Dosimetry Effects from Variable Rectal Gas Volume during Prostate Radiation Treatment Course

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Background
Changing rectal volume due to unpredicted gas distention during a therapy course can pose a decision-making dilemma for treatment personnel when executing IGRT for individual patients with prostate cancer. In this retrospective case study of a patient found to have frequent occurrences of rectal gas distention, dose coverage for the prostate was analyzed with sequential CBCT studies in order to determine if clinical intervention to mitigate rectal distention was necessary.

Methods
A prostate cancer patient found to have fluctuating rectal gas distention during his IGRT treatment course underwent at least 11 “routine” CBCT procedures, prompting therapists to consult with physicians frequently. The treatment setup was based on the orthogonal pair of KV images, using gold fiducial markers inserted permanently inside the prostate beforehand. CBCT images were analyzed to evaluate the bladder volume and rectal gas volume (RGV). The total RGV was measured around the treatment area (from 1 cm above to 1 cm below the PTV slice). By mapping the gas volume images obtained from 11 CBCT series onto the initial treatment planning CT, the original VMAT beam fluence arrangement was implemented to determine the resulting dose distributions. Varian Eclipse V11 with AAA algorithm was used for the dose calculations. These 11 dry-run plans were used to compare with the original plan. The prostate DVH parameters (i.e. V100%, Dmin), Paddick Conformality Index (PCI) and iso-dose distribution changes were analyzed as functions of the changing RGV.

Results
The daily RGV fluctuated with a range between 4.1 cc and 47.5 cc. Two plans with RGVs of 4.1 cc and 4.3 cc showed no significant changes in all the dosimetric parameters evaluated. When the RGV is more than 10cc, the 100% isodose line retracted back into the original prostatic boundary, up to 5.0 mm in its widest linear distance. On average, the 100% isodose line retracted back by 2.5±1.2 mm. In the worst case, the gas volume was located on the interface of rectum and prostate, and the total gas volume was 47.5 cc. The DVH dose distribution showed that V100% was reduced up to 0.75%. The Dmin of the prostate PTV was reduced up to 1.9%, while PCI was reduced up to 1.2%.

Conclusion
This study shows that a patient’s RGV may change the prostate PTV dose distribution significantly enough to warrant clinical intervention only if the gas volume is sufficiently large and if the location of rectal gas distention is close to the prostate/rectum interface. Such phenomenon may be of particular concern for prostate SBRT or hypofractionated treatment regimens. With the conventionally fractionated scheme, the overall tumor control outcome may not be affected significantly from a few fractions of widely variable rectal volume distention.