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Scientific Article

Impact of prone versus supine positioning on small bowel dose with pelvic intensity modulated radiation therapy

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Abstract

Purpose: To report the results of a prospective study that compares small bowel doses during prone and supine pelvic intensity modulated radiation therapy.

Methods and materials: Ten patients receiving pelvic radiation therapy each had 2 intensity modulated radiation therapy plans generated: supine and prone on a belly board (PBB). Computed tomography on rails was performed weekly throughout treatment in both positions (10 scans per patient). After image fusion, doses to small bowel (SB) loops and clinical target volume were calculated for each scan. Changes between the planned and received doses were analyzed and compared between positions. The impact of bladder filling on SB dose was also assessed.

Results: Prone treatment was associated with significantly lower volumes of SB receiving $\geq$20 Gy. On average, prone on a belly board positioning reduced the volume of SB receiving a given dose of radiation by 28% compared with supine positioning. Target coverage throughout the treatment course was similar in both positions with an average minimum clinical target volume dose of 88% of the prescribed prone dose and 89% of the supine ($P = .54$). For supine treatment, SB dose was inversely correlated with bladder filling ($P = .001$-$.013$; $P > .15$ for prone). For 96% of treatments, the volume of SB that received a given dose deviated >10% from the plan. The deviation between the planned and delivered doses to SB did not differ significantly between the positions.

Conclusions: Prone positioning on a belly board during pelvic IMRT consistently reduces the volume of SB that receives a broad range of radiation doses. Prone IMRT is associated with

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interfraction dose variation to SB that is similar to that of supine positioning. These findings suggest that prone positioning with daily image guided radiation therapy is an effective method for maximizing SB sparing during pelvic IMRT.

Introduction

Gastrointestinal (GI) toxicity is the most frequently encountered complication of pelvic radiation therapy with clinically significant acute and late toxicity occurring in up to 60% and 20% of patients, respectively.[1] Radiation dose to the small bowel (SB) and volume of SB irradiated are the strongest predictors of GI toxicity during pelvic radiation therapy.[2] Thus, methods to reduce SB radiation exposure have the potential to decrease GI toxicity and open the possibility for target dose escalation. Prone positioning on a belly board (PBB) and intensity modulated radiation therapy (IMRT) are 2 of the most effective and frequently used techniques for reducing SB dose from pelvic radiation therapy.

PBB is a simple method for physically displacing SB away from target structures within the pelvis. Three-dimensional treatment planning studies have demonstrated that PBB significantly reduces the volume of SB receiving prescription doses.[3-6] Clinically, retrospective studies have shown that 3-dimensional pelvic radiation therapy with prone positioning is associated with less acute GI toxicity compared with supine controls.[6,7] On the basis of these results, PBB is routinely used at some institutions for pelvic radiation therapy. IMRT aims to decrease GI toxicity in pelvic radiation therapy by improving target dose conformality. Treatment planning comparisons have shown that IMRT is capable of significantly decreasing dose to SB in patients with rectal, gynecologic, anal, and prostate cancer.[8-11] In clinical practice, both retrospective[12,13] and prospective studies[14] have shown that pelvic IMRT is associated with lower acute and late GI toxicity compared with 3-dimensional conformal treatment for select subsites.

The combination of both PBB and IMRT appears to offer increased SB sparing during pelvic radiation therapy. Treatment planning comparisons in patients with gynecologic, rectal, and anal cancer have demonstrated reduced SB doses with prone IMRT compared with supine IMRT or prone 3-dimensional conformal radiation therapy.[7,9,15-17] To date, no studies using pelvic IMRT have demonstrated improved clinical outcomes with PBB over supine treatment.

Despite the potential dosimetric advantages of prone IMRT, the combination raises several concerns. Compared with supine positioning, prone treatment may be associated with both increased interfraction position variation[18,19] and greater day-to-day anatomic deformation.[20] Given the increased conformality and complex beam fluences with IMRT, positioning errors and anatomic changes may result in unanticipated dose variations within SB and, potentially, target underdosage. Therefore, it is possible that the dosimetric advantage of prone IMRT seen in simulation may not be maintained through the course of treatment.

We conducted a prospective study to compare prone and supine pelvic IMRT on the basis of the reconstruction of "delivered" doses to target volumes and organs at risk. Each patient was simulated and planned for both supine and PBB. During the course of treatment, in-room computed tomography (CT) on rails was performed weekly in both positions. These datasets allowed us to use each patient as their own control and to calculate "real-world" on-treatment doses as if each patient had been treated in both positions. On the basis of the previously observed positional variations and anatomic deformations with prone positioning, we hypothesized that prone treatment would result in greater interfraction dose variation to SB than supine treatment.

Methods and materials

Ten patients receiving curative pelvic radiation therapy at the University of Utah Huntsman Cancer Hospital were enrolled in an institutional review board–approved, prospective study. Because the primary requirement for the study was to obtain weekly CT scans of each patient in both positions, inclusion criteria were intentionally broad. Disease sites were rectal ($n = 4$), cervical/endometrial ($n = 4$), and anal ($n = 2$). The radiation exposure from the additional CT scans was quantified and documented in the consent. All contouring and planning for the project was independent of actual patient treatment, and enrollment did not affect therapy.

Simulation

Patients were simulated on a GE LightSpeed RT 16-slice large bore CT using 2.5-mm slice thickness (GE