Variation of Clinical Target Volume Definition among Japanese Radiation Oncologists in External Beam Radiotherapy for Prostate Cancer

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Background: We investigated the interobserver variation in the prostate target volume and the trend toward the use of diagnostic computed tomography (CT) or magnetic resonance (MR) images for treatment planning.

Methods: Twenty-five radiation oncologists were asked to draw the external contour of the prostate on CT images (0.3 cm spacing) of a patient with localized prostate cancer. They also answered a questionnaire regarding the use of diagnostic CT or MR images for the contouring.

Results: Of the 25 physicians, 28% rarely or never referred to the diagnostic CT images. In contrast, the physicians tended to refer to the MR images more frequently. Approximately 50% of the physicians believed in the usefulness of contrast-enhanced images for the delineation of the prostate. As for the variation of the prostate contouring, the median cranio-caudal prostate length was 36 mm (range, 21–54 mm), and the median prostate volume was 43.5 cm³ (range, 23.8–98.3 cm³). The interobserver variability was not significant in the duration as a radiation oncologist, the board certification status as radiation oncologists, and the number of treatment plans developed for prostate cancer during the last 1 year.

Conclusion: A wide variety of the definitions of the prostate was found among Japanese radiation oncologists.

Key words: radiation oncology – urologic-RadOncol – radiology-CT/MRI

INTRODUCTION

Three-dimensional conformal radiotherapy (3DCRT) is used in many institutions for the treatment of localized prostate cancer in Japan (1,2). As 3DCRT can decrease the incidence of normal tissue toxicity, the dose delivered to the tumor can be higher than the dose delivered with conventional techniques for the same complication rate. Dose-escalation studies in patients with prostate cancer have been reported to improve the biochemical relapse-free survival rates (3,4). The radiation doses employed in Japanese institutions have also been increasing (1,2,5). To achieve a good treatment result, ensuring adequate coverage of the target area remains necessary.

Currently, one of the most important challenges for 3DCRT is the accurate delineation of tumor and target volumes (6). Several studies have shown marked
interobserver variability in target volume definition for prostate cancer (7–9). However, there have been few reports on this type of study among Japanese radiation oncologists.

This study aimed to investigate the interobserver variation in the prostate target volume among Japanese radiation oncologists. In addition, we evaluated the trend toward the use of diagnostic computed tomography (CT) or magnetic resonance (MR) images for treatment planning.

MATERIALS AND METHODS

Twenty-five radiation oncologists, who attended the 18th Annual Meeting for Radiation Oncologists in Kyushu, were enrolled in this study. The characteristics of the physicians were as follows: the median period of their career as a radiation oncologist was 8 years (range, 1–36 years) and 12 physicians (48%) were board-certificated radiation oncologists. All but one physician had experience with CT-based 3DCRT. The numbers of treatment plans for prostate cancer developed during the last 1 year were: 0–9, eight physicians (32%); 10–19, eight physicians (32%); 20–39, six physicians (24%); and >40, three physicians (12%).

The sample questionnaire for the contouring of the prostate is included in the Appendix. Briefly, it consisted of two sections: (1) questions regarding the use of diagnostic CT or MR images for the contouring; and (2) the sample CT images of a patient with localized prostate cancer for the delineation of the prostate.

The CT images were obtained using a Mx8000 (Philips Medical Systems, Andover, MA, USA). The CT data set (0.3 cm spacing) was from a patient with localized prostate cancer, who was treated by 3DCRT. This patient was considered to be typical, with an average prostate shape and size.

For the delineation of the prostate, 25 physicians were asked to draw its outline as the clinical target volume (CTV) directly on a high-quality hard copy (Appendix). The craniocaudal prostate length was calculated from the number of slices contoured multiplied by the slice thickness. The volume of the typical CTV outline of the prostate was calculated using three-dimensional treatment planning software Eclipse (Varian, Palo Alto, CA, USA). For the calculation of the prostate volume, the contours of the prostate were cut away from the hard copy, measured on a high-precision electrical balance (Sartorius BP211D, Goettingen, Germany), and compared with the weight of the typical CTV volume.

The Student’s t-test was used to compare means. A P value <0.05 was considered to indicate a statistically significant difference.

RESULTS

The trend toward the use of diagnostic CT and MR images for the contouring is shown in Fig. 1. Of all physicians, seven physicians (28%) rarely or never referred to the diagnostic CT images. In contrast, the physicians tended to refer to the MR images more frequently. As for the contrast-enhanced CT or MR images, approximately 50% of the physicians believed in the usefulness of contrast materials for the delineation of the prostate (Fig. 2).

The interobserver variation of the CTV delineation is shown in Fig. 3. The median craniocaudal prostate length and CTV volume were 36 mm (range, 21–54 mm) and 43.5 cm³ (range, 23.8–98.3 cm³), respectively. Although the board-certificated radiation oncologists tend to contour the prostate with smaller variability, the interobserver variation was not significant with regard to the duration as a radiation oncologist, the board certification status as radiation oncologists, and the numbers of treatment plans developed for prostate cancer during the last 1 year (Figs. 4–6).

DISCUSSION

The interobserver differences in the target volume definition for prostate cancer have been investigated. Livsey et al. (8)
reported that statistically significant differences were found in the CTV delineation among five experienced radiation oncologists, in agreement with the findings of other studies (7,9). Our study also showed the wide range of the prostate volume definition among Japanese radiation oncologists.

There has been considerable discussion in the literature regarding the relative merits of the various imaging modalities used to decrease the variation of the contouring in patients with prostate cancer. In particular, because MR improves soft tissue contrast between the prostate and surrounding tissues, attempts have been made to minimize these differences among observers by the use of MR images. Roach et al. reported that there was a tendency to overestimate the prostate volume by non-contrast CT compared with MR (10). Other works in the literature support this conclusion (11). In this study, most of the physicians referred to the MR images for the contouring of the prostate.

The use of contrast medium is also reported to produce smaller intraobserver variability. Zhou et al. (12) suggested that intravenous contrast appears to be of substantial benefit in visualizing the interface between the bladder and prostate gland. Valicenti et al. (7) showed that retrograde urethrography could increase the interobserver agreement in defining the prostate, because of urethral and bladder opacification. However, MR has several advantages compared with CT, improved soft tissue contrast between the prostate, rectum, and pelvic floor muscles and the ability to make possible a better definition of the prostatic apex. In addition, the interobserver variability could be improved, permitting observers to view the reconstructed sagittal and coronal images. The usefulness of contrast medium should be carefully evaluated in the future.

The present study revealed a large difference in the prostate volume definition among Japanese radiation oncologists. One of the reasons may be that the observers were blinded for the MR data in this study. In addition, in treatment planning systems, the observers are allowed to optimize image contrast by changing the window and level settings, to zoom and to scroll through the data set. Furthermore, some physicians who were not well experienced in prostate contouring were involved in this study. In actual treatment planning, there might be better agreement among multiple experienced physicians to define the prostate target volume.

Figure 3. Variation of the definition of the prostate among 25 radiation oncologists.

Figure 4. Variation of the prostate definition according to the duration as a radiation oncologist.

Figure 5. Variation of the prostate definition according to the board certification status as radiation oncologists.

Figure 6. Variation of the prostate definition according to the numbers of treatment plans developed during a year.
It is not clear whether the existence of these interobserver differences adversely affect the toxicity for the organs at risk. Steenbakkers et al. (13) showed that the dose delivered to the rectal wall and bulb of the penis was significantly reduced with treatment plans based on the MR-delineated prostate compared with the CT-delineated prostate. On the other hand, Livsey et al. (8) reported that the interobserver variation was the smallest at the rectal–prostate interface and that it also did not result in clinically relevant outcomes with respect to the irradiated volume of the rectum and bladder. In addition, contouring uncertainty should be combined with setup and organ motion uncertainties that generally may be expected to be more important. However, the increasing use of intensity-modulated radiotherapy (IMRT) provides a method of producing even greater conformity in dose distribution. The ability to accurately identify the target volume may be critical in the near future.

In summary, the present study revealed the wide variety of definitions of the prostate among Japanese radiation oncologists. Because of interobserver variations, we should keep in mind that quality assurance programs should include an evaluation of interobserver variations and should take an effort to minimize their impact in clinical studies of external beam radiotherapy for prostate cancer.

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Conflict of interest statement

None declared.

References


Appendix: Survey of the Contouring of the Target Volume in External Beam Radiotherapy for Prostate Cancer

1. Do you refer the diagnostic CT images for the contouring of the prostate?
   (1) Always (100%); (2) Usually (80–100%); (3) Sometimes (30–70%); (4) Rarely (<30%); (5) Never (0%).
2. Do you think contrast-enhanced CT images are useful for defining the prostate?
   (1) Useful; (2) Not useful; (3) No idea.
3. Do you refer to the diagnostic MR images for the contouring of the prostate?
   (1) Always (100%); (2) Usually (80–100%); (3) Sometimes (30-70%); (4) Rarely (<30%); (5) Never (0%).
4. Do you think contrast-enhanced MR images are useful for defining the prostate?
   (1) Useful; (2) Not useful; (3) No idea.
5. Outline the prostate only without seminal vesicles as the CTV. In the actual planning, the planning target volume will conform to the CTV plus approximately a 1.0 cm margin. Additional field and block margins will be placed to account the field edge effect of dose build-up.