

Bladder extension variability during pelvic external beam radiotherapy with a full or empty bladder

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Purpose

Varying bladder fillings during fractionated pelvic radiotherapy lead to a changing dose-volume load to the bladder and adjacent structures. The aim of the study was to define the extent of bladder wall movements during a planning CT scan series with a full bladder and a second series with an empty bladder.

Methods

A total number of 340 serial treatment planning CT scans (supine patient position, slice thickness of 5mm) were performed in 50 prostate cancer patients (30 primary and 20 postoperative). Each patient underwent a CT scan with a full bladder and an empty bladder before the start of treatment and 2-3 times during radiotherapy. The data was transferred to a commercially available stereotactic planning system (Brainlab®, Heimstetten, Germany). The scans were matched by alignment of the pelvic bones. Displacements of the bladder wall were compared at the anterior, posterior, superior, inferior and lateral borders and correlated with changing bladder fillings. A positive displacement corresponds to the superior, anterior and right direction on the respective axis (external direction, if right and left are combined).

Results

The mean bladder volumes of the full and empty bladder for the pretreatment (225cc and 82cc) and consecutive CT scans (217cc and 79cc) did not change considerably, but the variability of the full bladder volume was larger compared to the empty bladder volume (standard deviation for the difference of 124cc and 56cc; $p < 0.01$). Significant difference of bladder wall displacement variabilities were found only at the anterior and superior borders (Table 1).

Within a bladder volume range between -100 and $+200$ ml relative to the initial full bladder planning scan, the mean bladder wall displacement remained < 5 mm at the inferior, lateral, and posterior borders – as opposed to 15mm and 21mm at the anterior and superior borders (Figure 1).

To consider 90% of external displacements, a margin of 6mm would be sufficient at the inferior and lateral bladder borders, and 10mm at the posterior border with both a full and empty bladder. Larger margins would be needed with a full bladder at the anterior and superior borders (11mm vs. 6mm and 23mm vs. 14mm with a full vs. empty bladder, respectively).

Figure 2 presents an example of the wall displacements with varying bladder fillings.

Table 1. Variability of bladder wall displacement with full and empty bladder (*mean±standard deviation; **extreme upper and lower 10% excluded)

		full bladder	empty bladder	p-value concerning variance
superior wall displacement/mm	M±SD*	0.1 ± 19.3	0.9 ± 16.3	0.005
	range**	-26.5 - 23.1	-15.4 - 13.5	
	>10-20 / >20-30 / >30	25% / 18% / 11%	16% / 4% / 10%	
inferior wall displacement/mm	M±SD*	-0.2 ± 4.1	0.9 ± 6.8	0.105
	range**	-5.5 - 4.9	-5.6 - 7.6	
	>10-20 / >20-30 / >30	2% / 0% / 0%	2% / 2% / 0%	
right wall displacement/mm	M±SD*	-1.0 ± 4.7	-0.8 ± 4.9	1.000
	range**	-6.8 - 4.1	-7.5 - 5.2	
	>10-20 / >20-30 / >30	6% / 0% / 0%	7% / 0% / 0%	
left wall displacement/mm	M±SD*	-0.3 ± 4.5	1.0 ± 4.5	0.731
	range**	-6.0 - 5.9	-4.8 - 7.0	
	>10-20 / >20-30 / >30	5% / 0% / 0%	4% / 0% / 0%	
anterior wall displacement/mm	M±SD*	0.1 ± 10.6	-0.7 ± 6.9	0.001
	range**	-12.6 - 11.0	-8.8 - 6.4	
	>10-20 / >20-30 / >30	21% / 9% / 1%	11% / 2% / 0%	
posterior wall displacement/mm	M±SD*	1.2 ± 10.6	-0.6 ± 8.7	0.254
	range**	-10.4 - 14.4	-10.2 - 9.5	
	>10-20 / >20-30 / >30	20% / 5% / 2%	14% / 3% / 1%	

Figure 1. Mean anterior, posterior, lateral, superior, and inferior bladder wall displacements with changing bladder volumes relative to the initial treatment planning scan with a full bladder

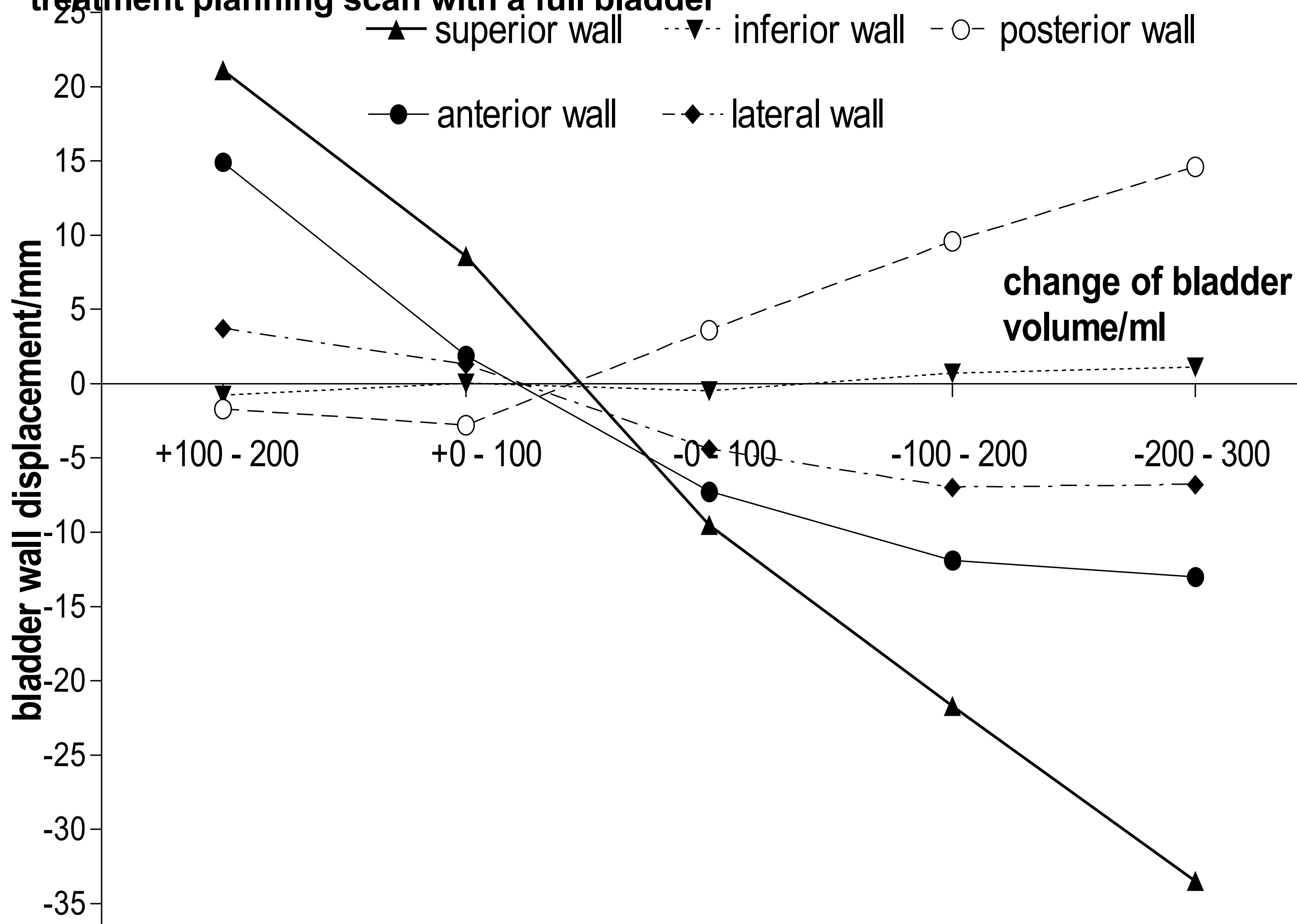
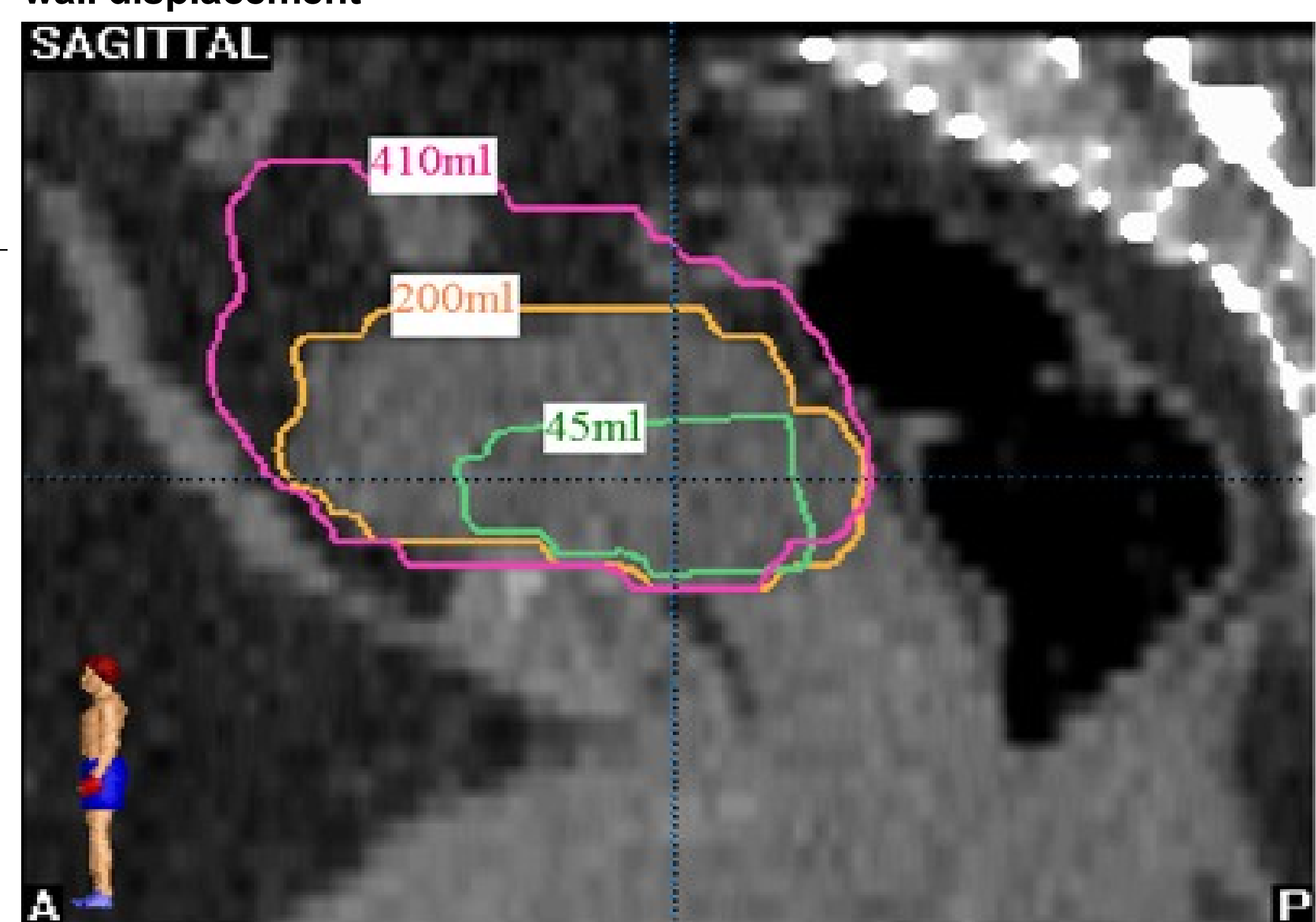


Figure 2. Example: sagittal CT scan reconstruction (bladder volume 200ml) with two superimposed bladder contours of subsequent scans

- +210ml: +11mm anterior, +30mm superior, -3mm posterior bladder wall displacement
- 155ml: -29mm anterior, -20mm superior, +12mm posterior bladder wall displacement



Conclusions

Treating the pelvis with an empty bladder compared to a full bladder, organ wall displacement can be significantly reduced at the superior and anterior border (influence on small bowel and sigma position). Safety margins have to be varied in dependence of the respective directions.

In spite of a larger volume variability, full bladder wall displacements are comparable with an empty bladder displacements at the inferior, lateral, and posterior borders – no target position disadvantage results for the treatment of the prostate, rectum, or uterus.