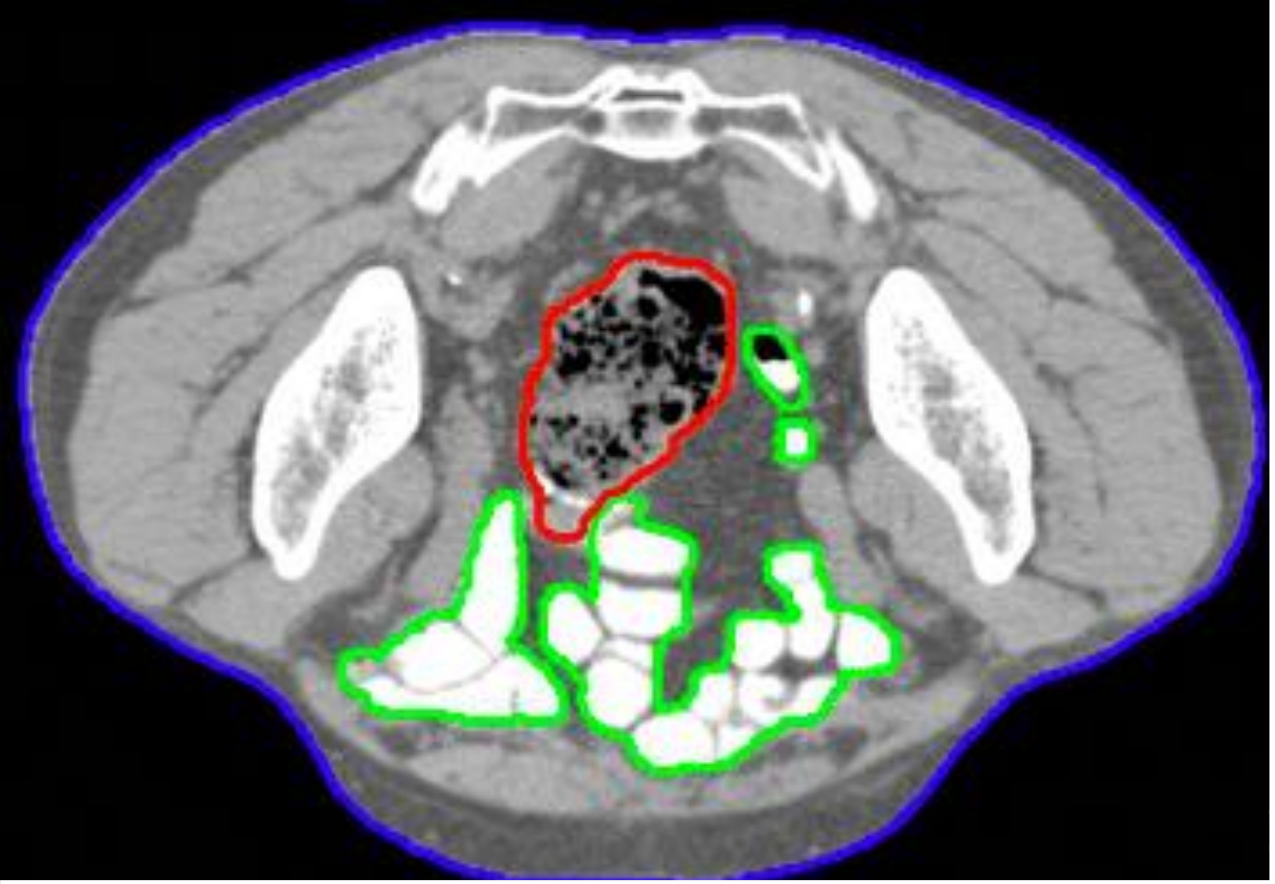
- Starts with simulation
- Bladder and bowel protocol
- Appropriate delineation of targets and OARS
- Selection of appropriate technique
- Tissue expanders/Slings

Steps of Simulation

Patient position

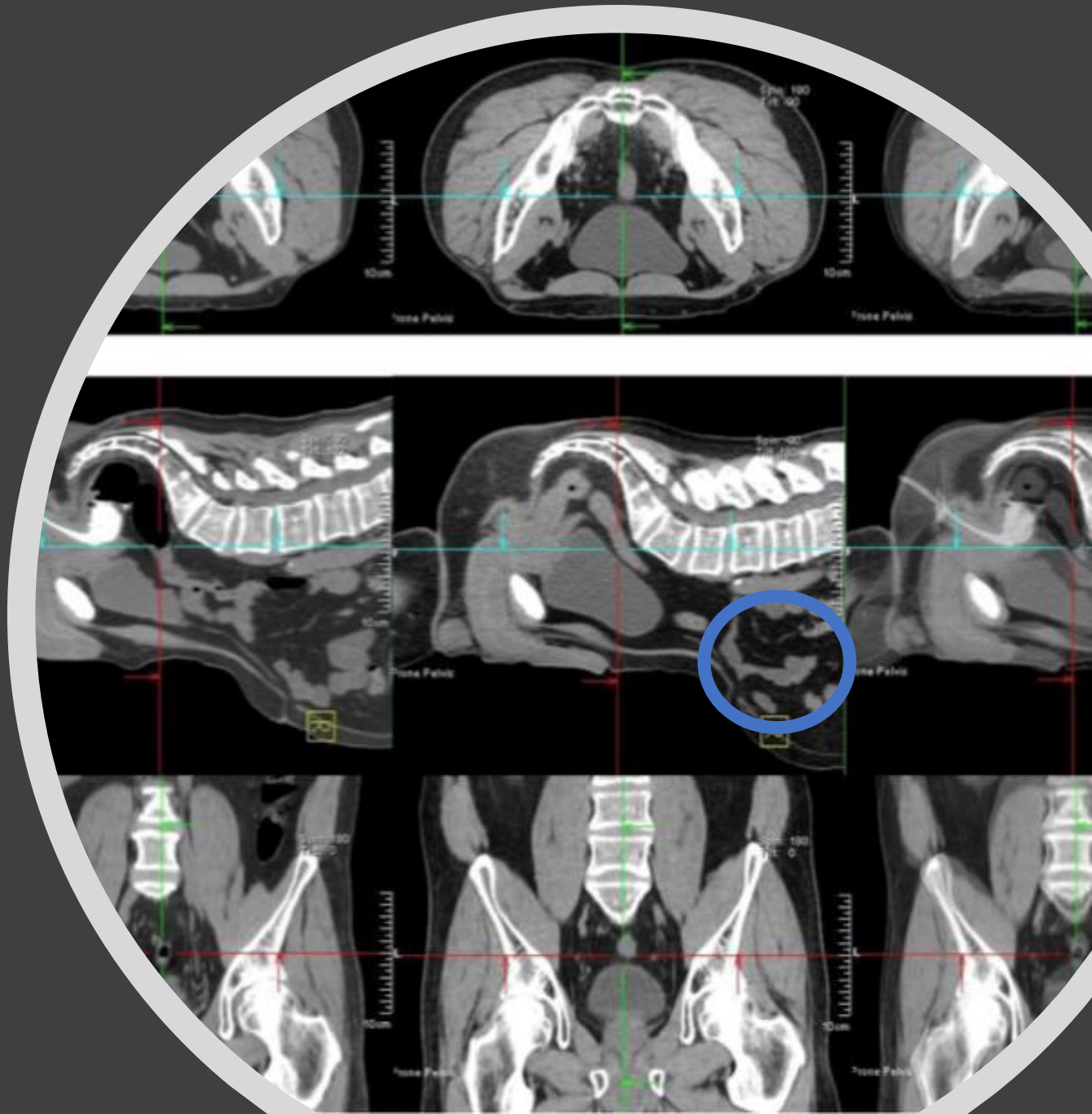
- Supine with body immobilization or
- Prone with use of a belly board for anterior displacement of bowel





Prone Belly Board

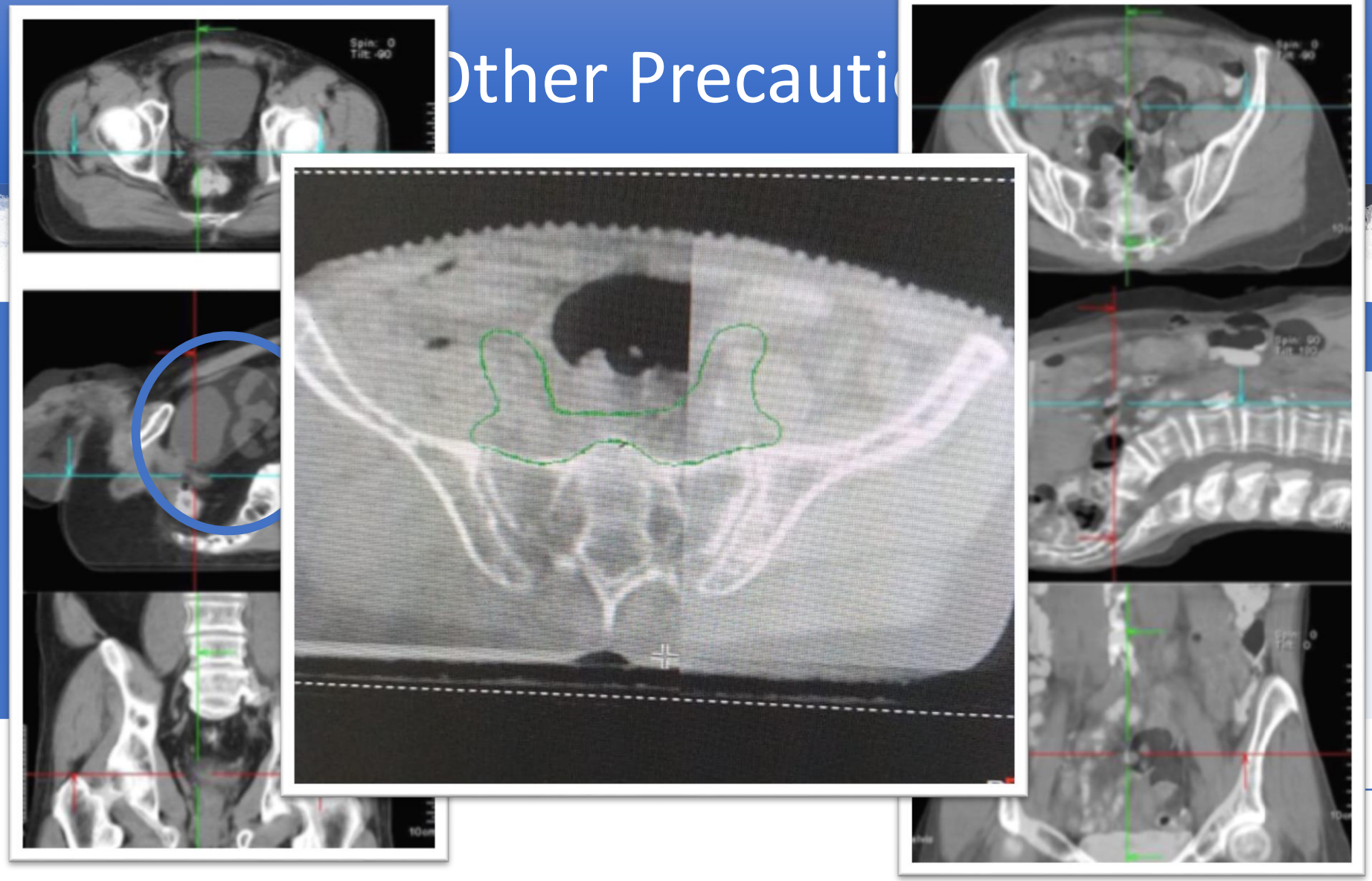
Impact of belly board



Tips for simulation

- Oral contrast 30 min prior to simulation - differentiate small bowel/large bowel
- Planning CT scan of abdomen and pelvis is obtained at 3-mm intervals (Inferior edge of the L2 through mid-thigh)
- IV contrast -delineate GTV and pelvic blood vessels
- Place fiducials at anal verge
- Diluted rectal contrast helps in tumour delineation

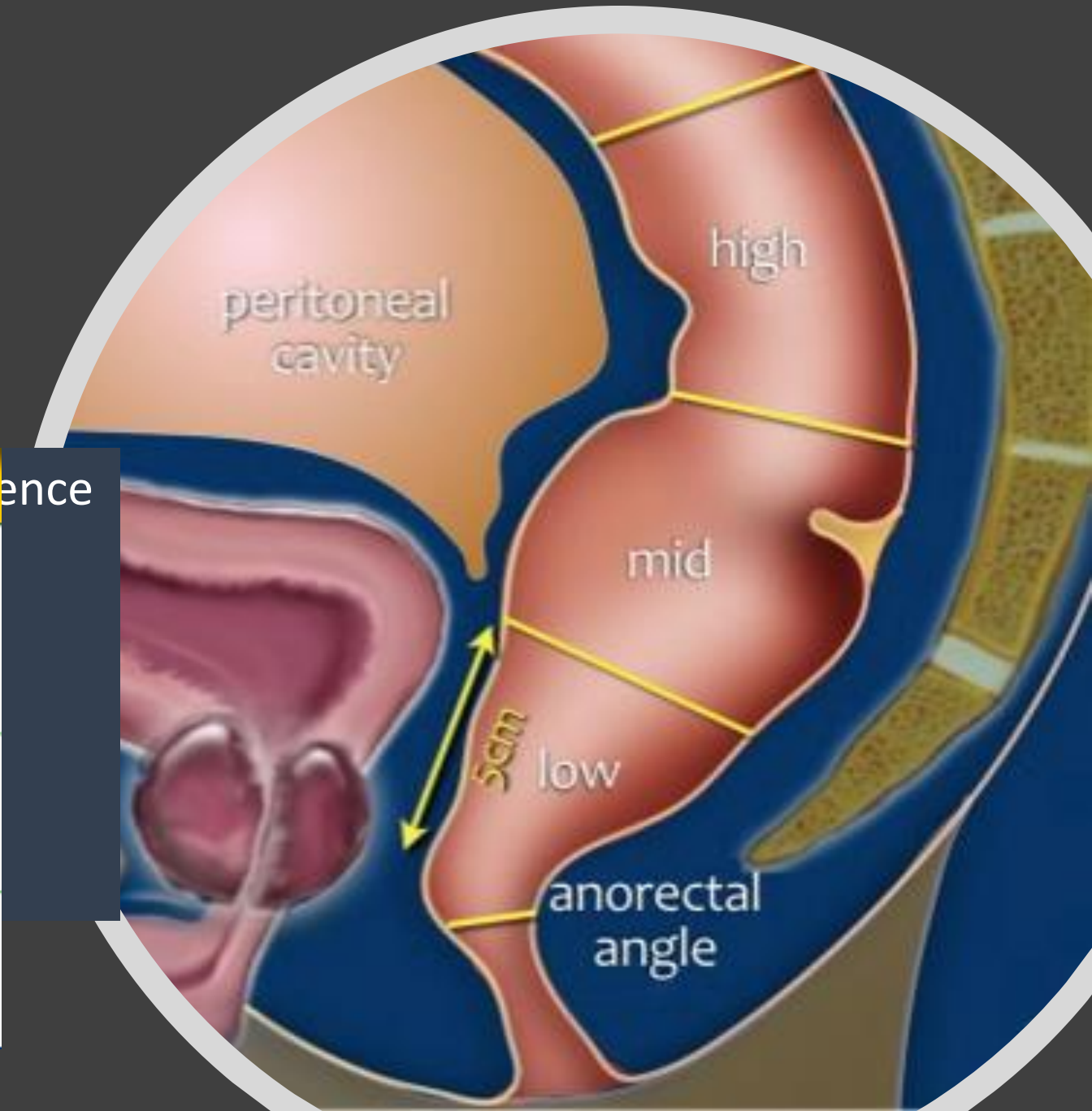
Other Precauti

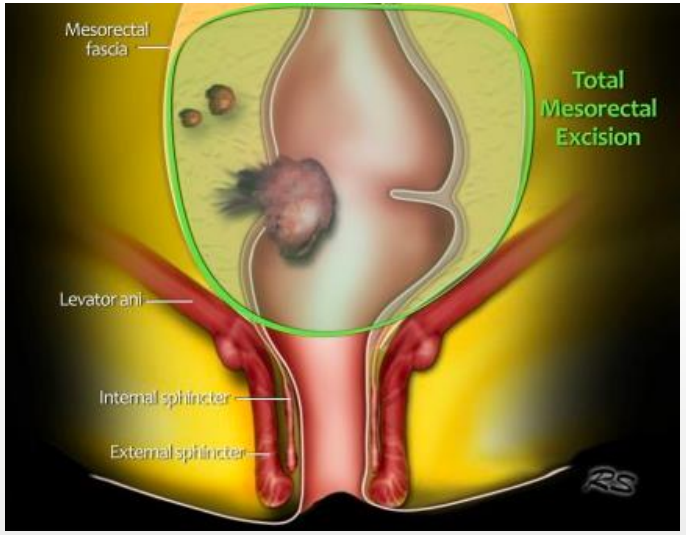


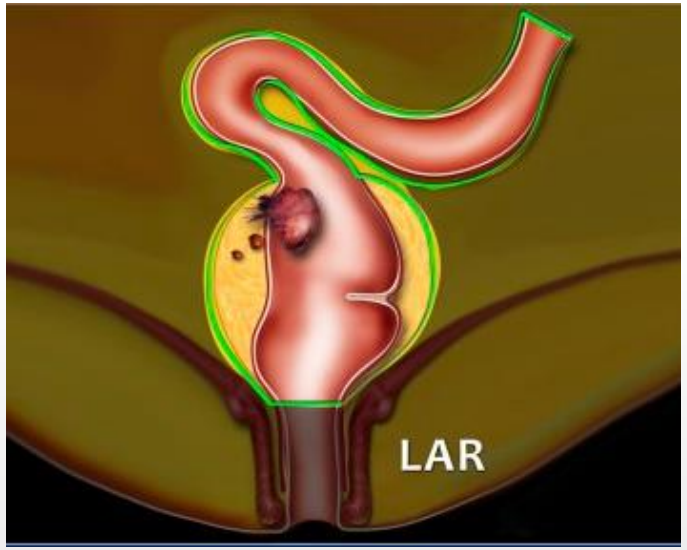
Checklist before starting contouring

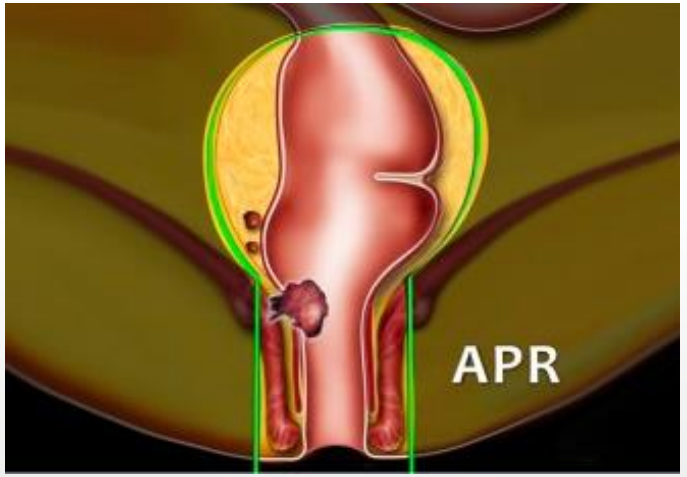
N-stage - suspicious nodes			
	Indistinct	Heterogeneous	Round
Malignant characteristics			
Short axis	- < 5mm : needs 3 malignant characteristics - 5 -9mm : needs 2 malignant characteristic - > 9mm : always suspicious		
cN-stage	- N0 : ***no*** *suspicious* lymph nodes - N1 : 1-3 *suspicious* lymph nodes - N2 : ≥ 4 *suspicious* lymph nodes		

ence







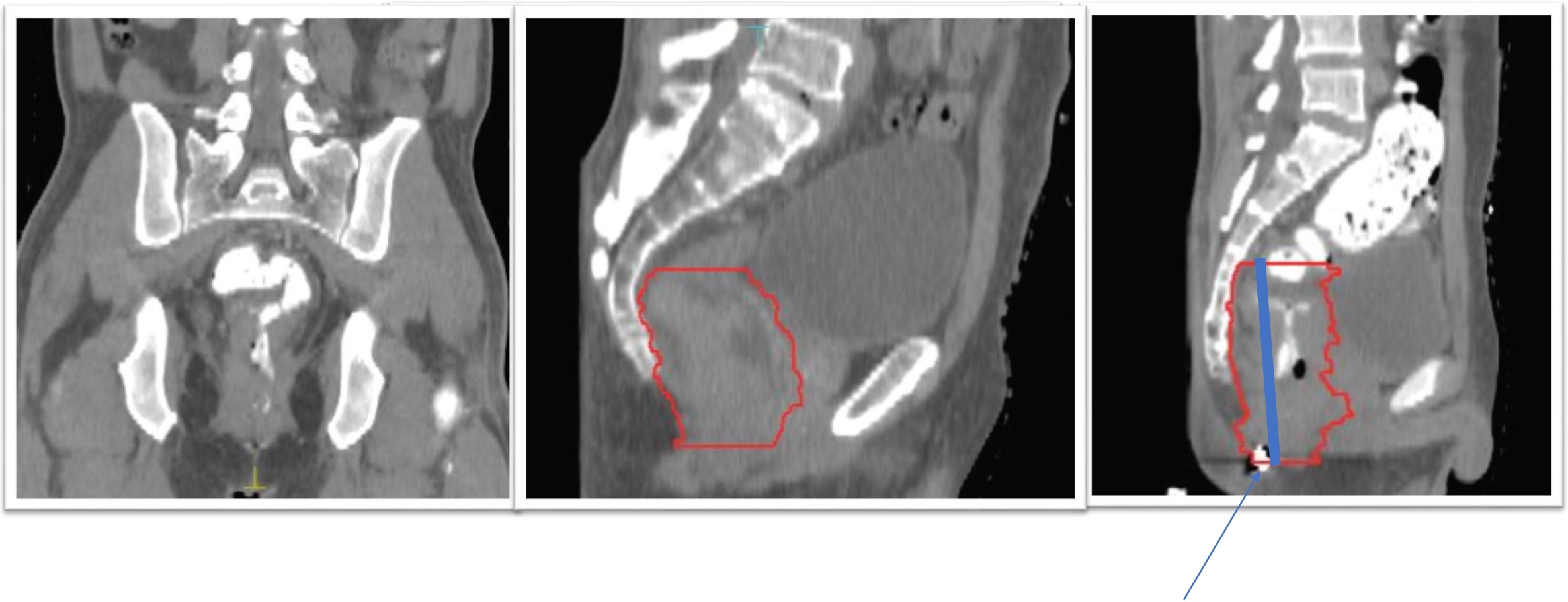


Site of tumour dictates surgery as well RT Ports

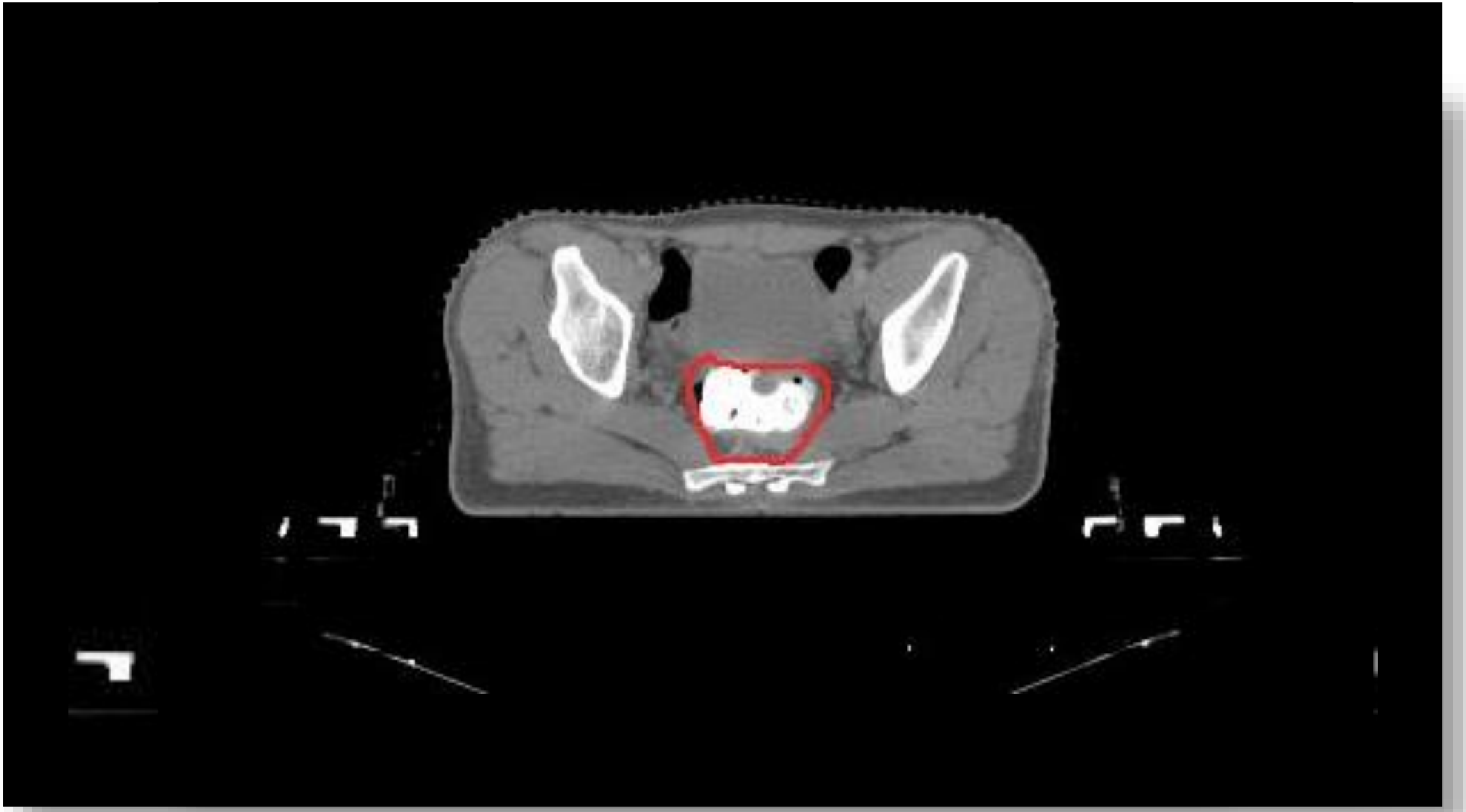
GTV delineation

- Basis for correct CTV delineation
- T1 post contrast MRI images
- CT scan with diluted contrast/water (10cc) helps in volume delineation
- Contour the contrast and fiducials

Contrast



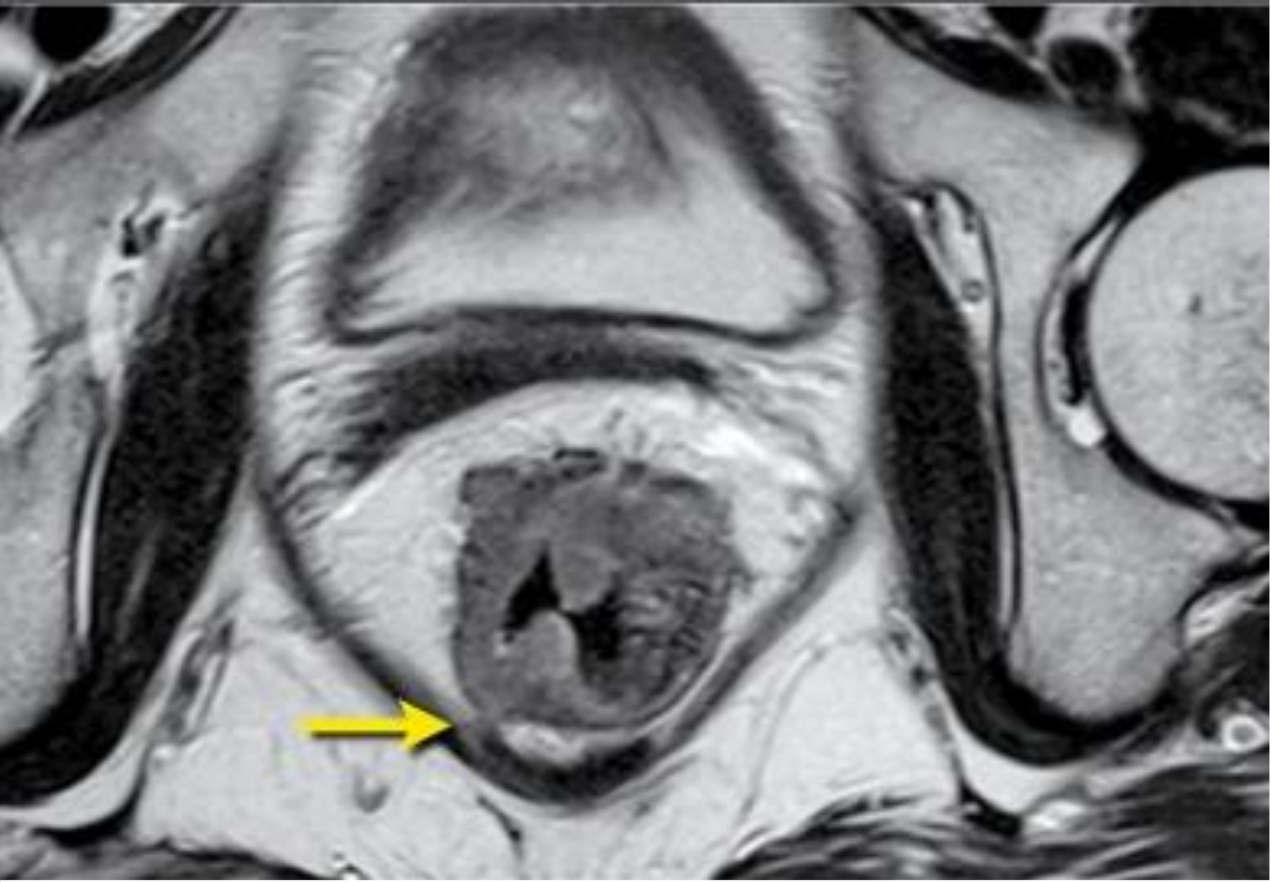
Fiducials help to determine cranio caudal extent

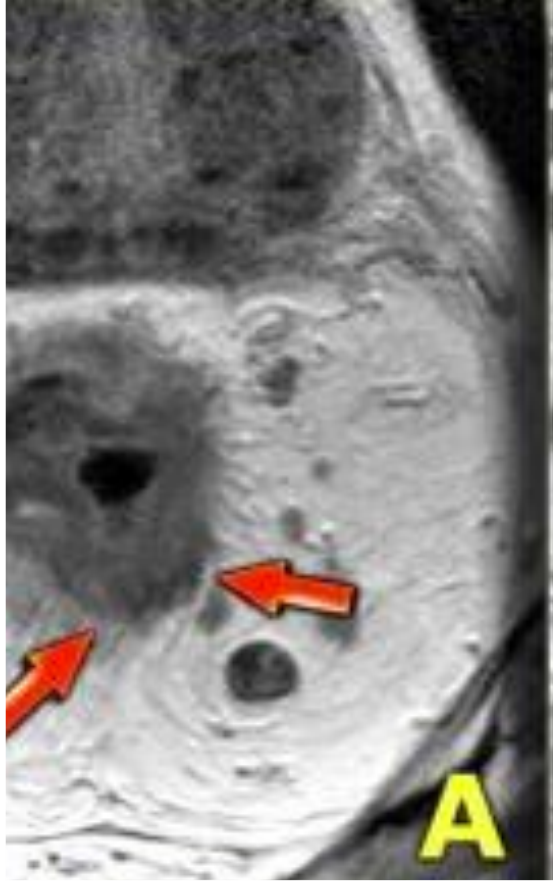


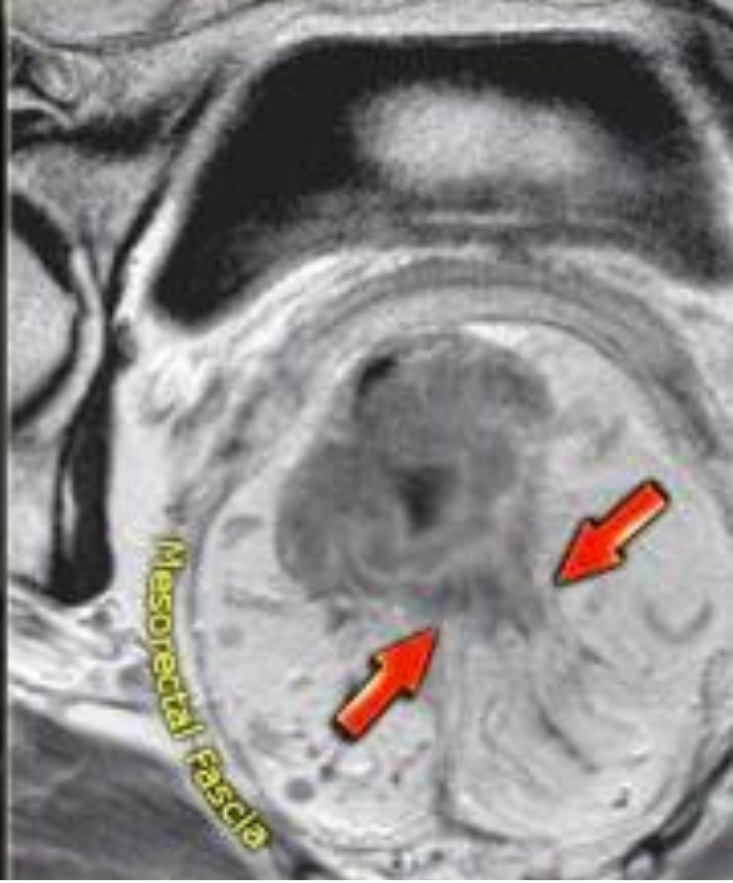
Role of MRI

- Identification of perirectal disease
- Identification of pelvic side wall disease

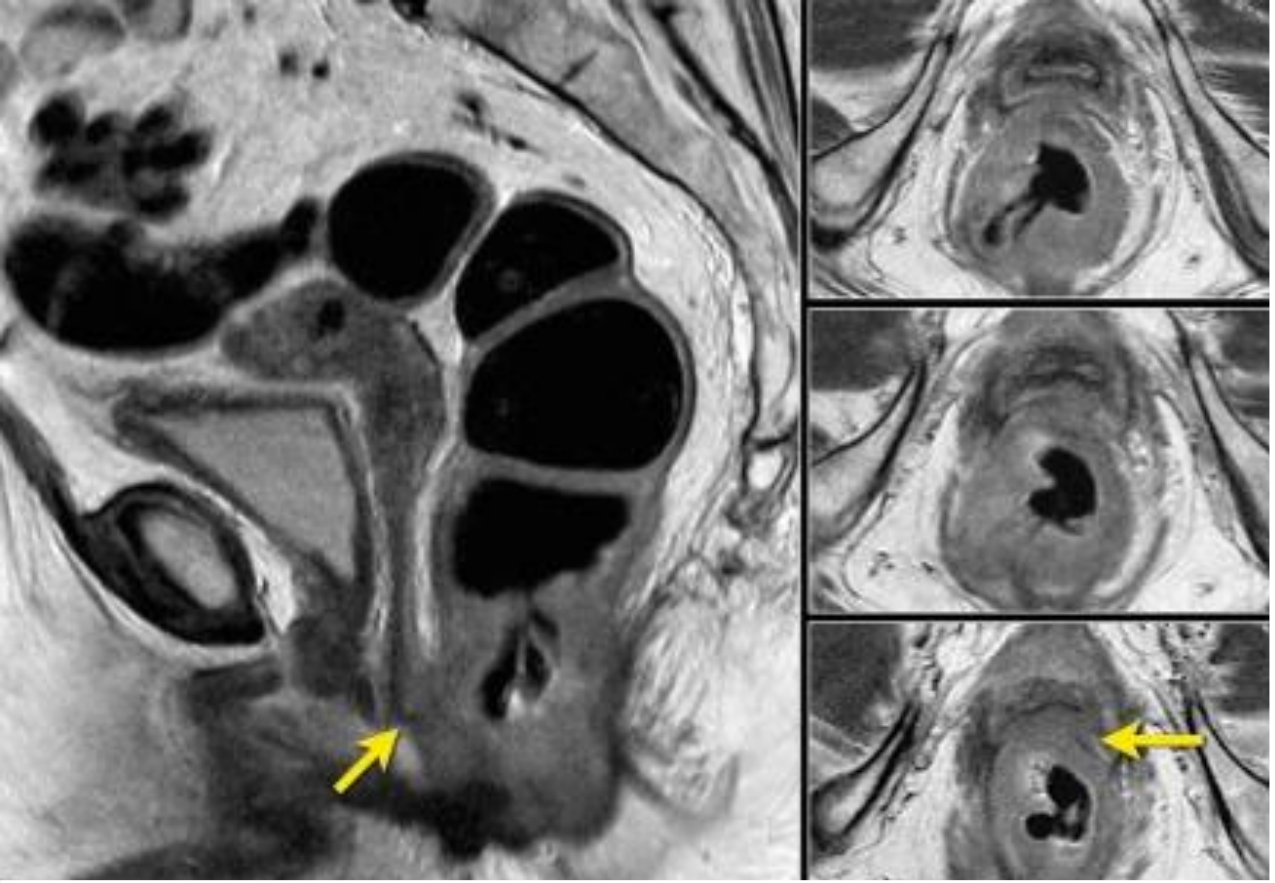
Identify site location of stalk or invasive border and relationship to puborectalis sling, peritoneal reflection, mesorectal or intersphincteric border



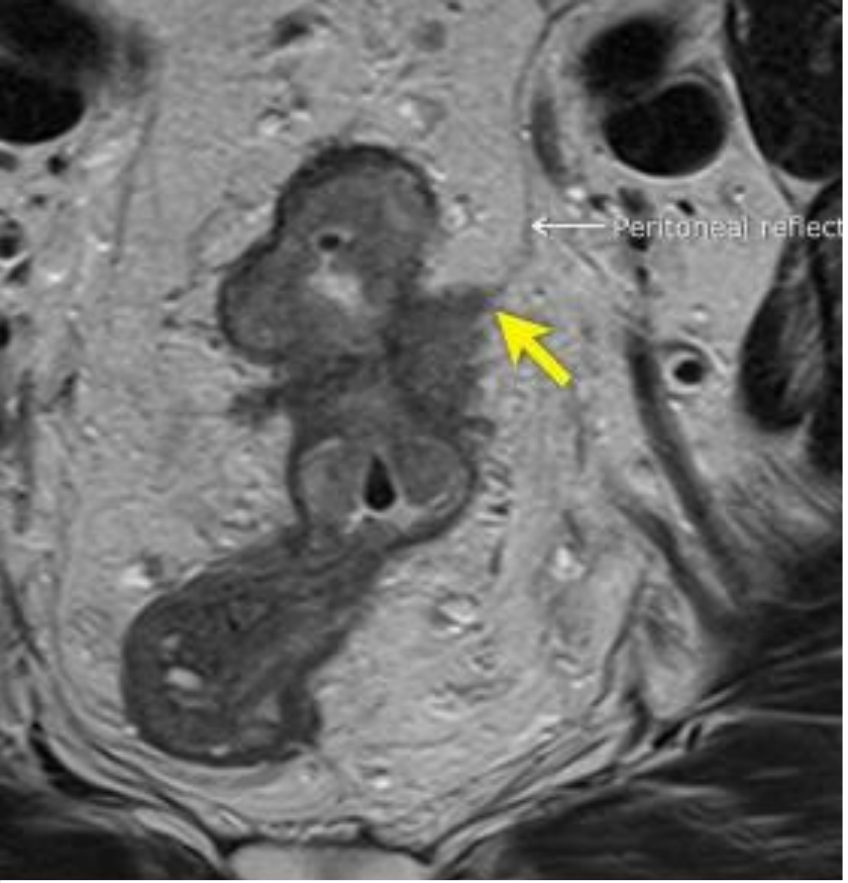


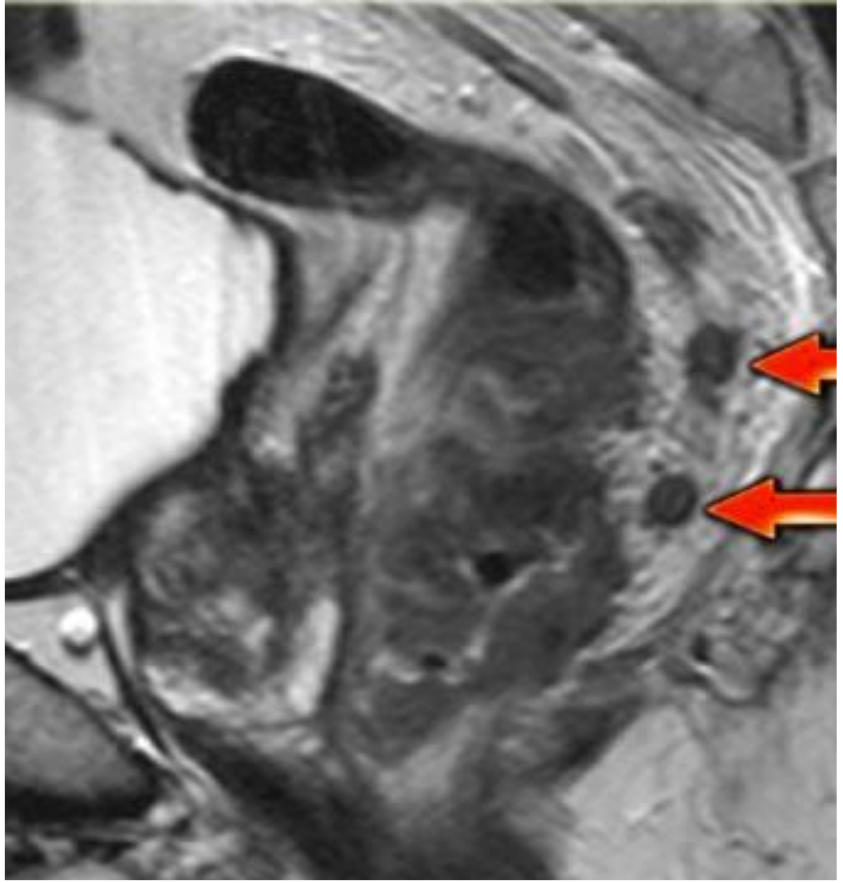


Peri rectal disease identification



Per rectal disease identification





Pre Saccral nodes

Multiple guidelines for target delineation

RTOG

International Working Group

Target Volumes as per RTOG

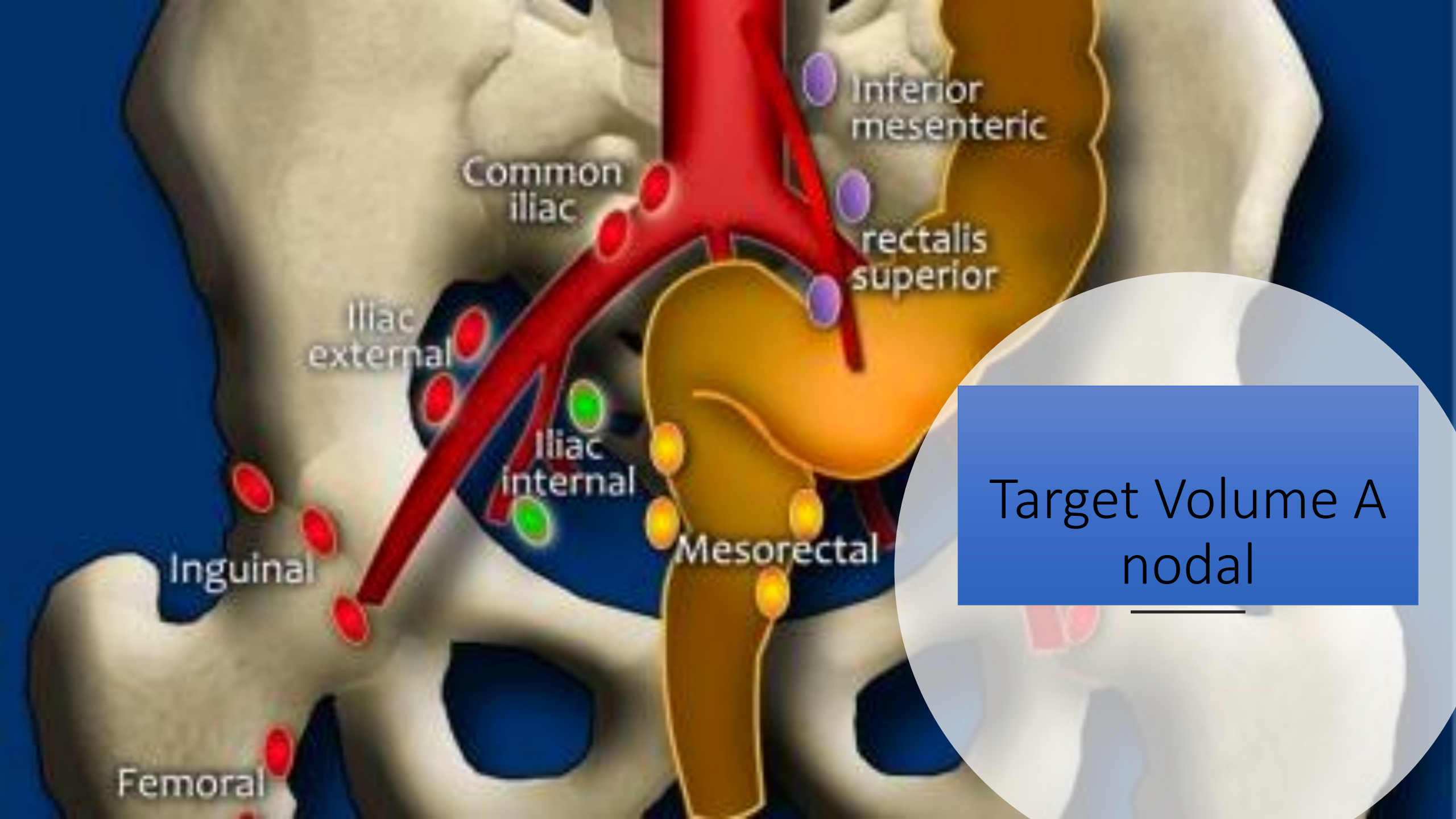
CTVA: always treated for rectal cancer: internal iliac, pre-sacral, and peri-rectal

- CTVB: external iliac nodal region

- CTVC: inguinal nodal region

International working group subsites

- Pre-sacral nodes (PN)
- Mesorectum (M)
- Lateral lymph nodes (LLN),
- External iliac nodes (EIN)
- Ischio-rectal fossa (IRF)
- Sphincter complex (SC)
- Inguinal Nodes (IN)

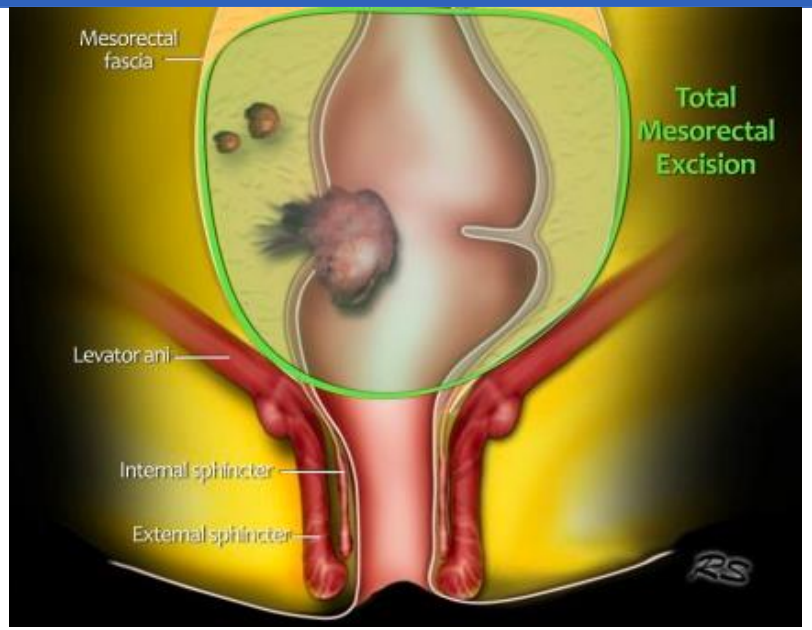


Target Volume A nodal

Target Volume A

Inferior

At least 2 cm caudad to gross disease, including coverage of entire meso-rectum to pelvic floor



Posterior and lateral

Lateral pelvic sidewall musculature or, where absent, the bone

Anterior

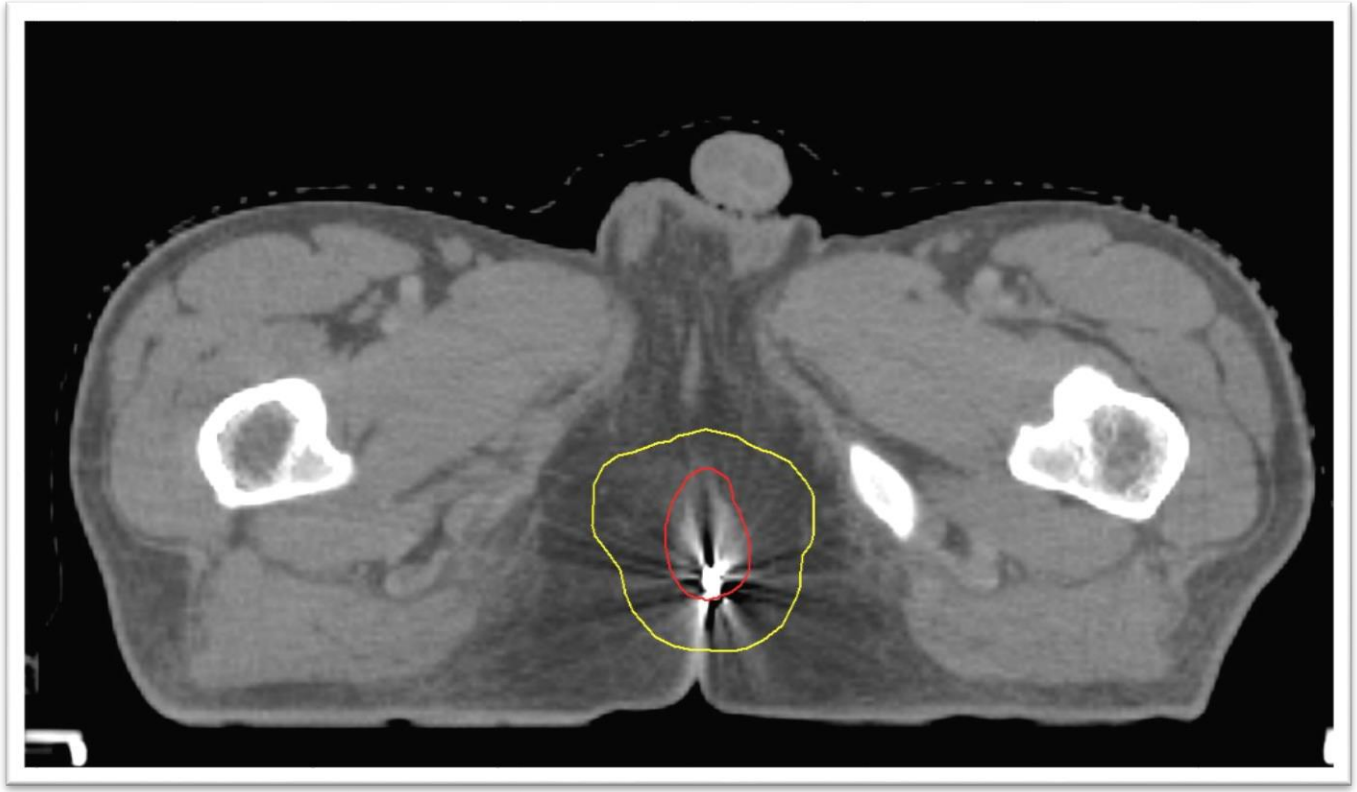
~1 cm into the posterior bladder and the posterior portion of the internal obturator vessels

Superior

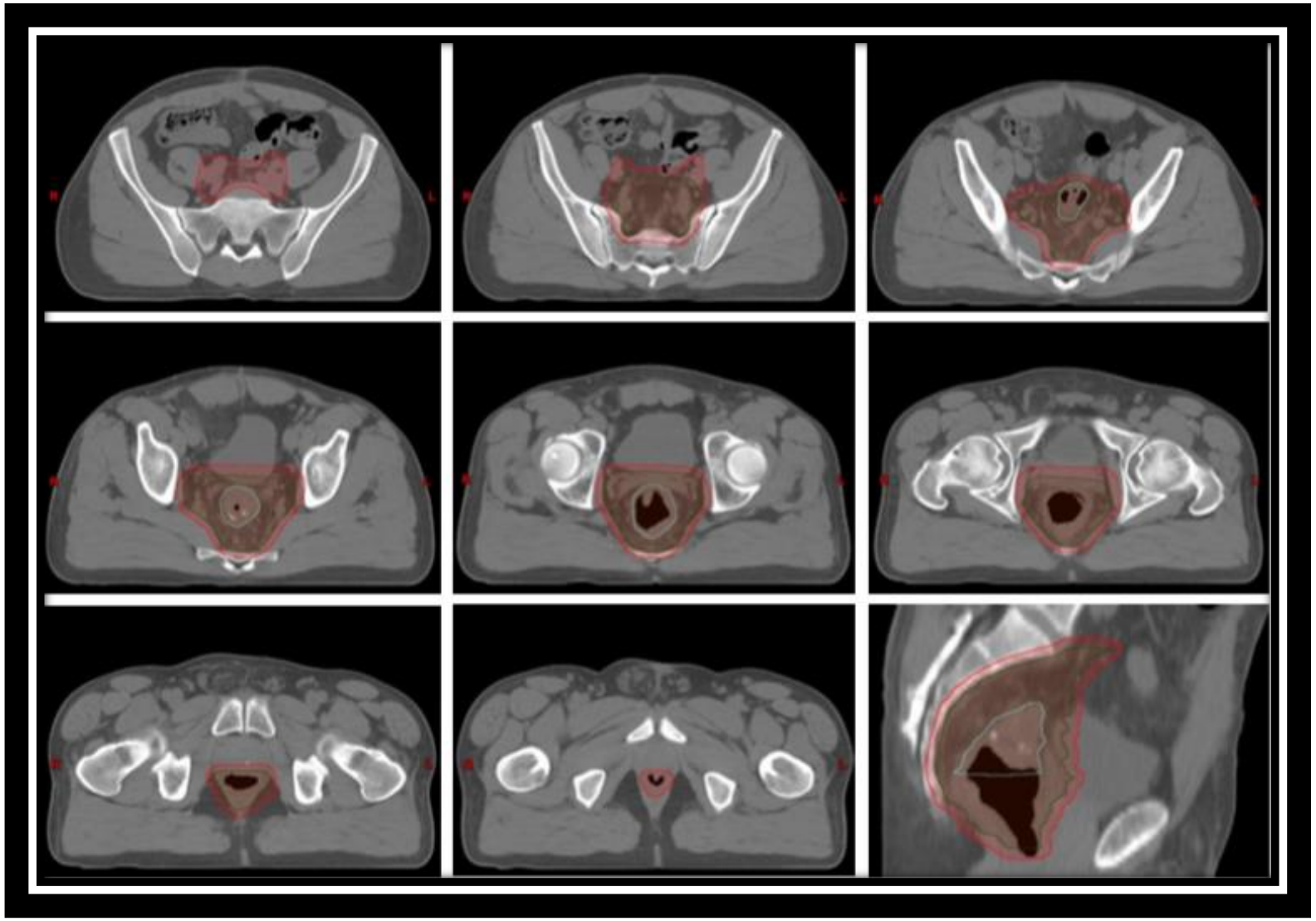
Recto-sigmoid junction or 2 cm proximal to superior extent of macroscopic disease

Target volume A lower pelvis

- Perianal skin involvement, CTV to extend at least 2 cm beyond areas of involvement.
- Unless evidence of extension into ischiorectal fossa, *CTV* need to go more than a few mm beyond levator ms.



CTV Delineation

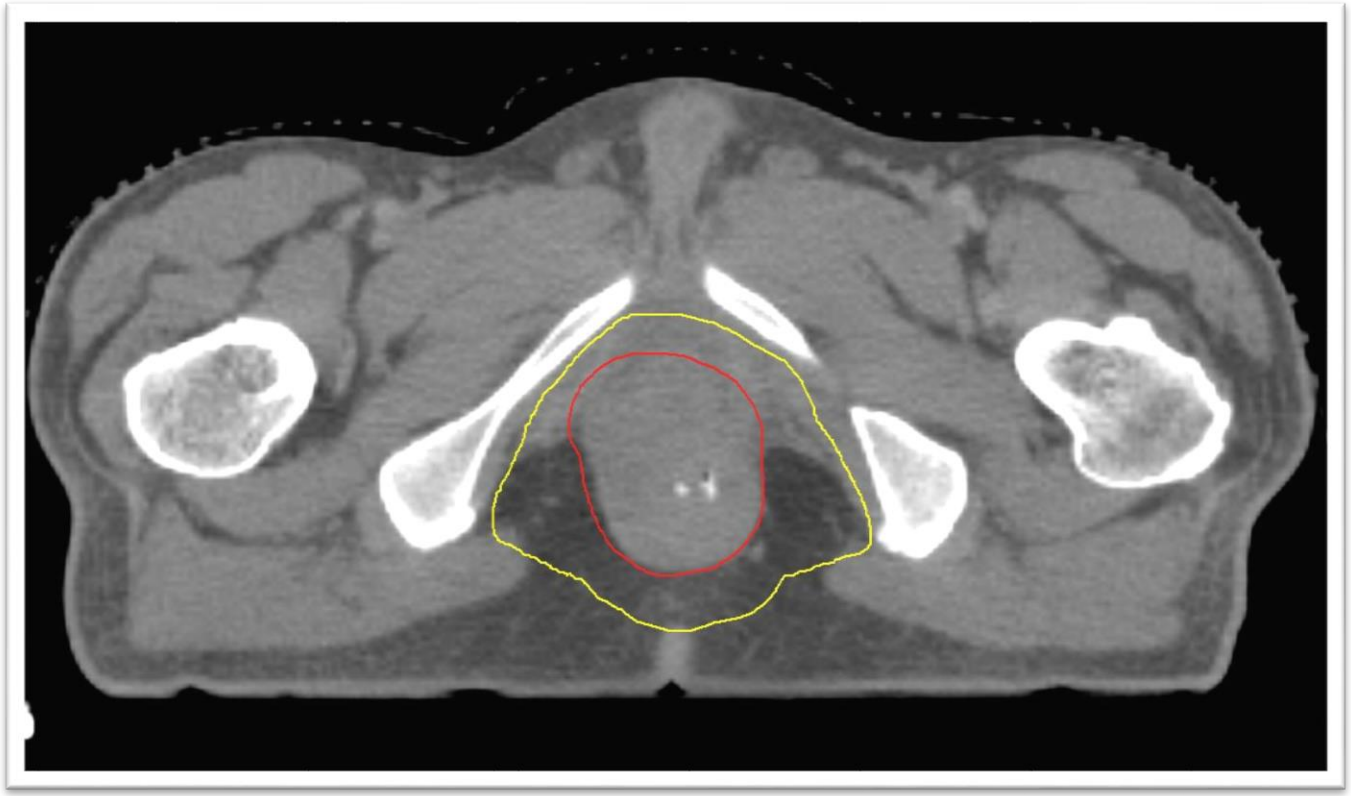


CTV

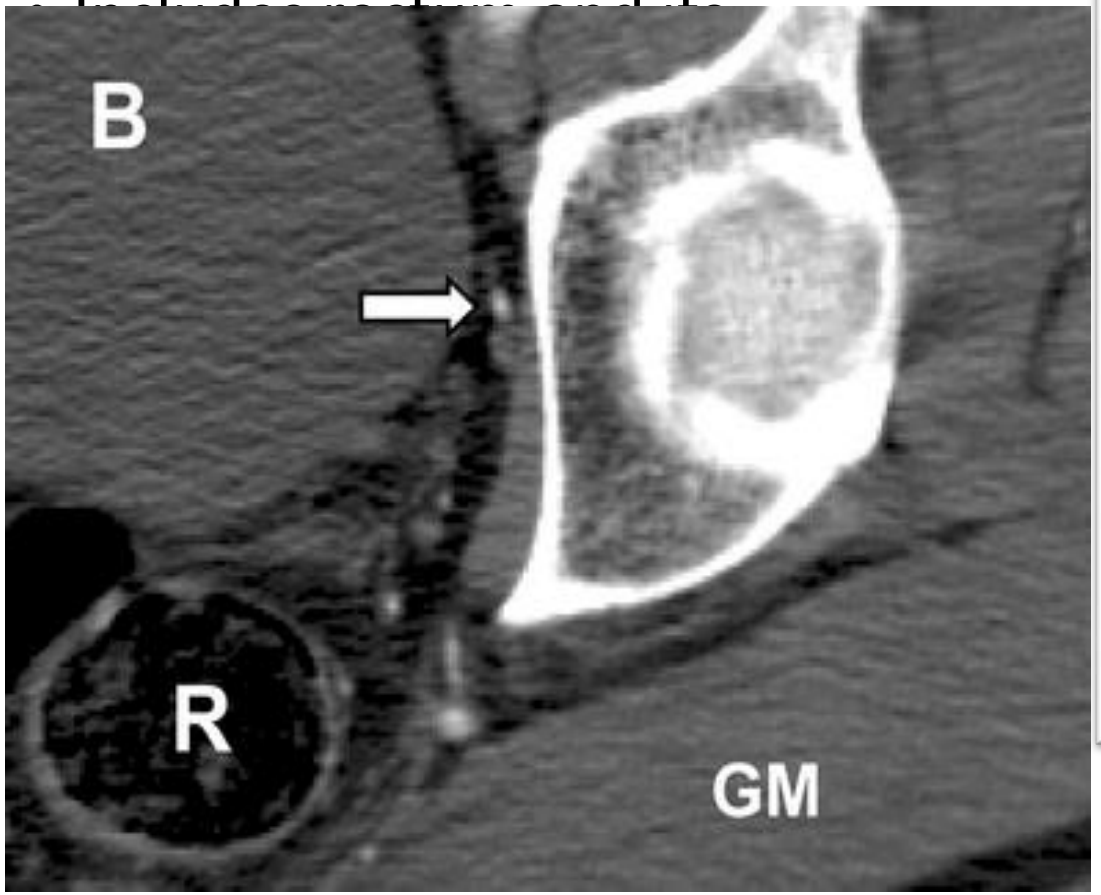
PTV

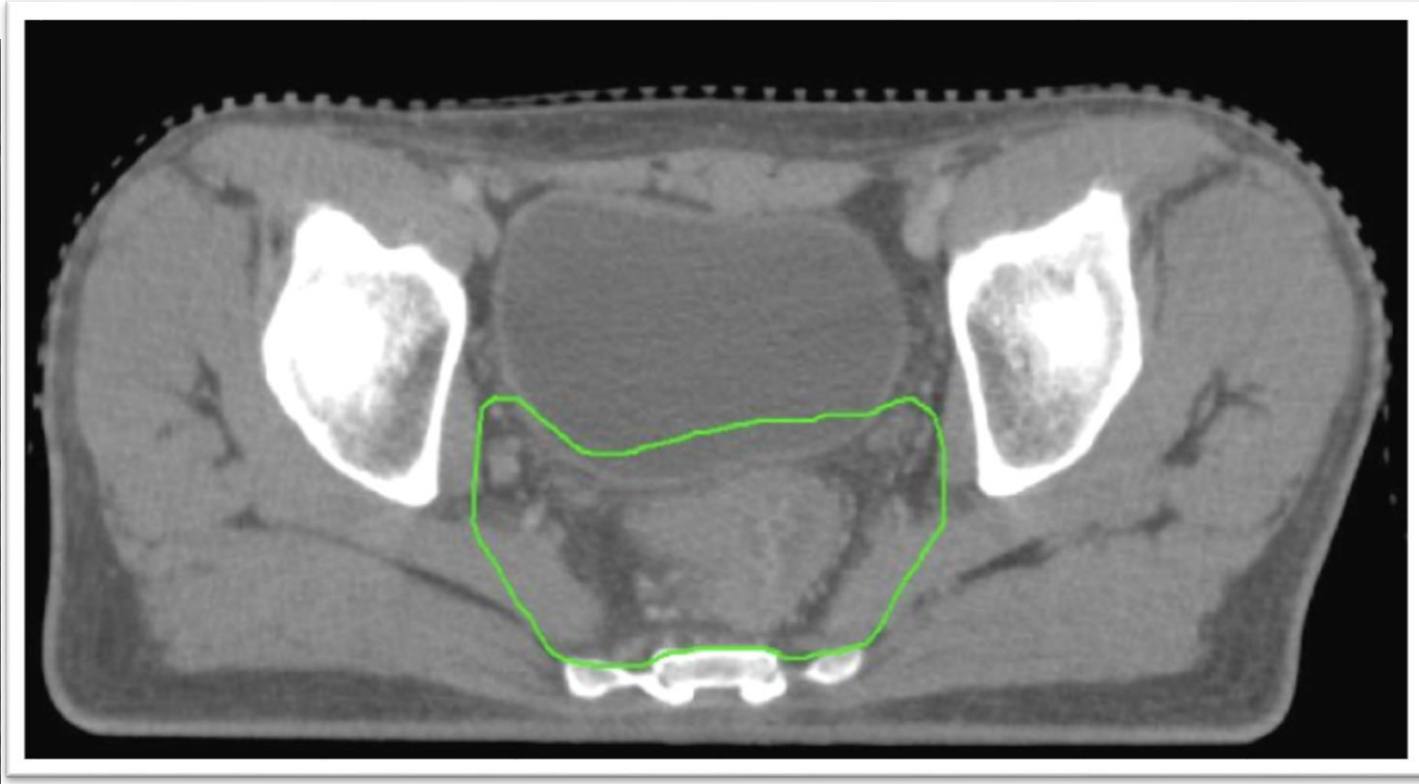
Target volume A lower pelvis

- Very advanced ds extending through mesorectum/ levators, add ~1–2 cm margin upto bone
- Tumor is invading a adjacent organ include a 1–2 cm margin around identified areas of invasion.



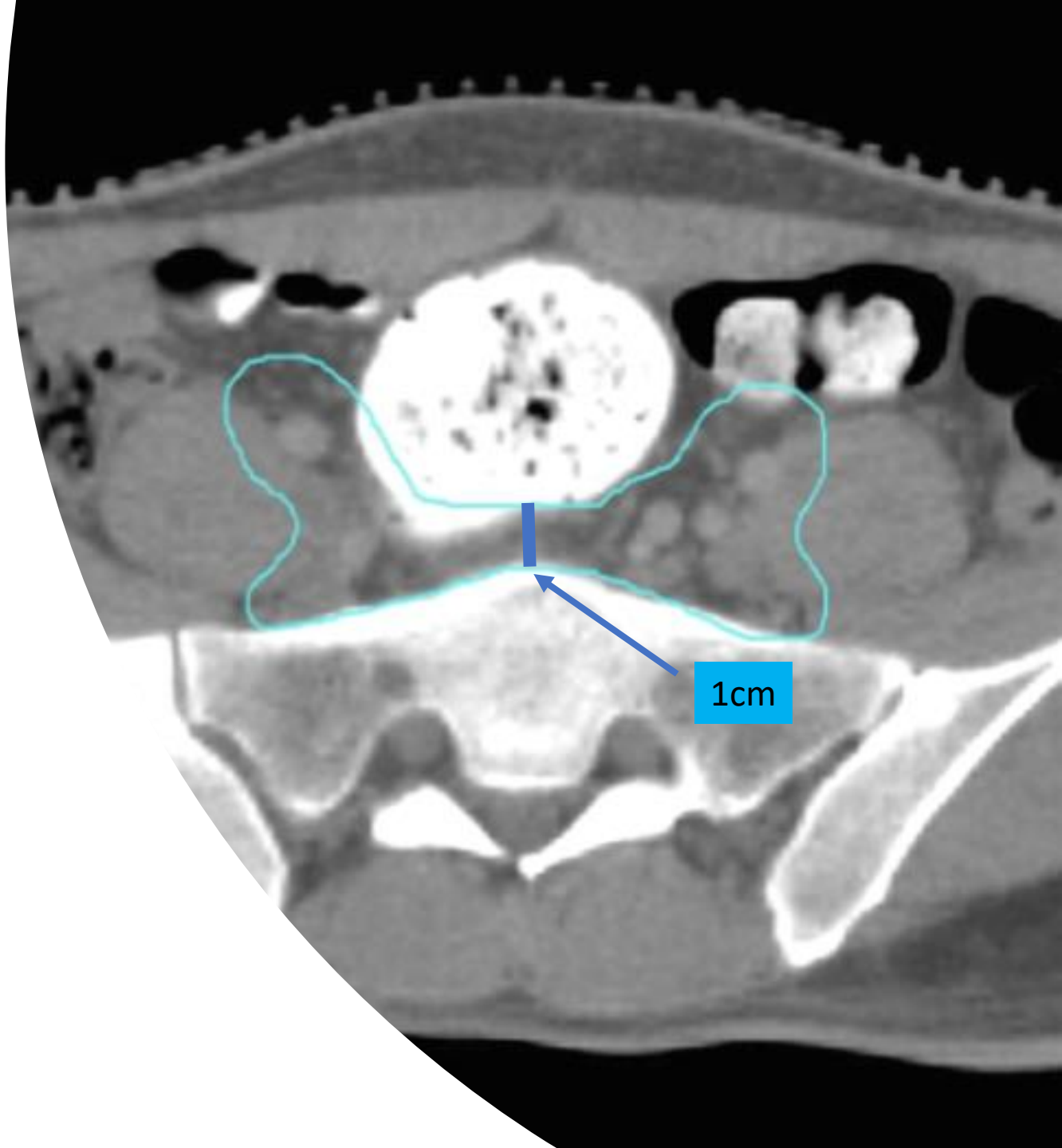
CTV A Mid Pelvis





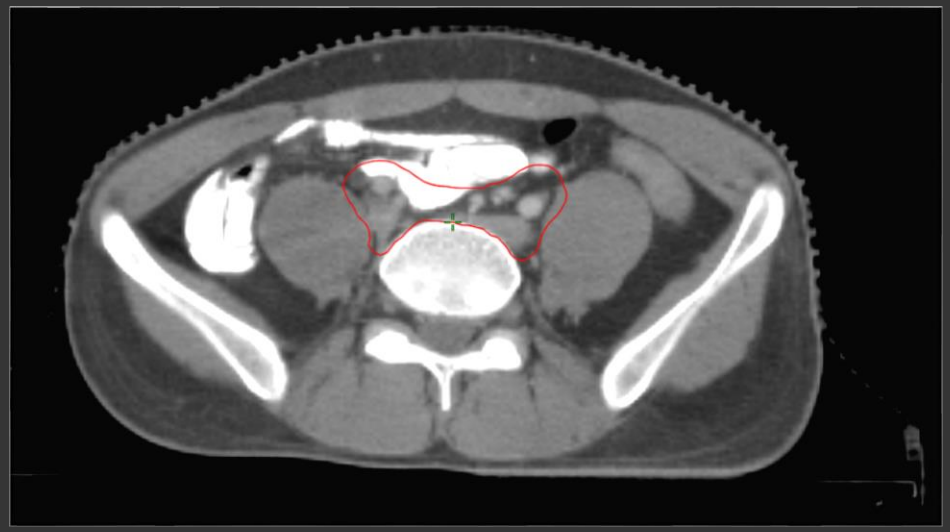
Upper pelvis

- **Superior extent** *is* rectosigmoid junction or at least 2 cm proximal to superior extent of macroscopic ds in rectum/peri-rectal nodes.
- Most cephalad extent will be higher than rectum, -to cover internal iliac & pre-sacral regions
- landmark: sacral promontory
- At midline, CTV should extend at least 1cm ant to sacrum

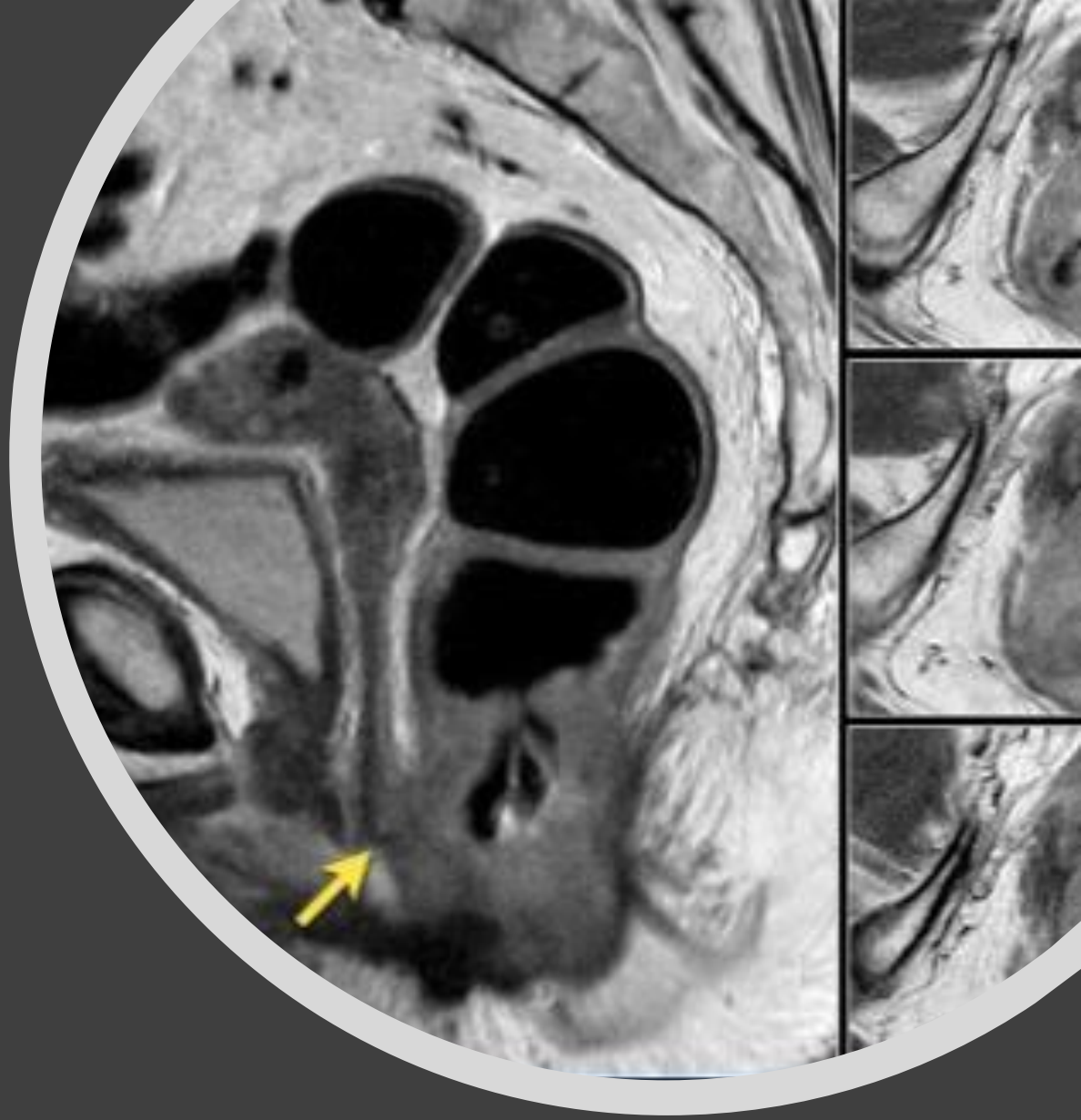


Upper pelvis (continued)

- Avoid contouring into uninvolved bone.
- Do not extend into uninvolved pelvic sidewall ms. but include levators.
- If small bowel falls into region of rectal mesentery it is included
- Daily variation of adjacent organs like bladder and bowel is incorporated



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



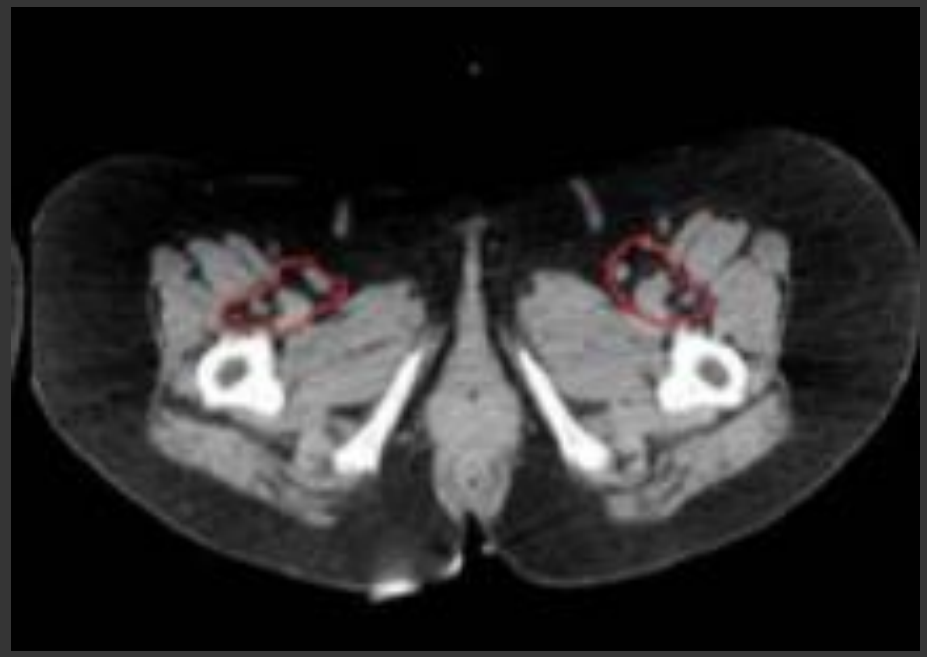
Indications

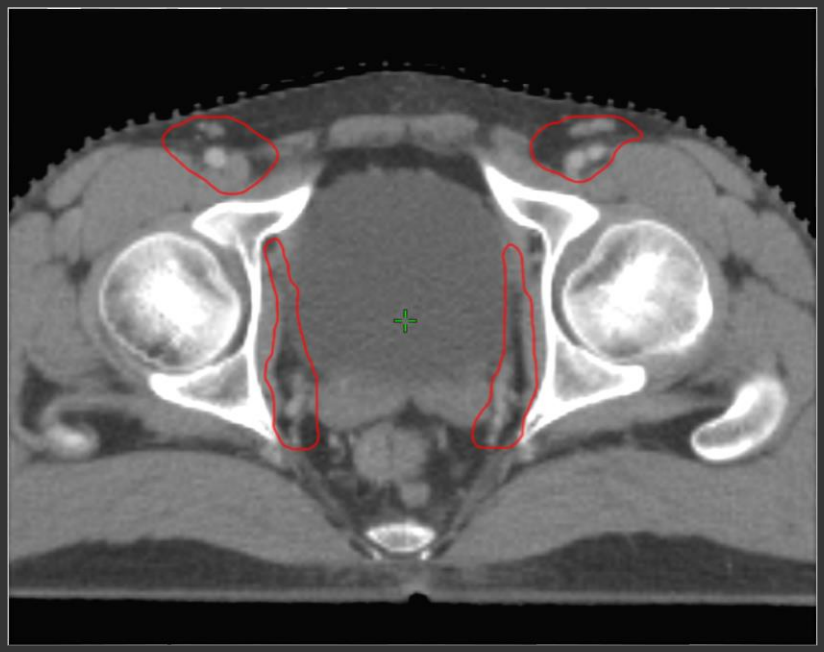
Rectal carcinomas extending into GYN or GU structures
External iliac region should be added (*CTVB*)

Caudad extent of elective target(CTV C)

- Caudad extent of inguinal region (*CTVC*) should be 2 cm caudad to saphenous/femoral junction.

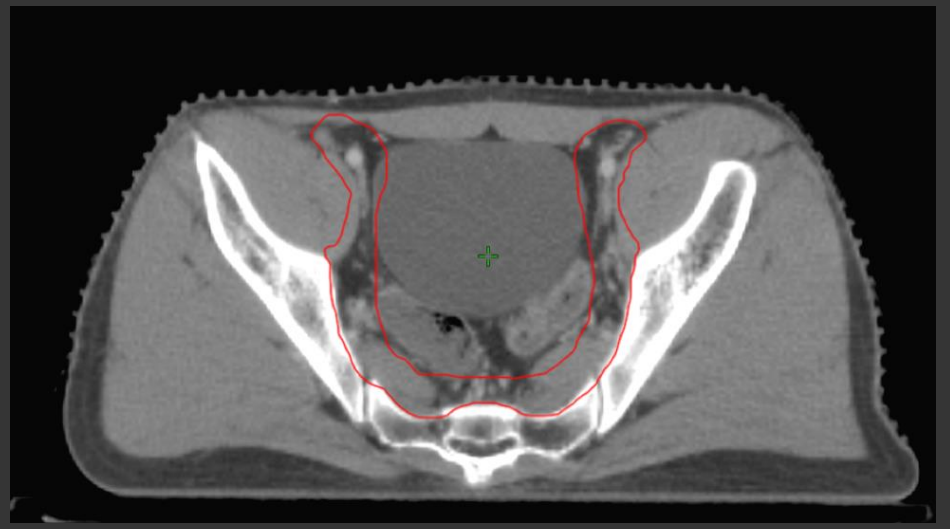
- Transition between inguinal and ext. iliac regions is arbitrary-lower extent of int. obturator vessels (landmark: upper edge of superior pubic rami).





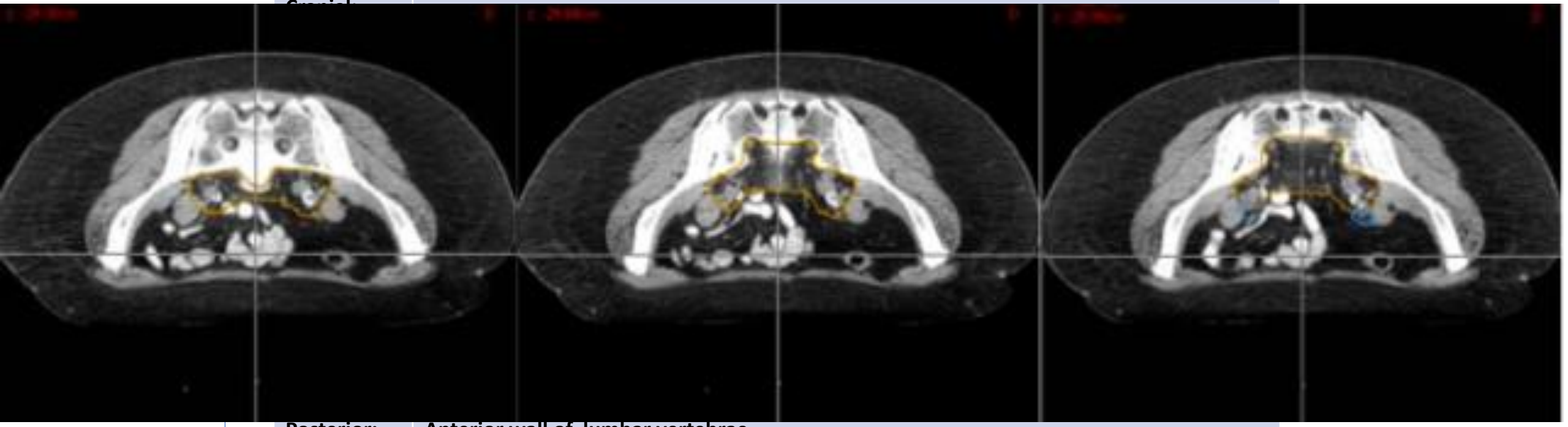
Nodal CTV -Margin around blood vessels

- At least a 7–8 mm margin in soft tissue around iliac vessels,
- A larger, 10+ mm, margin anterolaterally — especially if small vessels or nodes are identified
- Inguinal/femoral region should be contoured as a compartment with any identified nodes included.
- CTVs should be trimmed off uninvolved bone and muscle.



Pre-saccral Lymph nodes

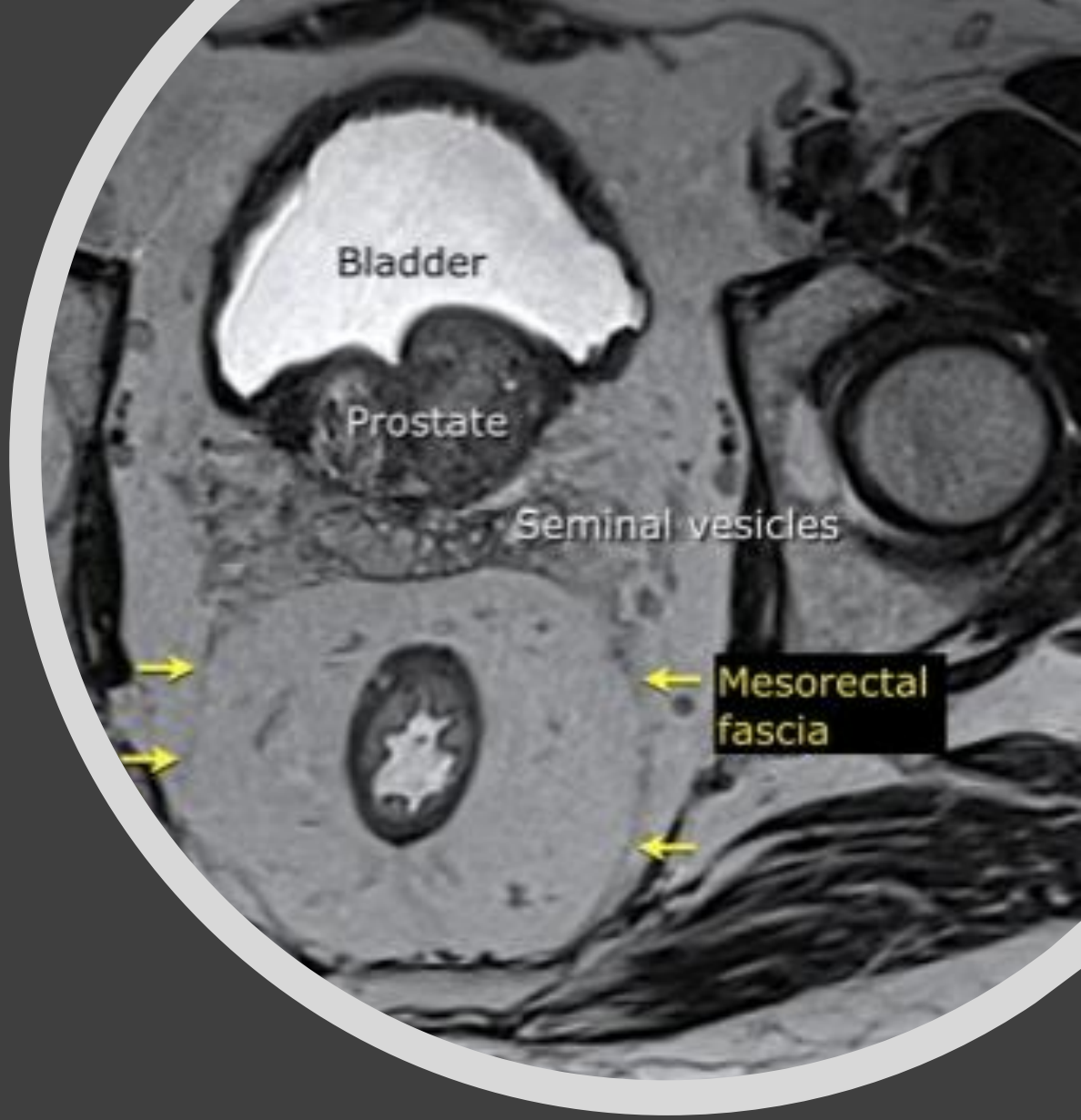
Subsites	limits
Cranial:	Bifurcation of aorta in common iliac arteries or 5 mm above most cranial positive LN
Posterior:	Anterior wall of lumbar vertebrae
lateral	Saccro-iliac joints



Neural foramina should not e included unless there is direct infilteration or close proximity of the tumour

Mesorectum (M)

- Fat around rectum, bounded by mesorectal fascia (MRF).
- **Anteriorly** - MRF & by post. border of the ant. pelvic organs (prostate, seminal vesicles, bladder & penis bulb in men & vagina & uterus in women).
- **Posteriorly** -ant. surface of sacrum.
- Medial part of PN into the M.



Mesorectum (M):

Subsites	limits
Cranial:	bifurcation of IMA in SA and SRA
Caudal:	Insertion of levator ani muscle into ext sphincter muscles (disappearing of mesorectal fat around rectum)
Anterior:	Superior: 7 mm beyond SRA excluding bowel Mid/inferior: mesorectal fascia, posterior border of anterior pelvic organs
posterior	Anterior surface of sacrum and coccyx to level of IRF (including the medial part of the PS)
lateral	Upper/mid: Mesorectal fascia if visible or medial border of LLN and EIN Lower: medial edge levator ani muscle

Consider anisotropic CTV-PTV margins anteriorly to account for bladder/uterus movement

Lateral lymph nodes (LLN):

Triangular lymph-vascular area located between pelvic wall & M, containing lymphatic vessels & nodes along Int iliac & obturator vessels .Divided into

- **Posterior lateral LN** have as ant. border a virtual coronal plane crossing ant. wall of ureters when they join bladder and post. aspect of ext. iliac vessels cranially
- **Anterior lateral LN** -have as ant. border post. wall of ext. iliac vessels lying anteriorly to virtual coronal plane crossing ant.wall of the ureters when it joins bladder, till ext.iliac vessels leave pelvis.

Lateral lymph nodes

Subsites	
Cranial:	Cranial: Bifurcation of common iliac artery into int. & ext. iliac arteries
Caudal:	Caudal: insertion of levator ani muscle into ext. sphincter muscles (pelvic floor)
Anterior:	Upper pelvis: 7 mm around vessel. Mid pelvis: a virtual coronal plane crossing ant. wall of ureters when they join bladder & post. aspect of ext.iliac vessels cranially Inferior pelvis: posterior limit of obturator fossa
posterior	Lateral edge of sacro-iliac joint
Medial:	Upper: Above M add 7 mm around vessel, excluding normal anatomic structures Mid/lower: Mesorectal fascia, pelvic organs
lateral	Upper: iliopsoas, pelvic bones Mid-lower: medial edge of pelvic wall muscles (pyriform and internal obturator muscles)
Mid pelvis:	posterior wall of the EIN
Low pelvis	(when external iliac vessels leave the pelvis): anterior surface of obturator artery

Posterior

Anterior

Include in case of:
(1) positive nodes in the posterior LLN (internal iliac) (2) cT4 (3) numerous mesorectal nodes (cN2)

External iliac nodes (EIN):

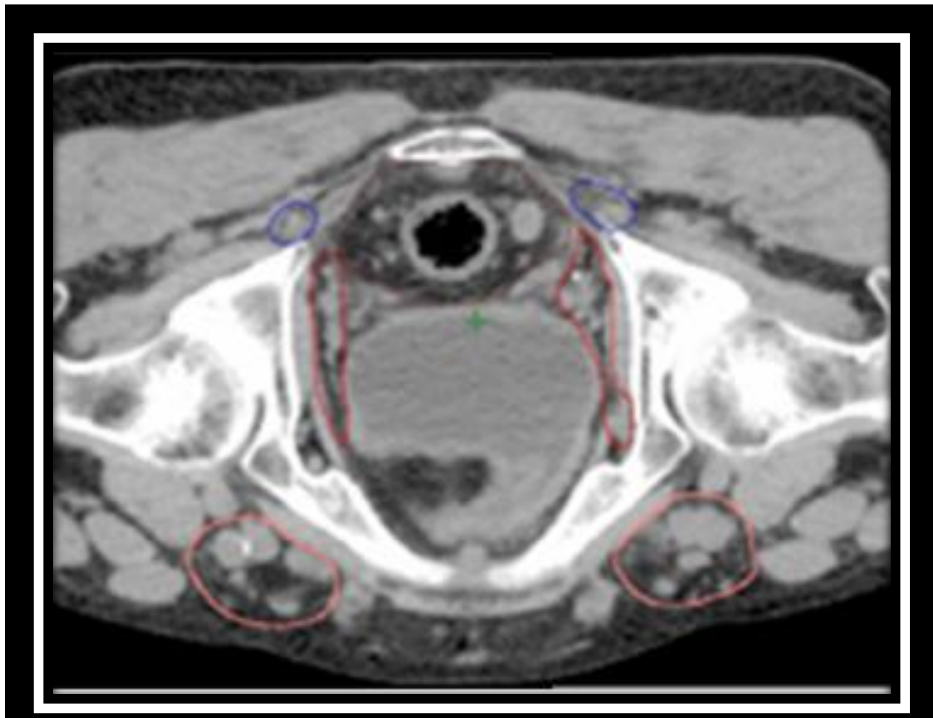
Subsites	
Cranial:	Cranial: bifurcation of common iliac artery into int. & ext. iliac arteries
Caudal:	Caudal: where deep circumflex vein crosses ext. iliac artery. Alternatively (if difficult detection on CT images) between acetabulum roof and superior pubic rami
Anterior:	0.7 cm ant. to vessels. 1.5 cm antero-laterally along iliopsoas ms to include antero-lateral nodes
posterior	posterior border of the external iliac vein
Medial:	7 mm medial to the vessel, excluding pelvic organs
lateral	Iliopsoas muscle

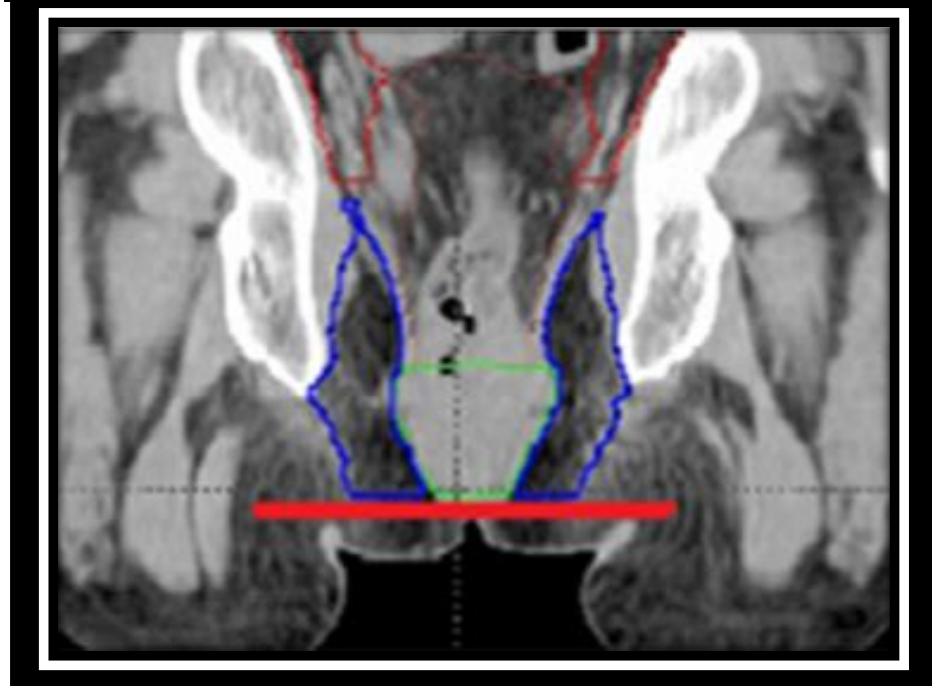
Include in case of:
1.(1) **cT4 tumors**
2.(2) **positive anterior LLN (ex obturator)**

Ischio-rectal fossa (IRF):

Subsite	
Cranial	Inferior pudendal artery leaves pelvis (ischial tuberosity, int.obturator muscle, gluteus maximus ms)
Caudal:	oblique plane joining inferior level of SC &ischial tuberosity.
Posterior	Mid-superior: major gluteus muscle Inferior: a virtual line tangent to the posterior level of the sphincter Medial: levator ani muscle
Lateral:	ischial tuberosity, internal obturator muscle, Gluteus maximus muscle

Include when there is infiltration of the external anal sphincter or the ischio-rectal fossa





Sphincter complex (SC):

- The SC consists of internal and external anal sphincter muscles which enclose anal canal.

From anal-rectal junction.
Around sphincter
To include in case of sphincter infiltration

Inguinal nodes (IN):

subsite	
Cranial:	Deep circumflex vein crosses ext. iliac artery. Alternatively between acetabulum roof & superior pubic rami
Caudal:	Great saphenous vein enters femoral vein
Anterior:	20 mm margin around inguinal vessels including any visible LN or lymphoceles
Posterior	femoral triangle formed by iliopsoas, pectineus & abductor longus ms
Medial	10-20 mm margin around femoral vessels including any visible LN or lymphoceles
Lateral:	medial edge of the sartorius or iliopsoas muscles

Boost Volumes and Planning Target Volumes

- Boost CTV extend to entire mesorectum and pre-sacral region at involved levels, including ~1–2 cm cephalad and caudad in the meso-rectum and ~2 cm on gross tumor within the anorectum.
- **PTV margin should be ~0.7 to 1.0 cm as per institutional protocol and technique employed**
- At skin, where it be trimmed to ~2–5 mm within the skin surface.

Organ At Risk (OAR) Delineation

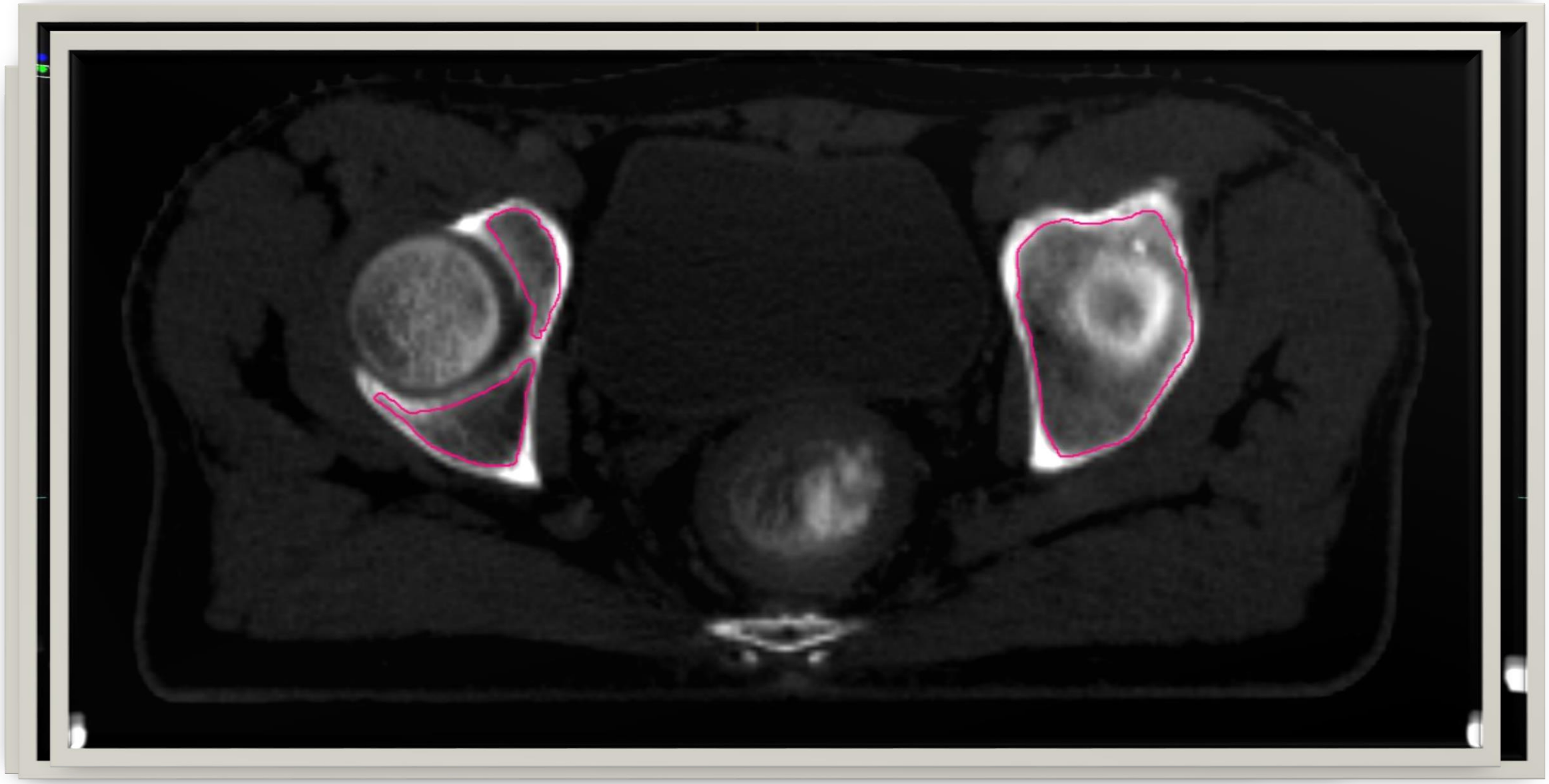
Correct identifications of organ at risk and ascribing appropriate dose constraints reduces toxicity

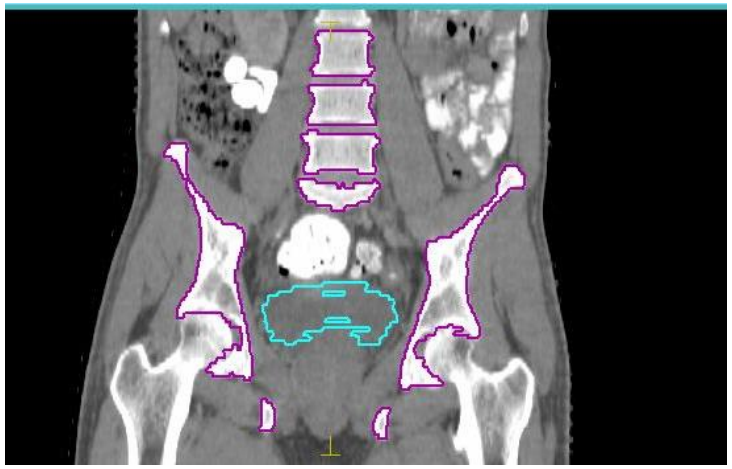
Likely Toxicities

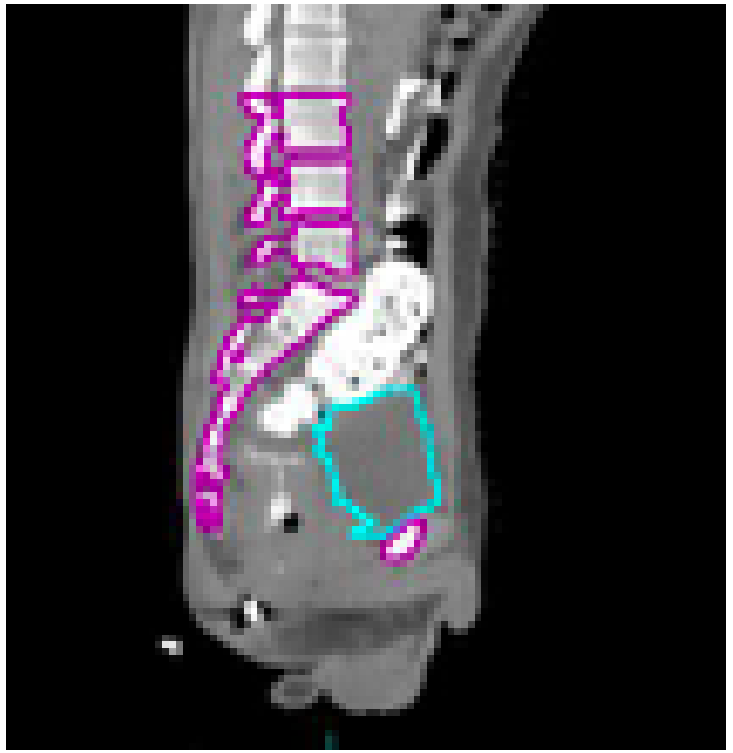
- Hematotoxicity
- GI toxicity
- GU toxicity
- Pelvic insufficiency

Bone marrow

- Whole bone comprises of bone & cavity, which has active and inactive yellow marrow.
- Cavity cannot be differentiated well on CT so can be contoured as bones on CT as a surrogate of active BM.
- **Intramedullary space of the iliac crests**
- **Stop at the top of the acetabulum**



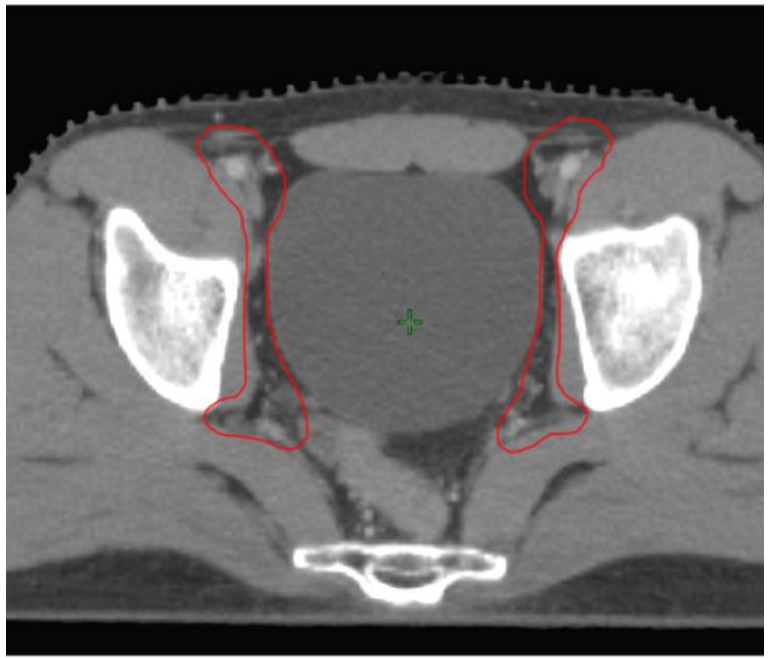




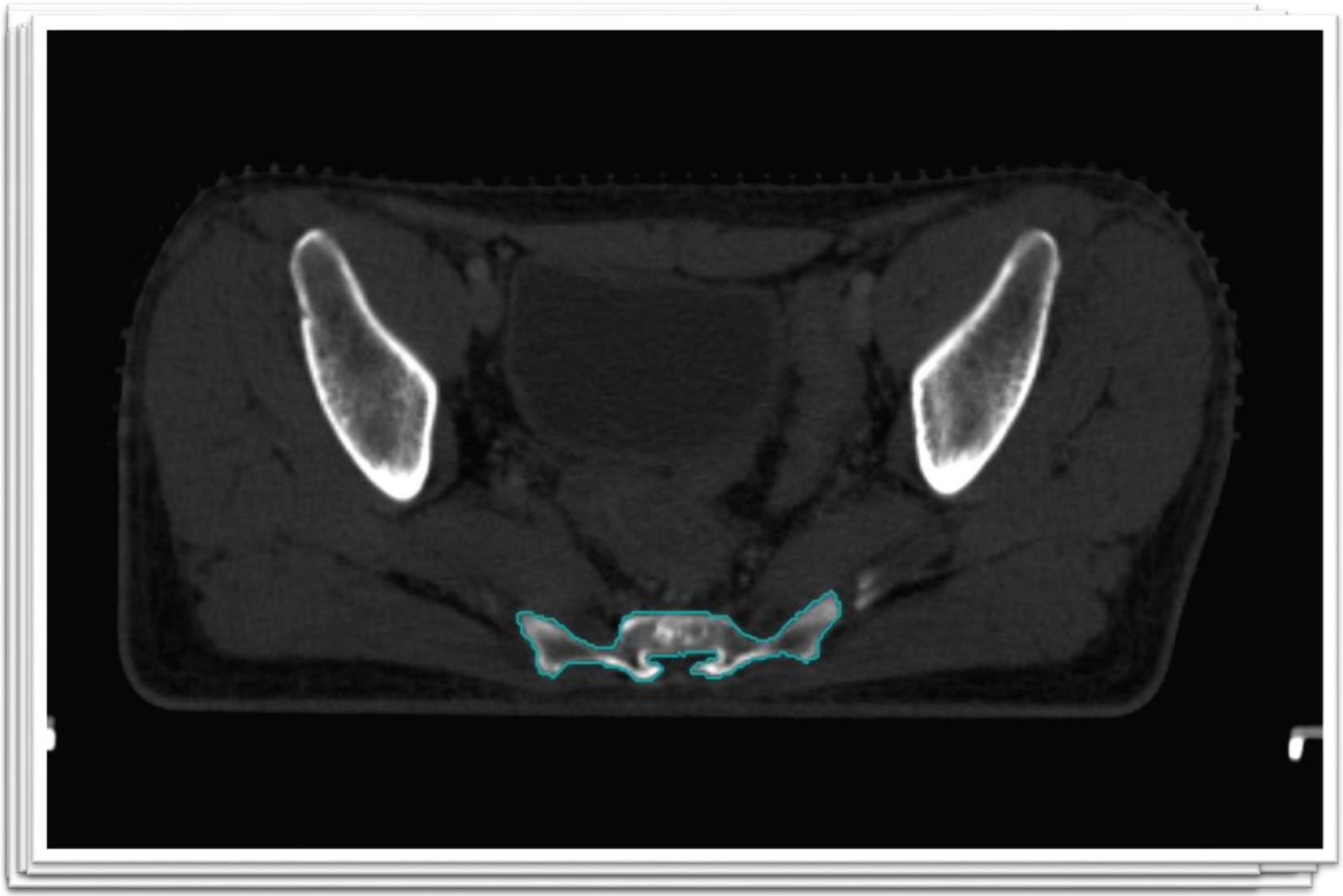
Bone delineation

Pelvic Insufficiency Fractures

- **Sacrum D50% is a significant risk factor in pts aged >50 years**
- **Reduction of sacrum D50% from 40 GyEQD2 to 35 GyEQD2 reduces PIF risk from 45% to 22%.**
- Reducing prescribed dose from 50 to 45 Gy may reduce risk of PIF by 50%.
- PTV margin reduction with use of Image guidance may help to decrease PIF.

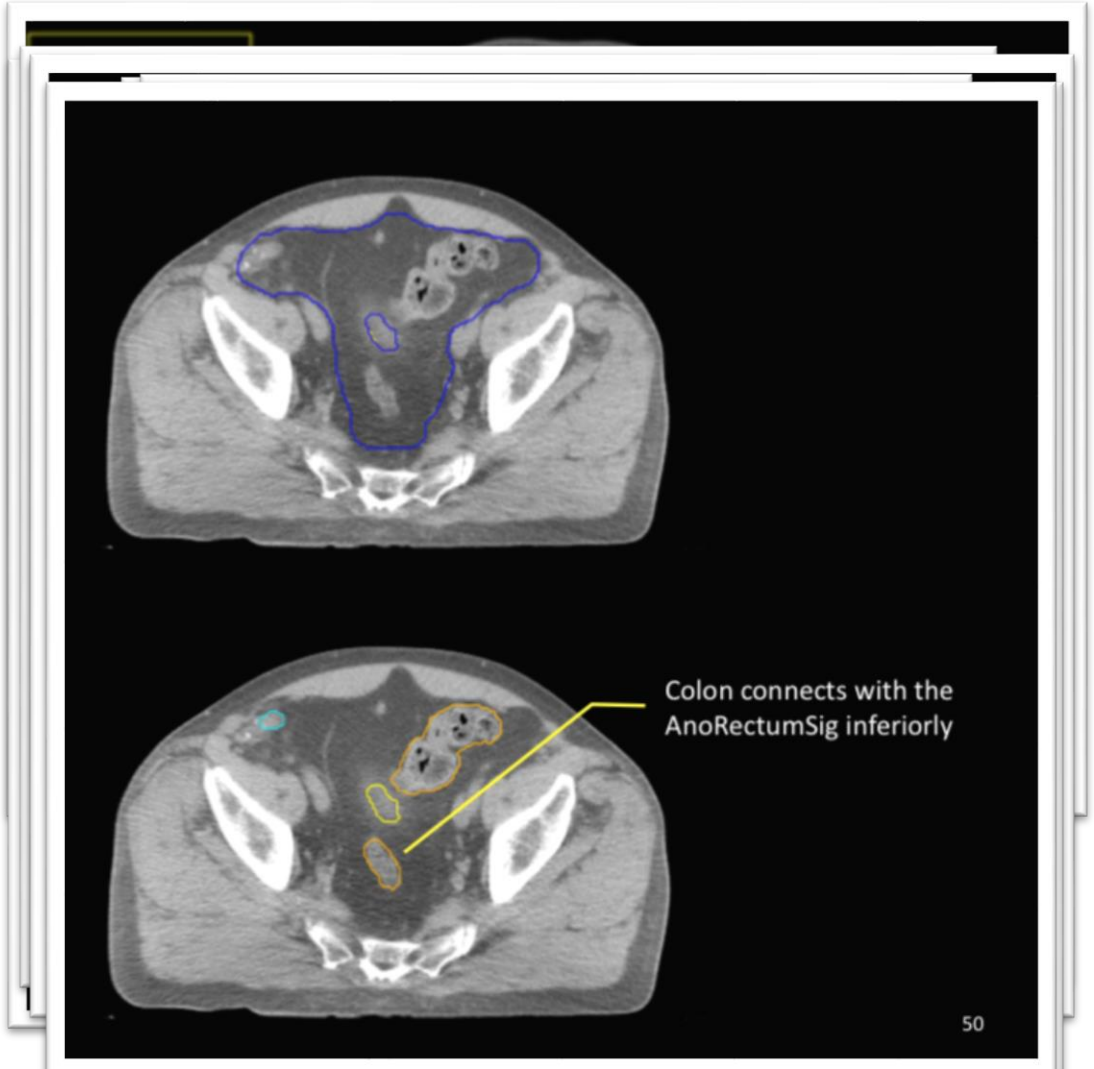


Saccrum



Bowel bag

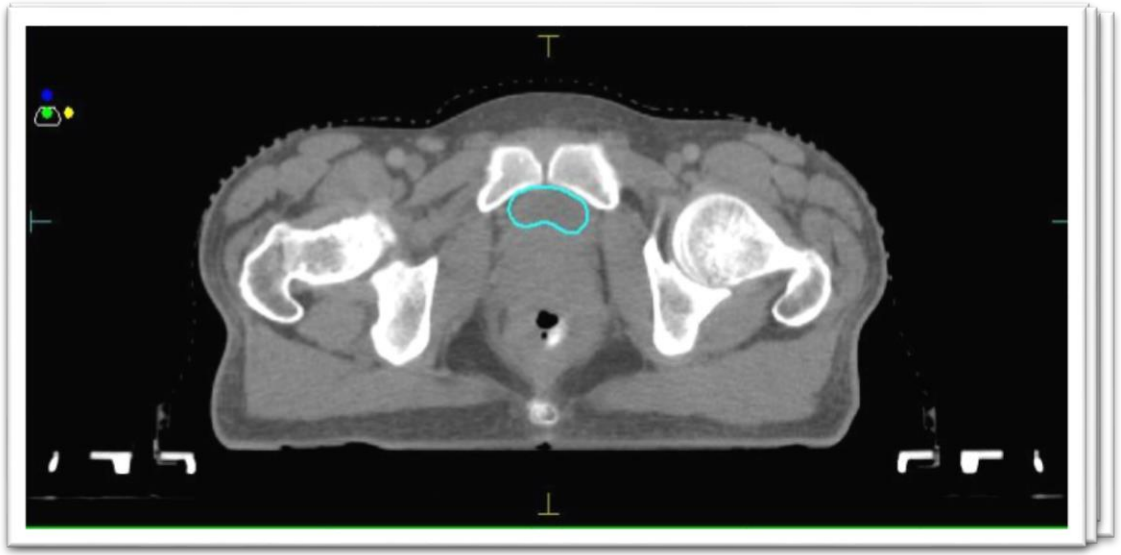
- Inferiorly from most inferior small or large bowel loop or above Rectum (GU) whichever is most inferior.
- If Rectum or AnoRectum is present in that axial slice, it should be included
- Contour abdominal contents excluding muscle & bones. Subtract any overlapping non-GI normal structures.



Small bowel

- After administration of contrast 30 minutes before scanning small bowel can be outlined as loops containing contrast.

Bladder



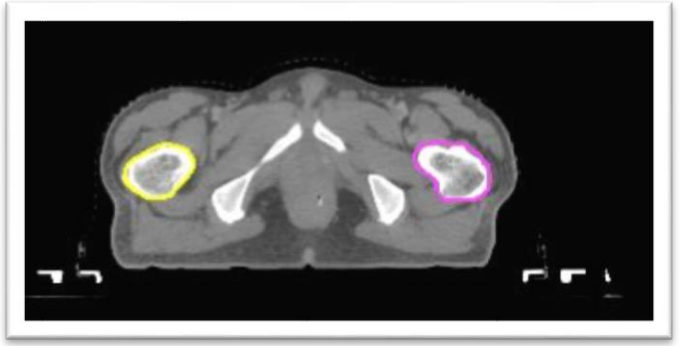
- The entire bladder wall along with contents is delineated.
- An Average volume of 250 -300 cc is preferred following the bladder protocol
- Over full bladder is difficult to reproduce during treatment
- Empty or lesser volume leads to bowel toxicity

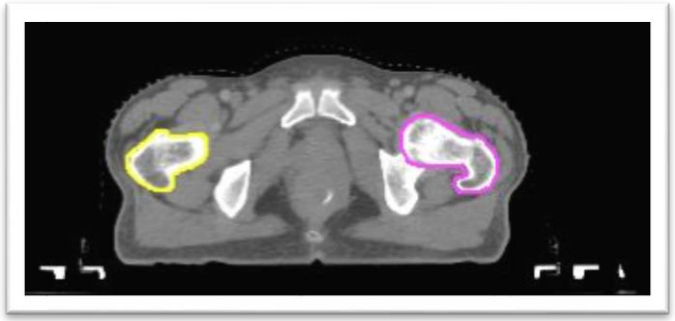
Femur

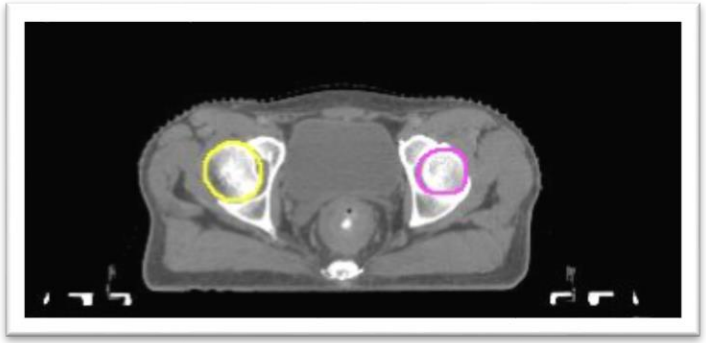
Proximal femur

Inferiorly from the lowest level of the ischial tuberosities

Superiorly to the top of the ball of the femur, including the trochanters.



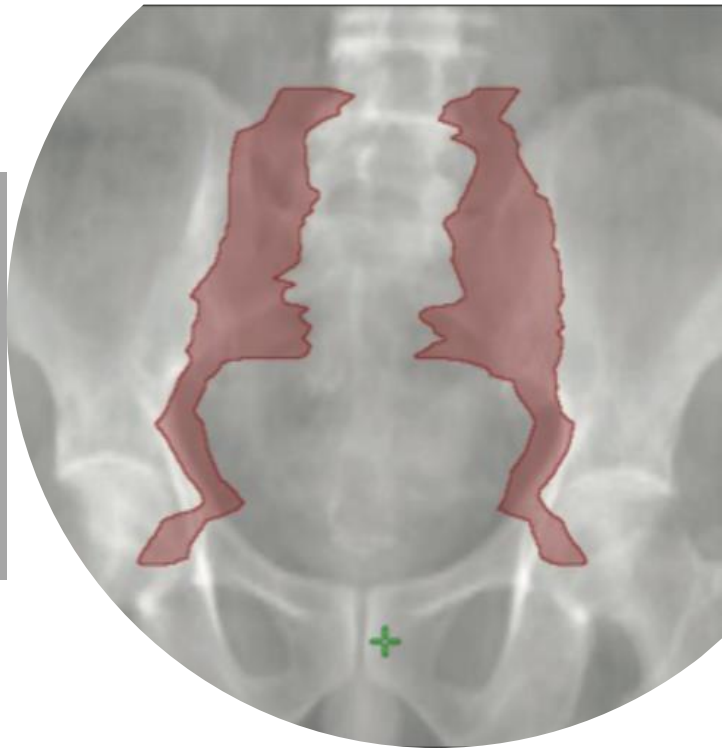




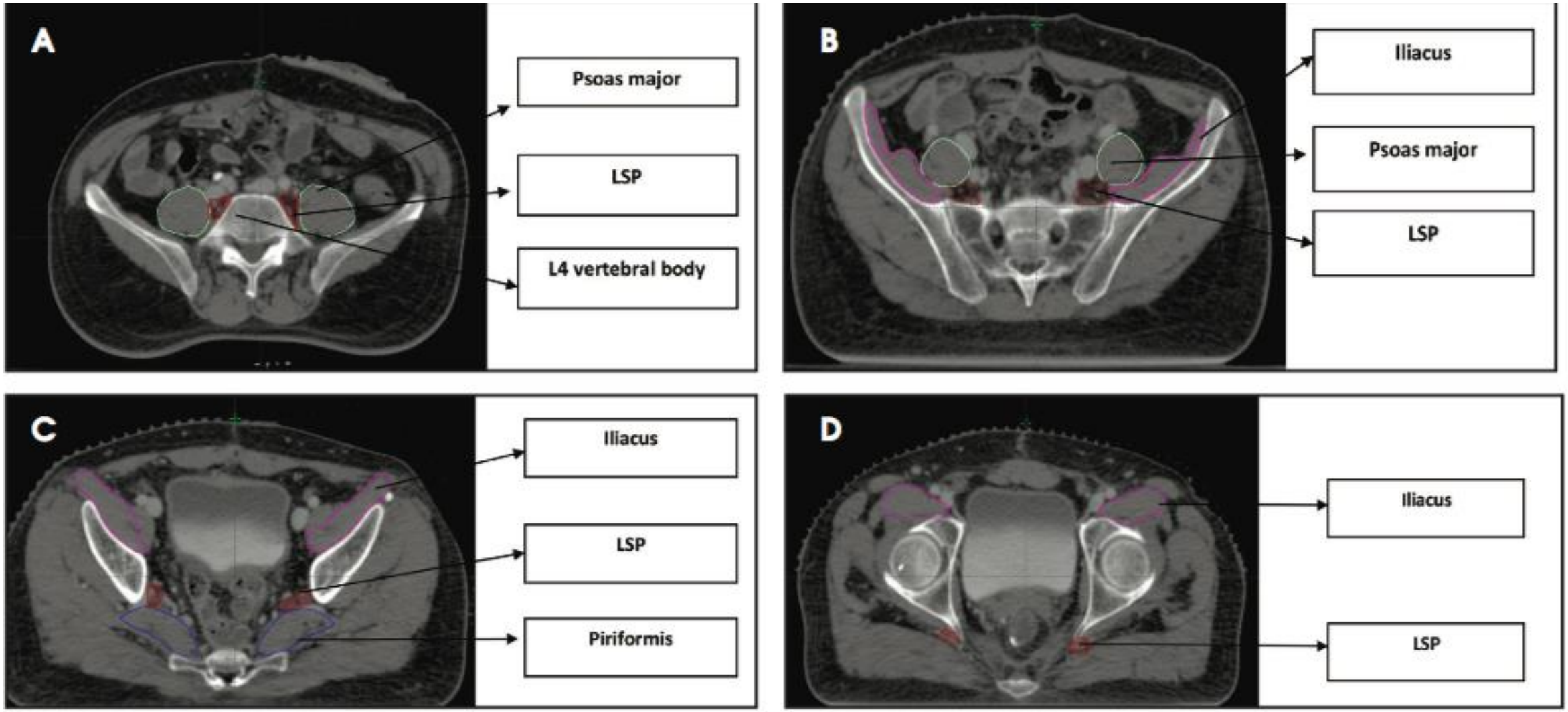
Lumbosaccral Plexopathy

- Depends on total dose, fraction dose,technique , chemo.
- Administration of a dose >10 Gy has caused changes in Schwann cells, endoneural fibroblasts, small vessel wall cells & in perineural cells

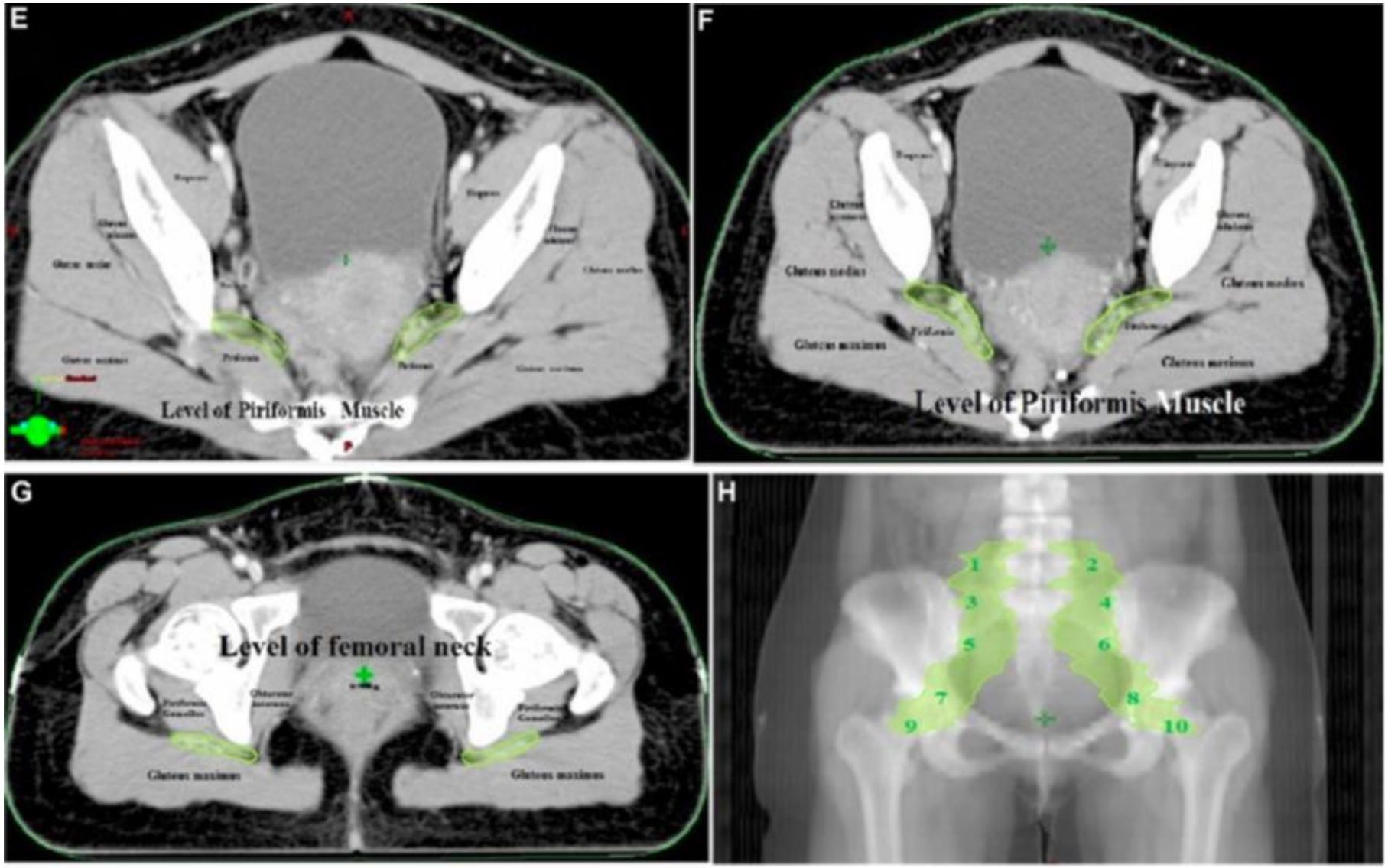
Lumbosacral plexus consists of lumbar (L1-L4)& sacral (L5-S5) portions, which are connected by lumbosacral trunk (L4-L5). L1-L4 nerve roots transverse through psoas muscle & coalesce into lumbar plexus, which divides into ant & post. divisions. Sacral plexus also divides into ant and post divisions, which further divide into various peripheral nerves



Lumbo sacral plexus



Axial sections of a planning CT scan from the level of the L4 vertebral body to the femoral head, representing the muscles and lumbosacral plexus in relation to the anatomic landmarks.



a 5 mm diameter paint tool was used

Pelvic Radiation Disease

- Defined as the ‘transient or longer term problems, ranging from mild to very severe, arising in non-cancerous tissues resulting from radiotherapy treatment to a tumour located in the pelvis’

Prevention

- Lifestyle Modification
- Increased gastrointestinal symptoms in smokers, over- weight and physically inactive men.

Thomas et al.

Technological advancements

- Intensity modulated radiotherapy (IMRT) provides an opportunity to spare critical normal tissue.
- Small bowel and the femoral heads can often be better protected with IMRT than conventional techniques.
- Retrospective and prospective cohort studies have reported lower gastrointestinal toxicity with IMRT in pelvic cancers compared with historical data and retrospective 3D-CRT cohorts
- RCTs comparing gastrointestinal toxic- ities of 3D-CRT versus IMRT reported reductions in grade !3 acute and late gastrointestinal toxicity

Dose Constraints

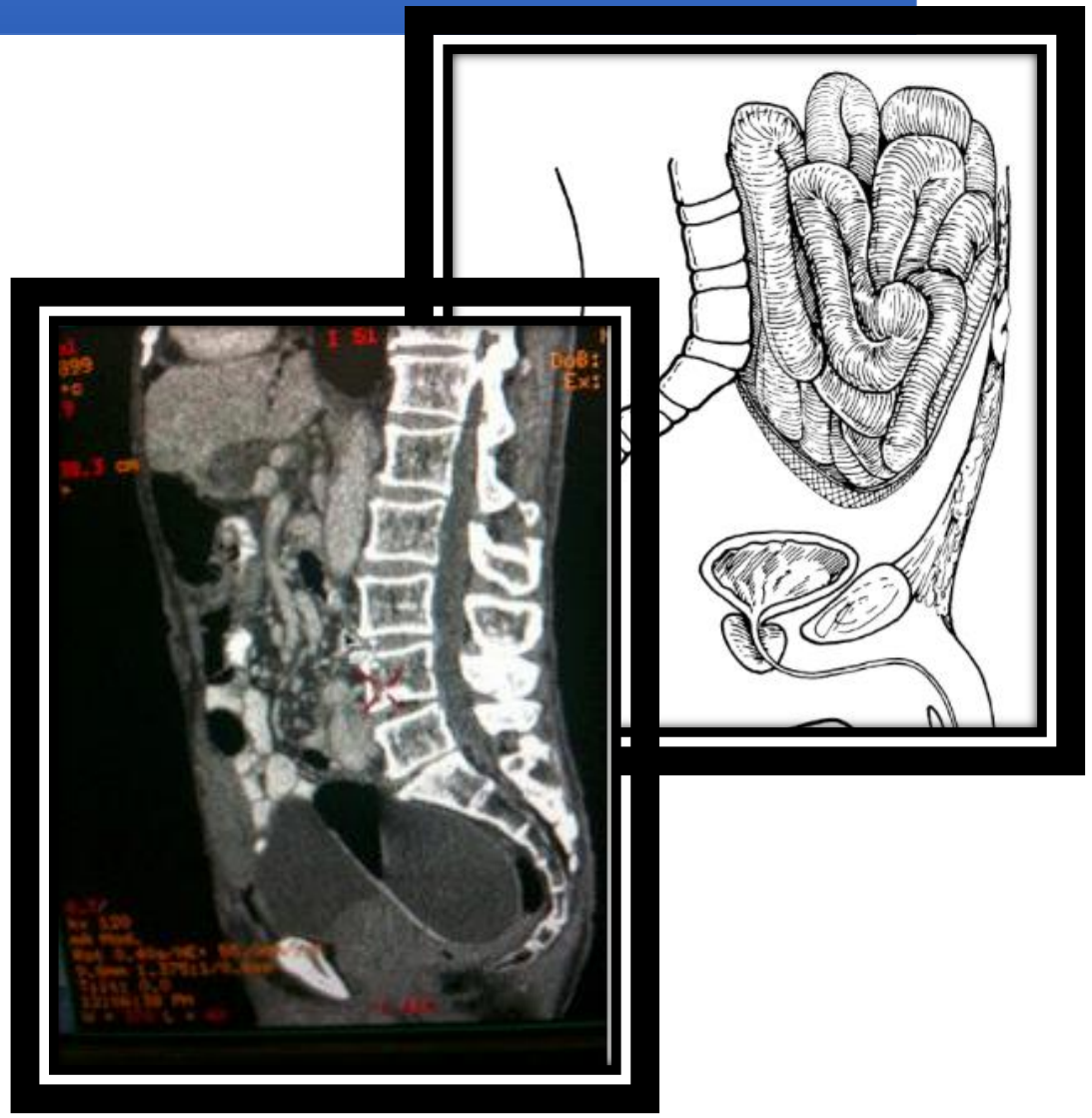
Small Bowel	**QUANTEC** V15Gy <120cc (Individual loops) V45Gy <195cc (potential space within peritoneal cavity) **RTOG 0822 (IMRT)** V35Gy <180cc V40Gy <100cc V45Gy <65cc Dmax <50Gy
Bladder	**QUANTEC** Dmax <65 Gy V65Gy <50% **RTOG 0822 (IMRT)** V40Gy <40% V45Gy <15% Dmax <50Gy
Femoral Heads	**RTOG 0822 (IMRT)** V40Gy <40% V45Gy <25% Dmax <50Gy

Advanced Radiotherapy Technology for reduction of toxicity

- Magnetic resonance imaging-based planning, with its greater soft tissue definition, can reduce the clinical target volume by about 20% compared with computed tomography-based planning, although no significant difference has been reported in late toxicity
- Image-guided radiotherapy, apart from improving target accuracy, allows a reduction in clinical target volume to planning target volume margins, thus reducing the volume of normal tissue receiving high radiation doses

Other Measures/Interventions to Reduce Normal Tissue Irradiation

- Tissue expanders exclude small bowel from pelvis by using implanted intra-peritoneal saline-filled tissue ex- panders
- Three small studies pre-1996, surgical creation of a small bowel sling using either omentum or an absorbable polyglycolic acid mesh resulted in lower late GI toxicities with orthogonal field RT.
- The invasive nature of these interventions & their benefits with current radiotherapy techniques are unclear.



Conclusion

- GTV: main tumor mass + involved lymph nodes
- CTV:GTV with 20 mm expansion, CC 20 mm margin
- Vessels with 7-10 mm expansion
- CTV to include mesorectum, lateral nodes,Internal iliac nodes, pre-sacrum
- where required -External Iliac LN,ischiorectal fossa, sphincter complex and inguinal nodes
- Avoid bone and small bowel
- PTV: 7-10 mm margin to the CTV as per institutional protocol

Elective Nodal subsites as per stage and location

	M	PS		LLN		EIN	IRF	IN	SC
		Pelvic	Abdominal	Post	Ant				
cT3	+	+	When LN+	+	+ (in case of numerous mesorectum nodes (N2)				
cT4 (anterior pelvic organ)	+	+	When LN+	+	+	+		+ (in case of infiltration of inferior third of vagina)	
cT4 (anal sphincter)	+	+	When LN+	+	+	+	+ (when direct tumor infiltration of IRF or external anal sphincter)	+	+
cT3 with extra mesorectal node	+	+	When LN+	+	+	+			

M: mesorectum, PS: Presacral Space LLN: Lateral Lymph Nodes, EIN: External iliac Nodes, IRF: Ischiorectal Fossa,IN: Inguinal Nodes, SC: Sphincter Complex.

Suggested Reading

Contents lists available at ScienceDirect

Radiotherapy and Oncology

journal homepage: www.thegreenjournal.com

Rectal cancer guidelines

International consensus guidelines on Clinical Target Volume delineation in rectal cancer

Vincenzo Valentini [a], Maria Antonietta Gambacorta [a,*], Brunella Barbaro [b], Giuditta Chiloiro [a], Claudio Coco [c], Prajnan Das [d], Francesco Fanfani [e], Ines Joye [f], Lisa Kachnic [g], Philippe Maingon [h], Corrie Marijnen [i], Samuel Ngan [j], Karin Haustermans [f]

Open Access Full Text Article

ORIGINAL RESEARCH

Lumbosacral plexus delineation, dose distribution, and its correlation with radiation-induced lumbosacral plexopathy in cervical cancer patients

This article was published in the following Dove Press journal:
OncoTargets and Therapy
23 December 2014
Number of times this article has been viewed

Review Article

Radiat Oncol J 2014;32(4):213-220
http://dx.doi.org/10.3857/roj.2014.32.4.213
pISSN 2234-1900 · eISSN 2234-3156

ROJ Radiation Oncology Journal

Insufficiency fracture after radiation therapy

Dongryul Oh, MD, Seung Jae Huh, MD, PhD

Department of Radiation Oncology, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Korea

Comparison of 2 Contouring Methods of Bone Marrow on CT and Correlation With Hematological Toxicities in Non–Bone Marrow–Sparing Pelvic Intensity-Modulated Radiotherapy With Concurrent Cisplatin for Cervical Cancer

Umesh Mahantshetty, MD, DNB, Rahul Krishnatry, MD, Suresh Chaudhari, DRP, Aarti Kanaujia, BSc, Reena Engineer, DNB, Supriya Chopra, MD, DNB, and Shyamkishore Shrivastava, MD, DNB

Suggested Readings

ELSEVIER

Available online at www.sciencedirect.com
ScienceDirect
Gynecologic Oncology 103 (2006) 1100–1104

Gynecologic Oncology
www.elsevier.com/locate/ygyno

Pelvic bone complications following radiation therapy of gynecologic malignancies: Clinical evaluation of radiation-induced pelvic insufficiency fractures

Hitoshi Ikushima [a,*], Kyousuke Osaki [a], Shunsuke Furutani [a], Kyou Yamashita [a], Yoshiomi Kishida [a], Takaharu Kudoh [b], Hiromu Nishitani [a]

[a] *Department of Radiology, Tokushima University School of Medicine, 3-18-15 Kuramoto-cho, Tokushima 770-8503, Japan*
[b] *Department of Oral and Maxillofacial Radiology, Tokushima University School of Medicine, Tokushima, Japan*

Elective Clinical Target Volumes in Anorectal Cancer: An RTOG Consensus Panel Contouring Atlas

R Myerson[1], M Garofalo[2], Iel Naqa[1], R Abrams[3], A Apte[1], W Bosch[1], P Das[4], L Gunderson[5], T Hong[6], J Kim[7], C Willett[8], L Kachnic[9]

From the Departments of Radiation Oncology: [1]Washington University, [2]University of Maryland Medical Center, [3]Rush University Medical Center, [4]UT, MD Anderson Cancer Center, [5]Mayo Clinic, Scottsdale AZ, [6]Massachusetts General Hospital, [7]Princess Margaret Hospital, University of Toronto, [8]Duke University, [9]Boston University Medical Center

Clinical Oncology (2007) ■■: ■■■–■■■
doi:10.1016/j.clon.2007.05.002

Original Article

An Atlas of the Pelvic Lymph Node Regions to Aid Radiotherapy Target Volume Definition

A. Taylor*, A. G. Rockall†, M. E. B. Powell*

Is the irradiated small bowel volume still a predictor for acute lower gastrointestinal toxicity during preoperative concurrent chemo-radiotherapy for rectal cancer when using intensity-modulated radiation therapy?

Benhua Xu[1], Yuyan Guo[1], Yuangui Chen[1], Haijie Lu[1], Tianlan Tang[1], Zhicao Yue[3], Guoxian Guan[2], Pan Chi[2] and Chi Lin[4*]

Narayana Health

Thank you