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Role of belly board device in the age of intensity modulated radiotherapy for pelvic irradiation

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ABSTRACT

Small bowel dose often represents a limiting factor for radiation treatment of pelvic malignancies. To reduce small bowel toxicity, a belly board device (BBD) with a prone position is often recommended. Intensity modulated radiotherapy (IMRT) could reduce dose to small bowel based on the desired dose-volume constraints. We investigated the efficacy of BBD in conjunction with IMRT. A total of 11 consecutive patients with the diagnosis of rectal cancer, who were candidates for definitive therapy, were selected. Patients were immobilized with BBD in prone position for simulation and treatment. Supine position computed tomography (CT) data were either acquired at the same time or during a diagnostic scan, and if existed was used. Target volumes (TV) as well as organs at risk (OAR) were delineated in both studies. Three-dimensional conformal treatment (3DCRT) and IMRT plans were made for both scans. Thus for each patient, 4 plans were generated. Statistical analysis was conducted for maximum, minimum, and mean dose to each structure. When comparing the normalized mean Gross TV dose for the different plans, there was no statistical difference found between the planning types. There was a significant difference in small bowel sparing when using prone position on BBD comparing 3DCRT and IMRT plans, favoring IMRT with a 29.6% reduction in dose ($p = 0.007$). There was also a statistically significant difference in small bowel sparing when comparing supine position IMRT to prone-BBD IMRT favoring prone-BBD IMRT with a reduction of 30.3% ($p = 0.002$). For rectal cancer when small bowel could be a limiting factor, prone position using BBD along with IMRT provides the best sparing. We conclude that whenever a dose escalation in rectal cancer is desired where small bowel could be limiting factor, IMRT in conjunction with BBD should be selected.

Introduction

Small bowel toxicity is a limiting factor for radiation treatment of pelvic malignancies (rectum, cervix, and prostate). It becomes extremely critical for dose escalation studies in an attempt to improve radiation outcome. Typically 40 to 45 Gy is accepted as the tolerance dose for small bowel.[1-3] Acute small bowel injury has been described with a threshold dose for grade 3 or greater toxicity when a volume of 120 cm^3 of individually contoured loops receive ≥ 15 Gy or when 195 cm^3 of the contoured peritoneal cavity receives ≥ 45 Gy.[3,4] It is, therefore, generally recommended to reduce the dose to small bowel as much as possible which may be difficult owing to anatomical position of the target volume, especially in pelvic malignancies.

Before the intensity modulated radiation therapy (IMRT) era, most of the small bowel sparing was performed by surgical placement of tissue expanders, slings, or meshes to move the mobile loops of the organ out of the treatment fields.[5] Noninvasive approaches have been used as well based on employing gastrointestinal contrast during treatment planning, patient positioning, abdominal compression, and bladder filling.[6,7] Another noninvasive method commonly used with 3-dimensional conformal radiation therapy (3DCRT) is a belly board device (BBD) in a prone position.[8-12] This simple device allows mobile, small bowel to fall superiorly and anteriorly away from pelvic treatment fields when a patient is positioned in a prone position with the anterior abdomen placed in a cut out in the board. In fact, the American College

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of Radiology accreditation program guidelines strongly recommend the use of BBD in prone position for all rectal malignancies, where small bowel could be a limiting factor in delivering appropriate radiation dose.[13] The BBD has been reported by various investigators to perform well dosimetrically.[9,14,15] It is a simple device which, as demonstrated pictorially in Fig. 1, allows for a great amount of small bowel displacement away from the pelvis.

With IMRT, where dose optimization can be performed on each organ of interest especially organs at risk (OAR), the question can be raised whether or not prone positioning and BBD are still needed to spare small bowel when offering neoadjuvant treatment for unresected rectal cancer. Beriwal *et al.*[16] provide some insights for treating gynecologic malignancies and showed that the use of prone position in IMRT gains no advantage for sparing small bowel, which seems contradictory to the general views and several publications,[14,15,17] as optimization should accomplish dose constraint objectives and reduce dose to OARs. This is clearly shown in a systematic review of the literature of BBD use[15] that concluded the use of a prone BBD with either 3DCRT or IMRT yielding better sparing of small bowel in pelvic radiation fields and might give the lowest gastrointestinal treatment related morbidity. Owing to such a contradiction, it was felt necessary to evaluate this topic again.

The efficacy of BBD in conjunction with IMRT in the neoadjuvant treatment of rectal cancer is investigated in this study, specifically to evaluate sparing small bowel and thus possibly reducing radiation toxicity. In this study, we make a direct comparison of 4 different possible setup/treatment modalities. They are: 3DCRT and IMRT treatments with a prone-BBD and without a BBD in a supine position.

Methods and Materials

In total, 11 patients with the diagnosis of rectal cancer were selected under Institutional Review Board exempt status. All the patients were preoperative with intact rectums with a plan to go on for an appropriate surgery after neoadjuvant therapy. Patient characteristics are provided in Table 1. Patients were immobilized with BBD in the prone position for computed tomography (CT) simulation. No specific bladder filling instructions were given. Scout radiographs were acquired before CT scans for localization with maximum extent of the small bowel sparing. If patients had diagnostic CT scans before simulation, it was used for planning to limit the radiation exposure and inconvenience to the patient. These scans were imported into our treatment planning system (Eclipse version 11.3, Varian Medical system, Palo Alto, CA) for image fusion and treatment planning with analytical anisotropic algorithm (AAA) for inhomogeneity correction. All contours were drawn by the senior physicians listed in this study with more than 20 years of experience.

Treatment plans were generated with 3DCRT and IMRT planning techniques in both sets of CT scans, that is, in prone position on the BBD and in the supine position without BBD. For 3DCRT, 4-field box technique was used, whereas for IMRT, 5 to 7 field step-and-shoot IMRT was used. Thus for each patient, 4 optimized treatment plans were generated as follows: Prone-BBD 3DCRT, Prone-BBD IMRT, Supine 3DCRT, and Supine IMRT. Gross target volume (GTV), clinical target volume, and planning target volume (PTV) as well OARs including the small bowel, bladder, and femoral heads/necks were delineated in all 4 plans. In each case, small bowel and target volume were maintained to be identical (Table 1). Dose prescription and OAR tolerance doses were optimized in each case without any bias of the treatment option selection. The optimization constraints for PTV coverage were 100% to 95% volume. For small bowel, a maximum of 50 Gy was allowed; however, additional constraints of 5, 100, and 150 cm^3, to a dose less than 45, 40, and 35 Gy, respectively, were maintained.

Patient's body dimensional analysis was performed at the isocenter plane of the pelvic fields to account for possible changes in anterior-posterior and lateral dimensions of the pelvis for both the prone and supine patient setups. Patients had different prescribed dose, therefore, doses were normalized for comparison purposes between plans. Statistical analyses were conducted for maximum, minimum, and mean normalized dose to the GTV, PTV, and small bowel, respectively, using 2-tail paired analysis. The homogeneity index (HI) was

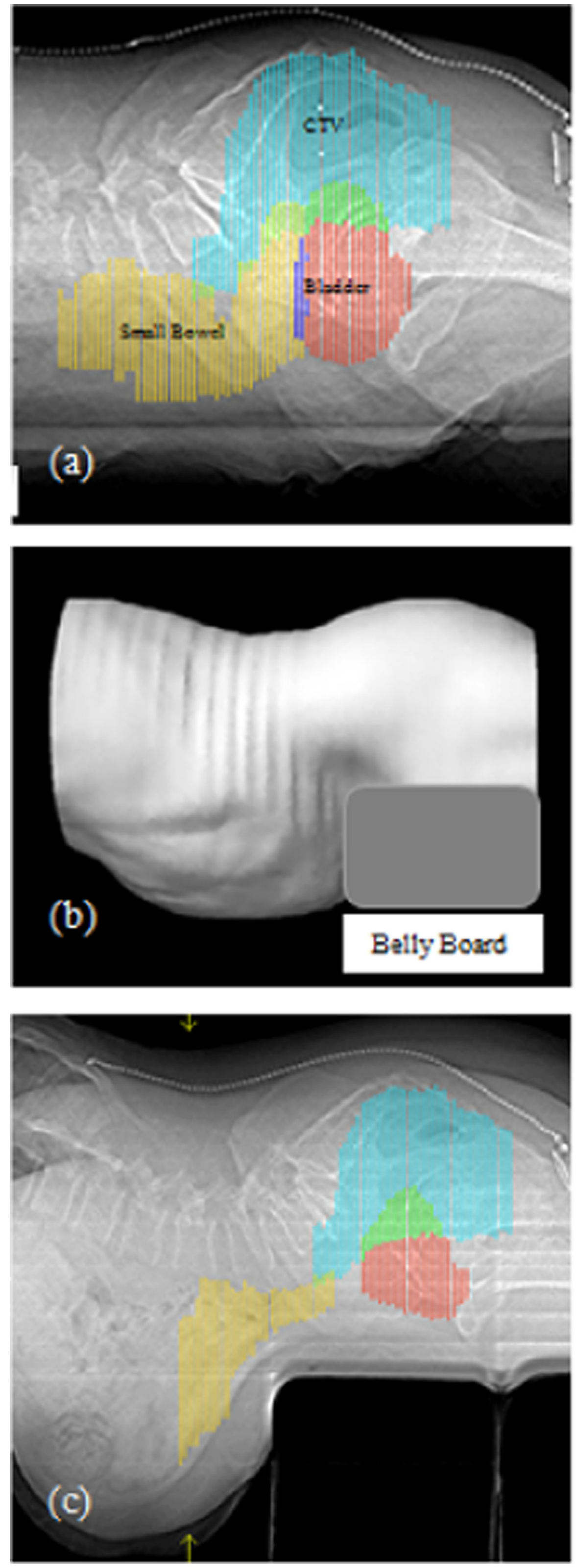

Fig. 1. Simulation of a patient in a prone position without (a) 3D view (b) and associated DRR (c) with belly board device, indicating small bowel movements. Color contours: yellow—small bowel, teal—CTV, red—bladder, green—overlap of CTV and bladder, and blue—overlap of small bowel and bladder are shown. Adapted from Das et al.[9] (Color version of figure is available online.)