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Rectal cancer planning

Plan selection strategy for rectum cancer patients: An interobserver study to assess clinical feasibility

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ABSTRACT

Background and purpose: In radiotherapy for rectum cancer, the target volume is highly deformable. An adaptive plan selection strategy can mitigate the effect of these variations. The purpose of this study was to evaluate the feasibility of an adaptive strategy by assessing the interobserver variation in CBCT-based plan selection.

Material and methods: Eleven patients with rectum cancer, treated with a non-adaptive strategy, were selected. Five CBCT scans were available per patient. To simulate the plan selection strategy, per patient three PTVs were created by varying the anterior upper mesorectum margin. For each CBCT scan, twenty observers selected the smallest PTV that encompassed the target volume. After this initial baseline measurement, the gold standard was determined during a consensus meeting, followed by a second measurement one month later. Differences between both measurements were assessed using the Wilcoxon signed-rank test.

Results: In the baseline measurement, the concordance with the gold standard was 69% (range: 60–82%), which improved to 75% (range: 60–87%) in the second measurement ($p = 0.01$). For the second measurement, 10% of plan selections were smaller than the gold standard.

Conclusion: With a plan selection consistency between observers of 75%, a plan selection strategy for rectum cancer patients is feasible.

The standard of care for non-metastasized locally advanced rectal cancer is chemo-radiotherapy combined with surgery [1–3]. In radiotherapy, sparing the organs at risk with the use of state-of-the-art planning techniques such as intensity-modulated radiation therapy (IMRT) or volumetric modulated arc therapy (VMAT), is often compromised by the large population-based margins that are necessary to compensate for the large shape changes of the target volume over the time of treatment. In rectum cancer patients, like in most patients treated in the pelvic region, day-to-day variation in rectum and bladder filling often causes large deformation of the target volume, which cannot be corrected for with a treatment couch adjustment [4–6]. Minimizing shape changes of the mesorectum with the use of drinking protocols to manage bladder filling, or dietary instruction to manage bowel motion, have been limited in their success [7].

An adaptive strategy with multiple plans made prior to treatment and tailored to a range of possible shapes can mitigate the effects of these variations in target volume, by selecting the best-fitting plan based on daily cone beam CT (CBCT) scans, and allows for smaller margins per plan. This strategy has been successfully applied for radiotherapy in bladder and cervical cancer, in which bladder filling is the predominant factor in the shape changes [8–11]. To create multiple plans, often a full and empty bladder pre-treatment CT scan is acquired from which a patient-specific model for bladder filling is derived, which is used to create intermediate target volume structures.

In rectum cancer, however, shape changes of the mesorectum are mostly driven by changes in rectum volume and shape, and to a much lesser extent by bladder filling [4–6]. Because of this, creating multiple plans based on varying the bladder filling is not useful. However, by applying different PTV margins to the upper anterior side of the mesorectum, which is the part of the target volume showing the largest deformations [4–6], multiple PTVs can be created based on a single CT scan. This can also correct for the shape changes that are encountered. A similar plan selection strategy based on a variable margin has been investigated for cervical

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cancer and was proven to be dosimetrically beneficial compared to a single population-based margin [12].

Selecting the optimal plan entails daily selection of the smallest PTV encompassing the entire mesorectum on CBCT images. This requires adequate visibility of the regions of interest. In the pelvic region, CBCT image quality can be hampered by imaging artefacts caused by moving air or bowel [13]. Identifying the boundaries of a complex target volume like the mesorectum can therefore be challenging.

The purpose of this study was to evaluate the feasibility of an adaptive plan selection strategy for radiotherapy in rectum cancer patients by assessing the interobserver variation in CBCT-based plan selection.

Methods and materials

Patient data

Retrospectively, 11 consecutive patients with resectable rectum cancer, treated between December 2014 and August 2015 at our department, were selected. Patients were included if the target delineation was in accordance with delineation guidelines and when the total target volume was visible on the CBCT. Patients were treated with a standard, non-adaptive strategy. In our institution, prone position on a bellyboard was the first choice of patient orientation, as historically this was considered the optimal position to spare small bowel [14], but supine position was used when pain or presence of a stoma prohibited prone position. Therefore, 6 patients treated in supine position were included, as well as 5 patients treated in prone position with bellyboard (Table 1 and Fig. 1). Three patients were treated with long-course radiotherapy, consisting of 28 fractions of 1.8 Gy, whereas 8 patients were treated with short-course radiotherapy, in which 5 fractions of 5 Gy were delivered. Further patient details can be found in Table 1. For the patients treated with short-course radiotherapy, all CBCT scans were included. For patients treated with long-course radiotherapy, one randomly selected CBCT scan from each week was included, resulting in 5 available CBCT scans per patient. Both treatment schemes were included in this study as both were the intended patient groups for the plan selection strategy.

Imaging data

For the pretreatment CT scan, patients were instructed according to the clinical drinking protocol. They were therefore asked to drink 500 ml of water 1.5 h prior to the CT scan after voiding the bladder, and refrain from voiding. This protocol was adopted to improve chances of a large bladder filling, as this is considered

Table 1
Patient characteristics.

Patient	Age	Sex	Treatment position	Tumor stage			GTV location	Treatment scheme	Further treatment	Bladder volume cm^3	Rectum volume cm^3	Available margins (mm)		
1	60	Female	supine	T3	N0	M0	distal	28 × 1.8 Gy	APR	313	121	−15	0	15
2	82	Female	supine	T3	N2	M0	distal	5 × 5 Gy	LAR	212	82	−15	0	15
3	73	Male	supine	T3	N1	M0	distal	5 × 5 Gy	LAR	265	68	−15	0	15
4	72	Female	supine	T3	N2a	M0	mid	28 × 1.8 Gy	LAR	130	46	−25	−15	0
5	61	Male	supine	T2/3	N1b	M0	proximal	5 × 5 Gy	LAR	493	117	0	15	25
6	66	Male	supine	T2/3	N2	M0	distal	28 × 1.8 Gy	APR	399	79	−15	0	15
7	44	Male	prone BB	T2	N2	M0	proximal	5 × 5 Gy	chemotherapy	637	76	0	15	25
8	55	Female	prone BB	T3	N1	M0	proximal	5 × 5 Gy	LAR	271	189	−15	0	15
9	63	Male	prone BB	T3	N1b	M0	distal	5 × 5 Gy	LAR	706	123	0	15	25
10	55	Male	prone BB	T2	N1b	M0	distal	5 × 5 Gy	LAR	378	56	−15	0	15
11	59	Female	prone BB	T3	N1	M0	proximal	5 × 5 Gy	LAR	282	54	0	15	25

LAR: Low Anterior Resection.
APR: AbdominoPerineal Resection.
BB: Bellyboard.

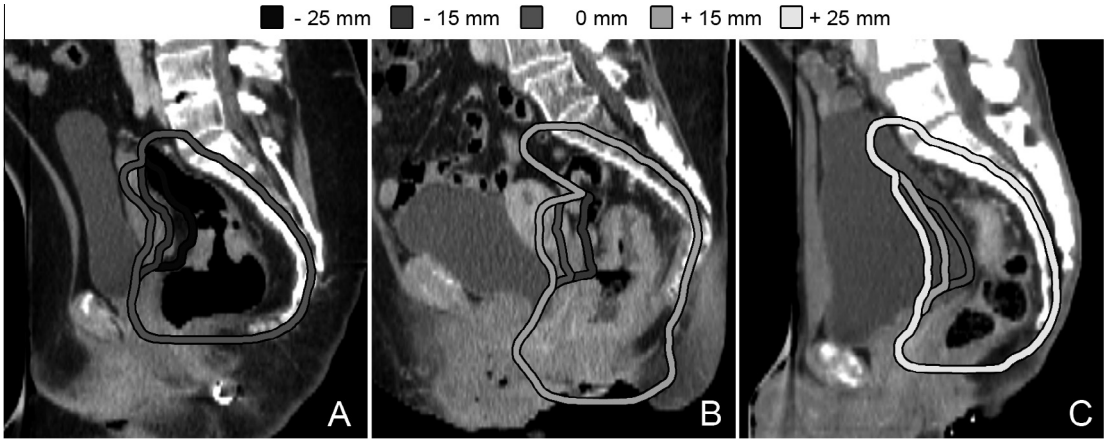

Fig. 1. Examples of possible margin selections. (A) for a patient with a full rectum and empty bladder on the planning CT scan, margins of −25 mm, −15 mm and 0 mm were used. (C) shows the opposite anatomy (full bladder and empty rectum) which warrants margins of 0 mm, 15 mm and 25 mm, and (B) shows a mixed situation for which margins of -15 mm, 0 mm and 15 mm were used. Patients were treated in prone position on a belly board (A + C), or in supine position (B).