RAPID COMMUNICATION

DAILY ELECTRONIC PORTAL IMAGING FOR MORBIDLY OBESE MEN UNDERGOING RADIOTHERAPY FOR LOCALIZED PROSTATE CANCER

LAURA ELLEN MILLENDER, M.D.,* MICHELE AUBIN, M.S.C.,* JEAN POULIOT, Ph.D.,* KATSUTO SHINOHARA, M.D.,† AND MACK ROACH III, M.D.‡

Departments of *Radiation Oncology and †Urology, University of California San Francisco, Comprehensive Cancer Center, San Francisco, CA

Purpose: We summarize our experience with a series of morbidly obese men treated using daily online portal imaging and implanted gold markers to guide external beam radiation therapy (EBRT).

Methods and Materials: Three consecutive morbidly obese men were treated with EBRT for localized prostate cancer. Daily electronic portal imaging was used to verify patient position. The magnitude and direction of patient positioning error were documented for each fraction.

Results: The absolute magnitude of positioning error was greatest in the left-right direction with a mean of 11.4 mm/fraction (median, 8 mm; range, 0–42 mm). Mean error in the superior-inferior direction was also substantial at 7.2 mm/fraction (median, 5 mm; range, 0–47 mm). Anteroposterior error was the least problematic with a mean value of 2.6 mm/fraction (median, 2.5 mm; range, 0–8 mm).

Conclusions: Daily electronic portal imaging combined with gold fiducial markers dramatically improves the precision of EBRT in the treatment of morbidly obese men with prostate cancer. Setup error rather than organ motion appears to be the dominant force in positioning error in obese men. © 2004 Elsevier Inc.

Obesity, Patient positioning, EPID, Radiopaque markers.

INTRODUCTION

Morbid obesity, defined as body mass index greater than 40, is associated with severe health complications and a twofold higher risk for all-cause mortality (1). The prevalence of morbid obesity in the United States has more than doubled over the last 10 years, with rates of morbid obesity in American men recently reported at 1.5–3% (1, 2). Given the incidence of prostate cancer in American men and the prevalence of morbid obesity, it can be expected that some men with prostate cancer will also be morbidly obese.

Treatment of this set of patients poses some unique challenges. These men are frequently not good candidates for general anesthesia, and surgical procedures such as radical prostatectomy and permanent or temporary brachytherapy are technically difficult. External beam radiation therapy (EBRT) is also challenging in obese patients. There are practical limitations of radiation therapy equipment such as table weight limits and computed tomography (CT) scan aperture limits. Daily setup is difficult because skin tattoos have increased mobility relative to bony structures, making them less reliable. Commonly used immobilization devices do not address lateral shifting of the lower abdomen, and standard weekly portal imaging fails to correct for daily patient positioning error. Ultrasound imaging is limited by user variability (3), and poor image quality is associated with increased distance from the abdominal surface to the isocenter and increased thickness of tissue anterior to the bladder (4).

Patient setup verification and correction based on bony anatomy with the use of an online portal imaging device has substantially reduced setup errors in the case of a 150-kg patient (5). Daily use of an electronic portal imaging device (EPID) in combination with implanted gold seed fiducial markers has been shown to be an accurate way to verify prostate position during EBRT (6–10) of the general prostate patient population. This option allows for correction of organ motion as well as daily setup error. We evaluated the daily patient positioning error in three consecutive morbidly obese patients using daily electronic portal imaging and gold seed fiducial markers to guide therapy.

METHODS AND MATERIALS

Three consecutive morbidly obese patients received EBRT for treatment of localized prostate cancer at the
University of California San Francisco between April 2001 and March 2003. All were entered as part of a prospective Internal Review Board–approved protocol to monitor organ motion and setup error using daily electronic portal imaging and gold marker seeds. All patients had T1 or T2 disease and Gleason scores less than or equal to 7. Maximum pretreatment prostate specific antigen levels ranged from 8.1 to 45.8 ng/mL.

All patients received EBRT in 180 cGy fractions to a prescription dose of 7200 cGy (maximum dose range, 7774–8000 cGy). All patients were treated with whole-pelvis fields followed by a cone down to the prostate and seminal vesicles and a boost to the prostate alone. Androgen-suppression therapy was initiated in all patients before radiation therapy and continued during radiation. Each patient underwent transrectal ultrasound-guided gold seed placement in the University of California San Francisco Department of Urology. Gold seeds were placed during radiation therapy before the first cone down in 2 patients and before the start of radiation therapy in 1 patient. One seed was placed in the prostatic apex and two seeds in the base for a total of three seeds per patient. Retrograde urethrogram and noncontrast CT scan were performed on each patient at the time of simulation. Three-dimensional treatment planning with Pinnacle software was used in all patients. Each gold marker (dimensions, 3 mm × 1.1 mm, Alpha Omega Services Inc., Bellflower, CA) was identified on the planning CT scans, contoured in the planning software, and clearly visible on digitally reconstructed radiographs, simulation films, and portal images.

Left lateral and anteroposterior (AP) portal images were acquired with 2 cGy each day before treatment using an amorphous silicon flat panel portal imager (11). The magnitude of patient positioning error was determined in three directions: superior-inferior (SI), left-right (LR), and AP. Bony landmarks were used to determine setup error on the whole pelvis field and gold seed markers were used to determine patient positioning error on the cone down and boost fields. Couch moves were made as necessary to align the pelvis or prostate appropriately within the treatment field. All moves were made by the radiation technologists under the guidance of the attending physician. The magnitude and direction of organ motion error was recorded as a separate endpoint in the patient with gold seeds placed before the start of radiation therapy.

RESULTS

On 80% of treatment days, a patient move was necessary to correct for positioning error. Patient moves were considered mandatory if the magnitude of error was greater than 4 mm in any one direction. For the majority of fractions, a patient move was required in one direction, but on 39% of treatment days repositioning was needed in two or more directions. The magnitude of setup error exceeded 20 mm on 20% of treatment days.

Table 1 summarizes the magnitude of patient positioning error in each direction. The most pronounced direction of positioning error was LR. Mean daily lateral error was 11.4 mm for all patients considered as a group. The median error was 8 mm, and the range was 0–42 mm. Error in the lateral direction exceeded 10 mm on 44% of treatment days, as shown in Fig. 1. SI positioning error was also large, with a mean of 7.2 mm per day, median of 5 mm, and range 0–47 mm. Most commonly SI error was less than 5 mm per day, but on 20% of treatment visits the magnitude of error in the SI direction exceeded 10 mm. AP error was the least problematic, with a mean of 2.6 mm and median of 2.5 mm. The magnitude of AP error did not exceed 10 mm on any treatment visit, and exceeded 4 mm only 23% of the time.

The nature and magnitude of positioning error for 2 patients are shown in Figs. 2 and 3. Figure 2 shows a sequence of portal images acquired immediately before treatment. These images were acquired using 18 MV photons and a 2 monitor unit exposure. The patient was positioned on the treatment couch using skin marks aligned with the treatment room lasers. The first image showed large setup error with no bony landmarks clearly identifiable within the radiation field. After correction, a second image showed SI setup error requiring the patient to be moved in the superior direction. During this translation, a new rotation error was introduced. This process was continued until adequate alignment was achieved, and only then was the patient treated. The global displacement of the isocenter between image 5 (correct position) and image 1 (original position based on skin marks) approached 5 cm. For subsequent fractions, the technologists learned to align the patient using two or three portal images per day. Before the prostate boost, three radiopaque markers were implanted to facilitate alignment and take organ motion into account. These markers were visible at all incidence angles using a 2 monitor unit exposure. Figure 3 illustrates the variability of positioning error in a different study patient over the course of treatment. Magnitude and direction of SI, LR, and AP error are documented for each of 40 fractions for a single patient.

Prostate organ motion was recorded as a separate endpoint for 1 patient. Gold seeds were placed before the start of radiation therapy in this patient. Bony anatomy and gold seeds were both visible on whole pelvis images, with three exceptions. Gold seeds were not visible on one
Fig. 1. Magnitude of patient positioning error by fraction in millimeters (mm) for all patients.

Fig. 2. Sequence of portal images acquired prior treatment delivery with corresponding simulation image for comparison.
AP and 14 left lateral cone down and boost images. Mean magnitudes of organ motion in the SI, LR, and AP directions were 1.4, 1.8, and 1.5 mm/fraction, and median magnitudes of organ motion were 1, 2, and 1 mm/fraction, respectively. Because bony anatomy and gold seeds were not visible on each image, it was impossible to determine organ motion for each fraction.

No patient experienced any Grade 3 toxicity from seed placement or radiation therapy. The reported side effects of seed placement were mild to moderate discomfort at the time of the procedure and minor rectal bleeding less severe than that commonly seen with prostate biopsy. The reported side effects of radiation therapy were mild and included loose stools and increased urinary obstructive symptoms. Prior studies have suggested that significant seed migration should not be expected during radiation therapy (9), and no obvious seed migration was seen in this patient group, although this was not specifically evaluated as a separate endpoint. Total daily treatment time using this technique is estimated to be 20 min.

**DISCUSSION**

Setup error in men receiving radiation therapy for treatment of prostate cancer has been previously documented to average 1–4 mm/fraction (6, 7, 10, 12). The results of this study clearly demonstrate that setup error in the SI and LR directions in morbidly obese men substantially exceeds these average values. Maximum expected daily prostate organ motion ranges from 1.7 mm/fraction in the LR direction to 4.5 mm/fraction in the AP direction (7), and in the majority of prostate cancer patients, prostate organ motion error exceeds setup error (6). In contrast to the average prostate cancer patient, setup error rather than organ motion appears to be the dominant force in positioning error in obese men.

The use of daily electronic portal imaging is beneficial for proper positioning of morbidly obese prostate cancer patients. Error correction based on bony landmarks is adequate for whole pelvis fields where multiple bony structures can be visualized. When small volumes are treated with conformal plans, implanted gold seed markers become important for proper patient positioning. Gold seed markers are more clearly visible than bony landmarks in small portal images, and they allow for the simultaneous correction of setup error and organ motion error. Implanted gold marker seeds maximize the potential benefit of daily on line portal imaging.

Proper patient positioning is critical to gain maximum benefit of modern treatment planning techniques such as three-dimensional conformal and intensity-modulated radiation therapy. Because of practical anatomic limitations it is doubtful that ultrasound-based approaches will be suitable solutions in this patient population. Given the low risks of this method of treatment and the substantial amount of setup error now documented in this group of patients, the daily use of EPID in combination with gold marker seeds should be strongly considered in all morbidly obese men receiving radiation therapy for treatment of prostate cancer. This technique clearly has the potential to be more broadly applied, but additional studies should be done before specific recommendations can be made. These findings are so compelling that we felt it was important to make the radiotherapy community aware of this potential problem despite the small sample size of this study.
REFERENCES


