Prostate Contouring- Guidelines, Tips and Tricks

Dr Vineeta Goel
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Headings

• 1. Simulation
• 2. Intact Prostate
• 3. Nodal Contouring
• 4. Post op Prostate
• 5. OARs
• Speak to your patient– Everyone is different and these are generally old people
• Understand his bowel bladder habits
• Chronic constipation– Give them laxatives 2-3 days prior to simulation and regularly on T/t
• Bloating of Abdomen- Use charcoal tablets
• Check water intake and advise on hydration
• Check Urine holding capacity and frequency and decide practical bladder protocol

Basics are basic!!

Graf et al. Radiation Oncology 2012, 7:125
http://www.ro-journal.com/content/7/1/125

Appropriate patient instructions can reduce prostate motion
Positioning and Immobilization

- If Gold fiducials or calypso is placed— then it should be placed at least 5 days before simulation
- Fiducials are useful especially if planar imaging

Positioning
- Supine, Comfortable
- Knee Rest- to correct for Lumbar Lordosis
- Locks knees and prevents side to side movement
- Ankle fix
- Thermoplastic shell and Vacuum bags– Desirable, Not mandatory, No consensus, Institutional Policy
CT Sim

- 2-3mm slice thickness from L3 to mid thigh (not 5mm)
- Check scan to look for empty rectum, full bladder
- Oral Contrast
- IV Contrast after checking KFT
- Infant feeding tube in Rectum

- We also take delayed scan after 3-5 minutes of planning scan (don’t use it for planning)
- IV contrast comes in Bladder
- Bladder prostate interface is better identified especially in medial lobe enlargement
- Post op Prostate- identify anastomosis
- Consider doing MRI on flat couch to register with planning CT
Empty Rectum Full bladder
IV contrast comes in Bladder
Bladder prostate interface is better identified especially in medial lobe enlargement
Post op Prostate- identify anastomosis
Difficulties encountered in Contouring on planning CT

Large Interobserver and intraobserver variations

• Delineation of the apex-- implications in late toxicity impotence & erectile dysfunction
• Base of prostate from the fibromuscular bundle
• Capsule from the NV bundle
• Delineation of GTV on CT
MRI

CT Scan overestimates Prostate by 20-60% when compared with MRI

Biggest discrepancy is in apex of prostate—MRI best delineates apex, urogenital diaphragm and plexus Santorini

At base of prostate, SV identified better on MRI
MRI helps correctly identify central SV Invasion
### Additional Risk Factors

**Percentage Positive Biopsy Cores**

<table>
<thead>
<tr>
<th>Risk Group</th>
<th>Low</th>
<th>Intermediate</th>
<th>High</th>
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<tbody>
<tr>
<td>CCN</td>
<td>cT1c + cT2a and</td>
<td>cT2b – 2c and/or</td>
<td>cT3 or</td>
</tr>
<tr>
<td>PSA</td>
<td>&lt;10 ng/ml and</td>
<td>&gt;10–20 ng/ml and/or</td>
<td>&gt;20 ng/ml or</td>
</tr>
<tr>
<td>Reason mm</td>
<td>&lt;7</td>
<td>=7</td>
<td>8–10</td>
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Amico et al. (1997a, 1998, 1999)

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<tr>
<td>stage</td>
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<tr>
<td>CTV</td>
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<tr>
<td>-----------------------------------------</td>
<td>----------------------</td>
<td></td>
<td></td>
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<tr>
<td>Low risk &amp; Intermediate risk</td>
<td>Prostate + base of SV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SV involved</td>
<td>Prostate+ whole SV-tip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High risk</td>
<td>Prostate+ SV+LN</td>
<td></td>
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</table>
Guidelines for primary radiotherapy of patients with prostate cancer

Dirk Boehmer\textsuperscript{a,*}, Philippe Maingon\textsuperscript{b}, Philip Poortmans\textsuperscript{c}, Marie-Hélène Baron\textsuperscript{d}, Raymond Miralbell\textsuperscript{e}, Vincent Remouchamps\textsuperscript{f}, Christopher Scrase\textsuperscript{g}, Alberto Bossi\textsuperscript{h}, Michel Bolla\textsuperscript{i}, on behalf of the EORTC radiation oncology group
Tumour related factors for determining CTV

• SV invasion
• ECE
• PNI

• Determinants of Local Recurrence
SV invasion

- Kestin et al. have shown from surgical specimens that Prostatic Ca never involves whole of SV.
- Including 2-2.5 cm proximal SV – covers 90% of pathologically involved SV.
- Possibility of SV invasion can be calculated by Roach Formula.
- Lieberfarb et al. in their series of 2009 prostatectomy specimens showed lower incidence of SV invasion and ECE in low risk pts with <50% PPB and intermediate risk pts with <17% PPB.
ECE

• Largest study comes from Teh et al who studied radial distance of ECE in 712 prostatectomy specimens
• Focal ECE-38%
• ECE<2mm-19%
• ECE 2-5mm-36%
• ECE >5 mm-7%

• There is significant relationship b/w ECE with GS, Pre T/t PSA, SV and LN positivity
CTV - Intact Prostate

• Generally no GTV
• CTV = Visible boundaries of Prostate on Planning CT
• Begin contouring mid gland where prostate borders are most easily identifiable
• Caudally - identify apex well – take help of MRI coronal view
• Apex lacks capsule
• Lateral = Levator ani
• Anterior - Anterior Fibromuscular stroma
• Posteriorly, rectum is opposed at mid gland
Nancy Lee Text
Book of Contouring
Neuro Vascular Bundle

- Careful about Neurovascular bundle placed in posterior oblique direction
Pathological considerations for defining CTV

• 1997- D Amico found that in 749 prostatectomy specimens-risk of SV invasion and ECE is <2% in LR patients
• LR Ca Prostate CTV= Prostate Only
IR and HR

• 90% pathological specimens have ECE up to 4-5 mm from prostate gland; <2% have it beyond 5mm
One may consider adding 5 mm CTV but not on posterior side towards rectum.
PTV

- Safety margin
- Institutional
- 6 mm posteriorly and 8 -10 mm all around
- Auto generation
- No tempering
- Daily imaging
Prostate Moves

- Intrafraction movement
- 427 patients with gold fiducial, 11,000 measurements
- 66% patients had motion within 2mm and 28% within 3mm
- Daily set up imaging- 5mm PTV margin is adequate
- Weekly imaging 10 mm
CTV Distal SV
Sagittal View CTV
PTV HR
Understanding of which LNds are to be included comes from Surgical series of LND Radiological series using Lymphotropic Nano particle based MRI which can discriminate b/w normal and abnormal MRI with high sensitivity and specificity.
LN to be included

- Distal Common iliac LN
- Internal and External iliac LN
- Pre sacral (S1-3)
- Obturator LN
Cranial- L5-S1 Interspace
At level of Distal common Iliac And proximal Presacral LNs
Place 7 mm margin around iliac vs connecting external and internal iliac contours

Connecting strip has to be 18 mm wide

Presacral LNs –S1-S3-10 mm strip anterior to sacral bone carving out bladder, bone and bowel
Stop External Iliac LN contouring at top of femoral head
Stop Obturator LN contouring at top of pubic symphysis
Post Op Ca Prostate

• CTV definition in post Op setting is complicated
• 1. change in anatomy caused by surgery
• 2. Limited information on pre op location of prostate
• Four Contouring Guidelines are there

POF
• Retropubic space
• Bladder Neck
• VUA
• Distinguish whether its post op RT or Salvage RT

• If it’s a salvage RT do MRI to identify GTV recurrence/residual for dose escalation
Guidelines for target volume definition in post-operative radiotherapy for prostate cancer, on behalf of the EORTC Radiation Oncology Group

Jeff M. Michalski, M.D., * Colleen Lawton, M.D., † Issam El Naqa, Ph.D., * Mark Ritter, 

prostatectomy radiation therapy: Consensus guidelines of the Australian and New Zealand Radiation Oncology Genito-Urinary Group

A. Sidhom, Andrew B. Kneebone, Margot Lehman, Kirsty L. Wiltshire, Lyn L. Millar, Rahul K. Mukherjee, Thomas P. Shakespeare, Keen-Hun Tai
Postoperative Radiotherapy in Prostate Cancer: The Case of the Missing Target

Jennifer Croke, M.D.,* Shawn Malone, M.D., F.R.C.P.C.,*
Nicolas Roustan Delatour, M.D., † Eric Belanger, M.D., F.R.C.P.C., †
Leonard Avruch, M.D., F.R.C.P.,‡ Christopher Morash, M.D., F.R.C.S.C.,§
Cathleen Kayser, M.R.T.(T.), C.M.D.,* Kathryn Underhill, B.Sc.(Hons.),*
and Johanna Spaans, M.Sc.*
Our Guidelines

Compensated Radiotherapy in Prostate Cancer: Case of the Missing Target

Croke, M.D., * Shawn Malone, M.D., F.R.C.P.C., * 
CTV Delineation Planning CT thickness 2.5-3mm

- **Inferior Border**: 5 mm below VUA but should be extended to include all surgical clips inferiorly

- VUA is first slice below where urine is last visible

- If VUA is not clearly identified, inferior border will be slice above the penile bulb

- **Last Section showing urine**

- **VUA in one section (3mm) below it**

- **Caudal Border 5-6mm mm below it (some studies say 8mm), include all surgical clips**

- OR One slice above penile bulb
Anterior

from the lower border of CTV to 3cm superior, anterior border of CTV is the post aspect of symphysis pubis
Anterior

More superiorly, anterior border of CTV includes post 1.5 cm of bladder
Posterior

- Caudally- Anterior rectal wall
- Cranially- anterior MRF
Lateral Border

Lani and Obturator Internus Ms
Superior Border

- Include all residual SV especially if pathologically involved
- Include distal portion of Vas deferens
PTV 10mm

Space bound by L Ani and Rectum is potential site for recurrence—so pay attention to it.

Distance b/w post part of CTV and Post wall of rectum should be > 2cm to avoid circumferential rectal irradiation.
Reason behind these proposed margins
Caudal

- Although the transacted urethra above the urethral sphincter defines inferior most extent of surgical bed, retraction and manipulation of tissues can result microscopic seeding immediately inferior to VUA.
- Distance b/w VUA and inferior border of surgical bed is almost 5 mm and PB is never exposed to surgical cavity.

Wiltshire et all IJROBP Vol 69, No 4, pp1090, 2007
Anterior

- Anterior Caudal Border- Post edge of symphysis pubis up to top of symphysis pubis—anterior surgical plane follows posterior edge of symphysis pubis

- Anterior Cranial Border-posterior 1.5 cm of Bladder wall—posterior bladder wall bounds the anterosuperior surgical plane

- Substantial deformation of bladder and rectum to fill the space previously occupied by prostate gland, anterior extension is estimated to be about 1.5 cm

Wiltshire et al. IJROBP Vol 69, No 4, pp1090, 2007
Lateral

• Lateral caudal boundary- medial border of L Ani and Obturator Internus– as in the caudal aspect of surgical volume, pelvic muscles bound the lateral dissection

• Lateral Cranial Boundary- was the sacro recto genito pubic fascia, lateral to NV bundle

Wiltshire et all IJROBP Vol 69, No 4, pp1090, 2007
Posterior

• Posterior Caudal boundary- anterior rectal wall and L ani
• During surgery, rectum is empty and rectal wall has no tone, which eliminates convexity b/w levator ani and anterior rectal wall
• Surgical dissection plane (Denovillier’s fascia) follows the anterior edge of rectal wall and L ani
• Posterior cranial boundary –Mesorectal fascia– surgical plane is anterior to mesorectal fascia

Wiltshire et all IJROBP Vol 69, No 4, pp1090, 2007
Cranial

- Cranial boundary- superior surgical clips (if present) or 5mm above inferior border of vas deferens
- Retained SV were included when pathologically involved
- Vas deferens was transacted at the cranial aspect of surgical bed, commonly using surgical clip
- In absence of surgical clip, transacted VD is difficult to visualize; therefore 5mm is added to cover for this uncertainty

Wiltshire et all IJROBP Vol 69, No 4, pp1090, 2007
VUAnastomosis – one section below it
Levator Ani

Pay attention to this groove
Cover Retro pubic space and all surgical clips
Cover 1.5 cm of bladder and all surgical clips
Cranial level at level of Vas Deferens
Top level Vas Deferens
Radiographic and Anatomic basis for prostate contouring Errors and methods to improve accuracy

Patrick W McLaughlin, Mary Feng et al

IJROBP vol 76 no 2 p369-378, 2010

Fig. 1. Regions of contouring errors: white circle = anterior; light gray circle = superior base (bladder neck); black circle = inferior base; arrow = mid prostate; dark gray circle = apex.
Apex - Overestimation of prostate at apex due to
1. Minimal radiographic difference b/w anatomy of prostate and ms on CT
2. Circular elements within GUD can be mistaken as prostate
variation In anatomy- especially when bony landmarks are used
Suggestions

- Keep an eye on sagittal and coronal view
- Take opinion of other colleague (peer review)
- Take help of a radiology colleague
- Use MRI
OARS
Comparison of different contouring definitions of the rectum as organ at risk (OAR) and dose-volume parameters predicting rectal inflammation in radiotherapy of prostate cancer: which definition to use?

1,2 MIRKO NITSCHE, MD, 3 WERNER BRANNATH, PhD, 3 MATTHIAS BRUCKNER, PhD, 1 DIRK WAGNER, 4,5 ALEXANDER KALTENBORN, MD, 1 NILS TEMME, Msc and 1,6 ROBERT M HERMANN, MD

Table 1. The rectum as an organ at risk. 13 different definitions of contouring the rectum were available from the current literature

<table>
<thead>
<tr>
<th>Definition name</th>
<th>Caudal limit</th>
<th>Cranial limit</th>
<th>Citation</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>Lowest slice of ischial tuberosity including the anus</td>
<td>One slice below the layer in which the rectum gives up its round shape and the sigmoid anteriorly connects</td>
<td>de Crevoisier et al\textsuperscript{15}</td>
</tr>
<tr>
<td>R2</td>
<td>Lowest slice of ischial tuberosity</td>
<td>For a length of 15 cm or to the point where the rectosigmoid flexure could be identified</td>
<td>Michalski et al\textsuperscript{14}</td>
</tr>
<tr>
<td>R3</td>
<td>Lowest slice of ischial tuberosity</td>
<td>Inferior border of the sacroiliac joints or when the rectum anteriorly leaves the sacrum</td>
<td>Rasch et al\textsuperscript{13}</td>
</tr>
<tr>
<td>R4</td>
<td>Lowest slice of ischial tuberosity</td>
<td>11 cm above</td>
<td>Kuban et al\textsuperscript{16}</td>
</tr>
<tr>
<td>R5</td>
<td>2 cm below the ischial tuberosity</td>
<td>11 cm above</td>
<td>Huang et al\textsuperscript{17}</td>
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<tr>
<td>R6</td>
<td>Anal verge</td>
<td>The slice in which the rectum gives up its round shape and connects to the anterior sigmoid</td>
<td>Costa et al\textsuperscript{2,3} Thor et al\textsuperscript{18} Fonteyne et al\textsuperscript{18}</td>
</tr>
<tr>
<td>R7</td>
<td>One slice above the anal verge</td>
<td>The slice in which the rectum gives up its round shape and connects to the anterior sigmoid</td>
<td>Valdagni et al\textsuperscript{2}</td>
</tr>
<tr>
<td>R8</td>
<td>One slice above the anal verge</td>
<td>One slice below the rectosigmoid flexure</td>
<td>Vavassori et al\textsuperscript{29} Foppiano et al\textsuperscript{21}</td>
</tr>
<tr>
<td>R9 “RTOG”</td>
<td>Lowest level of ischial tuberosity</td>
<td>Before the rectum loses its round shape (when the rectum leaves the sacrum anteriorly)</td>
<td>Vargas et al\textsuperscript{21} Gay et al\textsuperscript{22}</td>
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<tr>
<td>R10 “PTV-based”</td>
<td>Most inferior CT slice of the PTV</td>
<td>Most superior CT slice of the PTV</td>
<td>Oral et al\textsuperscript{19}</td>
</tr>
<tr>
<td>R11 “PTV-linked”</td>
<td>1 cm below the most inferior CT slice of the PTV</td>
<td>1 cm above the most superior CT slice of the PTV</td>
<td>Guckenberger et al\textsuperscript{23}</td>
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<tr>
<td>R12</td>
<td>2 cm below the most inferior CT slice the PTV</td>
<td>2 cm above the most superior CT slice of the PTV</td>
<td>Lin et al\textsuperscript{11}</td>
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<tr>
<td>R13</td>
<td>3 cm below the most inferior CT slice the PTV</td>
<td>3 cm above the most superior CT slice of the PTV</td>
<td>In-house definition</td>
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</table>
Follow one guideline consistently or 1 cm cranial and caudal to PTV
PENILE BULB IMAGING

Kent E. Wallner, M.D.,*† Gregory S. Merrick, M.D.,‡§ Mark L. Benson, M.D.,‖ Wayne M. Butler, Ph.D.,‡ Jeffrey Maki, M.D.,¶ and Bryan G. Tollenaar, M.S.†

CT
mid bulb

corpora cavernosum

MR
mid bulb

crura
pubic arch
levator ani
rectum

Anatomy - Body of penis consists of paired corpora cavernosa and the middle spongiosum.

Followed posteriorly, into perineum, the two corpora cavernosa separate and form crura of penis, attached to inferior pubic ramus.

Between the crura, corpora spongiosum enlarges to form bulb of penis, which is attached superiorly to inferior surface of diaphragm.

Radiology - Best identified on T2 weighted MR images in axial, sagittal and coronal planes.

Top of bulb is typically located 10 mm inferior to apex of prostate.

GUD is b/w apex of prostate and top of penile bulb.
Vessel sparing RT to decrease ED

- Some evidence that ED after prostate RT has vascular etiology
- Corpora cavernosa (CC) and internal pudendal A (IPA) are critical structures related to ED
- Most accurate on MR Angiogram
THANK YOU

Acknowledgement- Dr Arun Verma