

# Clinical experience with adaptive radiotherapy for urinary bladder cancer

*Anne Vestergaard, Morten Høyer, Mai-Britt B Ellegaard, Jimmi Søndergaard, Ulrik V Elstrøm, Jørgen B Petersen, Ludvig P Muren*

*Department of Medical Physics and Department of Oncology, Aarhus University Hospital, Aarhus, Denmark*

*ICTR 2014*



# Introduction

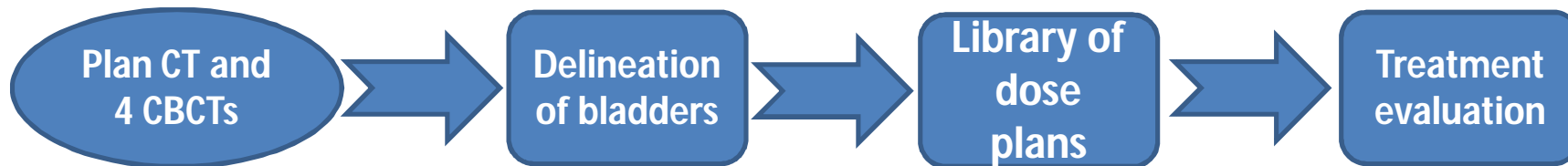
---

- In November 2012 a 75 years old man with cardiac morbidity and ulcerous colitis presents with a urinary bladder cancer
- Treated according to adaptive protocol
- He had no gastrointestinal morbidity during the course of radiotherapy



# Introduction to plan selection in bladder cancer

## Planning of plan selection treatment



## Delivery of plan selection



# Aim

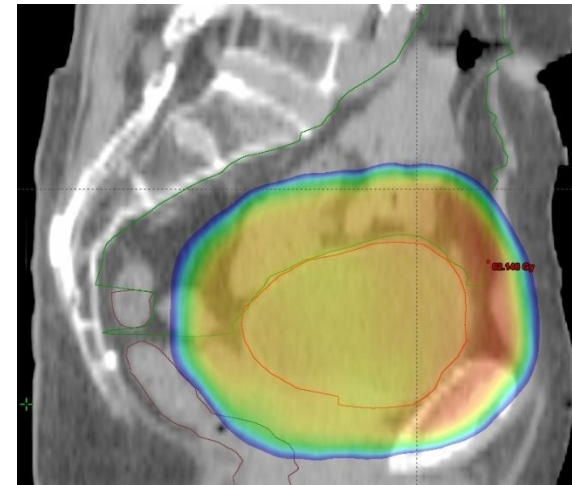
---

The aim of this study was to assess the differences in dose to the normal tissue for ART using plan selection compared to non-adaptive RT in treatment of bladder cancer and to evaluate our early clinical experiences

# Patient and image data

---

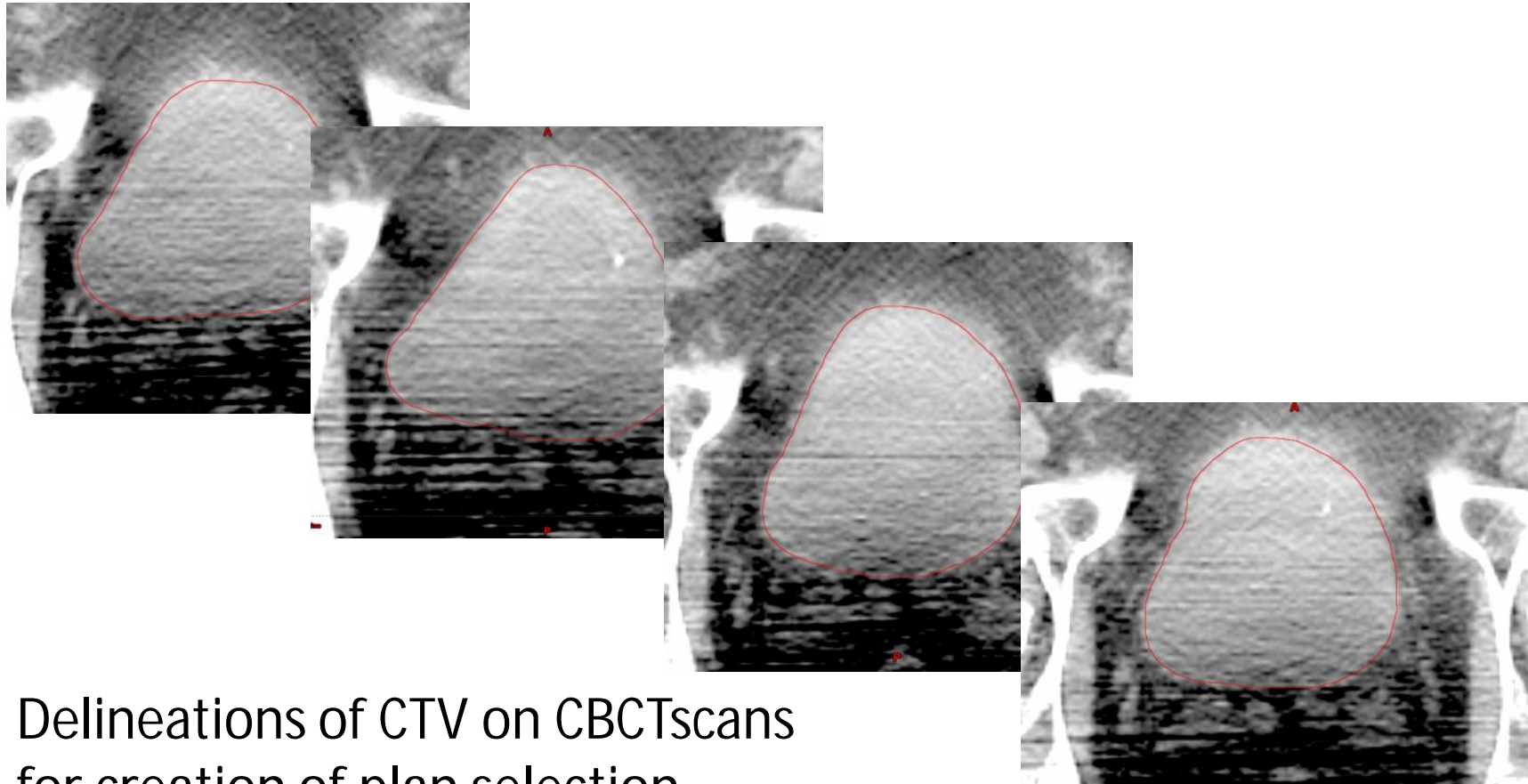
- In total, 11 patients included in the adaptive protocol
- Seven patients received 60Gy in 30 fractions to the bladder, 4 patients 48 Gy to pelvic lymph nodes (SIB)
- All patients received VMAT plans (normally 2 arcs)
- Patients treated on TrueBeam
- Daily cone beam CT (CBCT) acquired for setup on pelvic bone
- First week treated non-adaptively, using population-based margins (ant/sup 2 cm; post 1.5 cm; inf/ lat 1 cm)
- Fraction no. 6 to 30: CBCT used for selection of treatment plan from library



Muren et al.: Radiother Oncol 2003

# M&M: Delineation on first 4 CBCTs

---



Delineations of CTV on CBCTscans  
for creation of plan selection  
volumes

Wright et al.: Phys Med Biol 2009

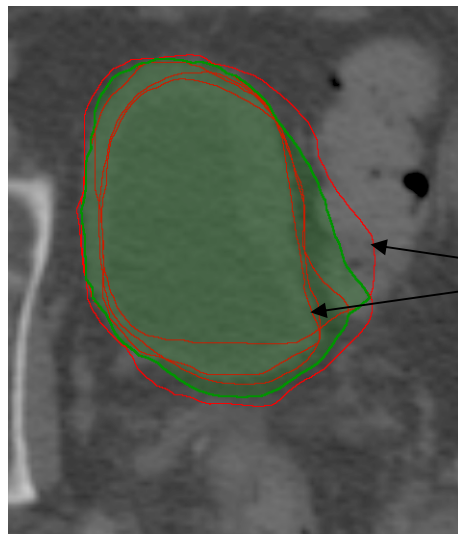
# M&M: Generating plan selection volumes

---

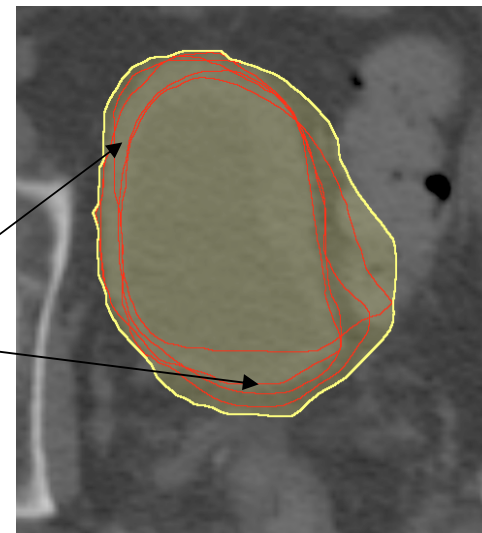
Bladder(CTV) delineated on plan CT and CBCTs from the first 4 treatment fractions

**Small:** The volume contained in at least 2 out of 5 CTVs

**Medium:** Union of same 5 CTVs



Individual CTVs in red



**Large:** Standard non-adaptive margin

Vestergaard et al, Acta Oncol 2010  
Wright et al, Phys Med Biol 2009

# M&M: Planning target volumes and organs at risk

---

- A 3 mm isotropic margin was added to the plan selection volumes to account for uncertainties
- Planning target volumes (PTVs) were generated from plan selection volumes adding 5mm isotropic margin
- Bowel cavity: Superior border L5, inferior last slice with bowel segment
- Rectum including rectal wall and content from the recto-sigmoid transition or sacro-iliac joint to the anal canal

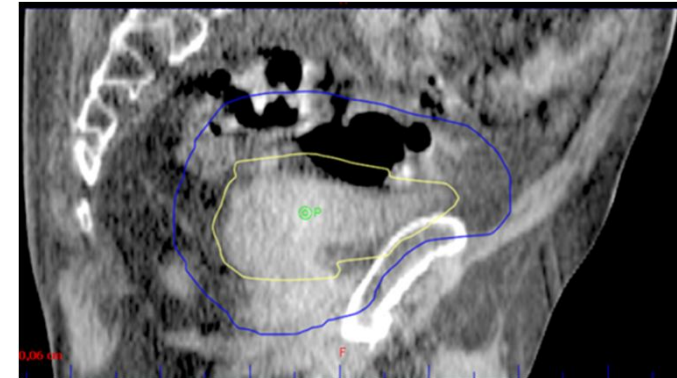




# M&M: Plan selection and toxicity

---

- Plan selection was performed online
  - The smallest plan covering the bladder as identified on pre-treatment CBCT was selected
  - Plan selection frequencies were calculated
- Morbidity scoring using CTCAE v. 4.0



Common Terminology Criteria for Adverse Events (CTCAE) v4.0

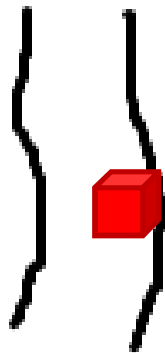
# M&M: Dose on planCT vs. fractional dose summation

---

How do you calculate the delivered dose to rectum and bowel?

## *Dose addition on planCT*

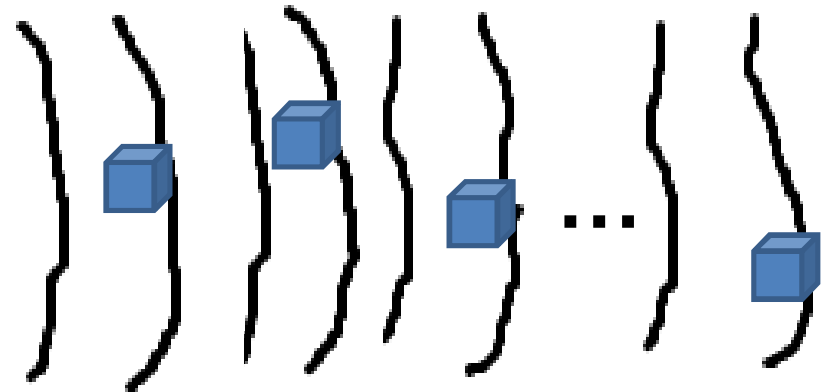
Dose calculated as linear combination of plan selections and corresponding dose matrices



planCT

## *Fractional dose summation*

Dose to the hottest e.g. 2 ccm calculated for each fraction and summed to give an estimate of maximum delivered dose



Fx 1

Fx 2

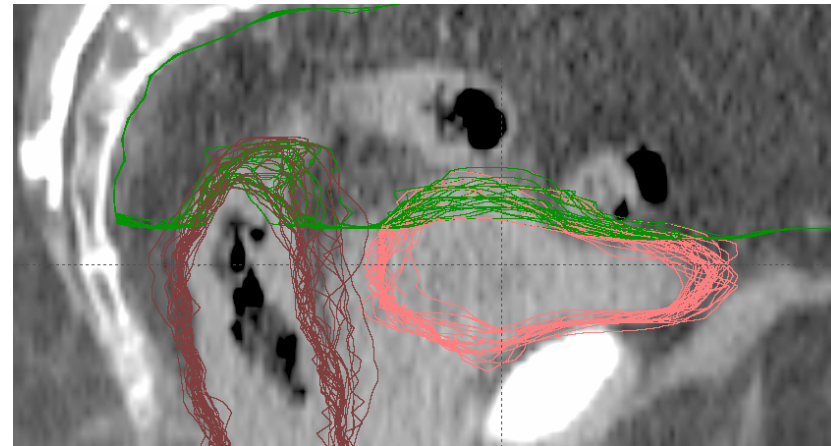
Fx 3

Fx 30

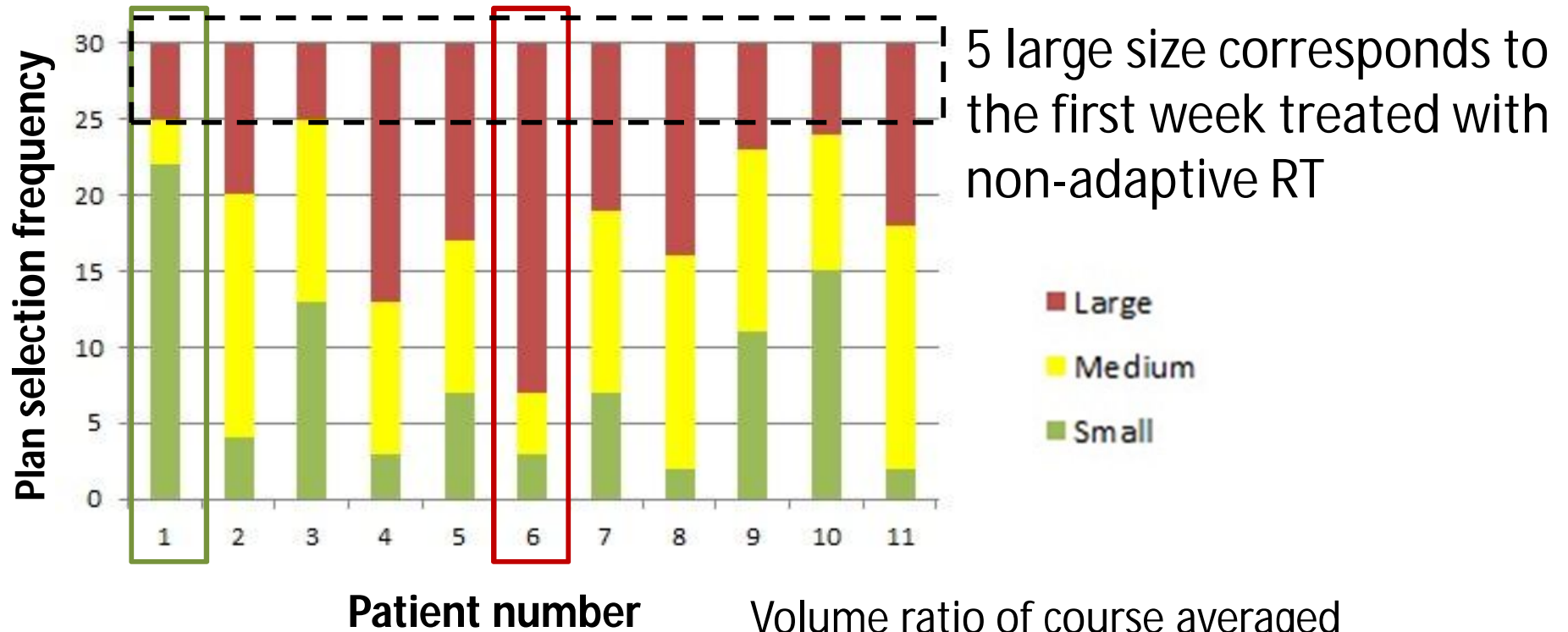
# M&M: Delineations on daily CBCT for fractional dose summation

---

- For one patient bladder, bowel and rectum was delineated on every CBCTscan
- Structures was copied to the plan CT using online registrations
- Combinations of selected plan and corresponding structures were used to assess fractional dose volume histograms (DVHs)
- Maximum dose to bowel cavity and rectum was calculated
- Minimum dose to the bladder was calculated



# Results: Plan selection frequencies



Volume ratio of course averaged

$PTV_{ART} / PTV_{nonART}$  Median 0.72 [0.63;0.89]

# Results: Rectum and Bowel cavity

---

## Example of one patient

Dose in Gy	planCT	Dose summation	nonART
D2cc rectum	43.3	46.1	51.2
D10cc rectum	32.6	35.1	40.8
D100cc bowel	59.2	57.9	60.4
D200cc bowel*	46.3	44.4	59.7

The 2% bladder volume with the lowest dose received more than 97.5 % of the dose in each fraction delivered

\*Kavanagh IJROBP 2010 (QUANTEC)

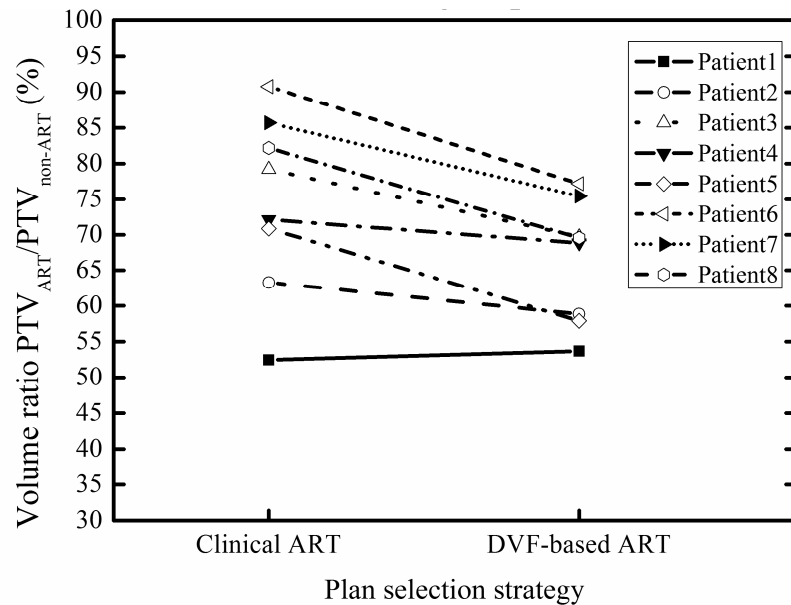
# Conclusion

---

Adaptive RT using daily plan selection for bladder cancer considerably reduces the treated volume and this may translate into a reduction of treatment related GI morbidity

# Future perspectives

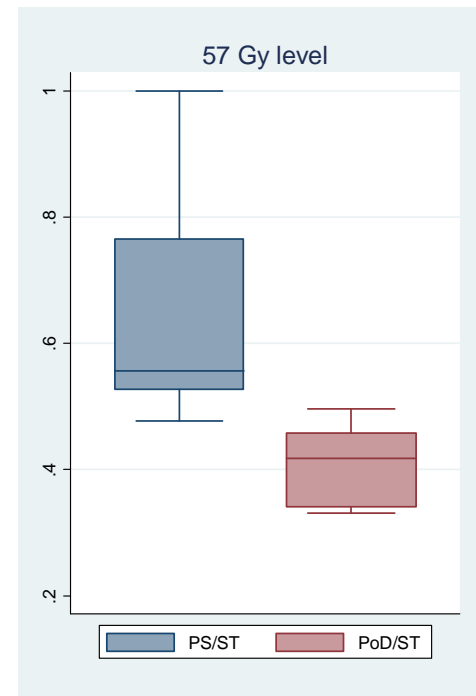
## DIR based CTV - PTV expansion



Mean VR decreased from 0.74 to 0.64 (p=0.02)

Vestergaard et al. manuscript in preparation

## Daily on-line re-optimization



Mean  $V_{95,ART}/V_{95,nonART}$  0.41

Vestergaard et al. Radiother & Oncol 2013

# Future perspectives

---

- Evaluation of intra-fractional bladder motion using cine MR and CBCTscans
- Comparison of dose summation vs. dose accumulation in online ART
- Include an initial boost in the adaptive protocol
- Further steps towards online re-optimization



# Acknowledgements

**Thank you for your attention**

*Ludvig P. Muren*

*Morten Høyer*

*Jørgen B. Petersen*

*Jesper F. Kallehaug*

*Jimmi Søndergaard*

*Ulrik V. Elstrøm*

*Cai Grau*

*Annette Bøjen*

*Rune Hansen*

*Lise Bentzen*

*Sara Thörnqvist*

*Maria Thor*

*Pauliina Wright*

*Ole Nørrevang*

*Dorte Oksbjerg Mortensen*

*Mai-Britt B. Ellegaard*

*Anne B. Kirk*

*Eva Kjærsgaard*

*Copenhagen University Hospital, Herlev*

*Henriette Lindberg*

*Kirsten Legaard Jakobsen*

*Odense University hospital*

*Lars Dysager*

*Henrik R. Jensen*