

Correlating tissue toxicities with EUD and NTCP for metallic prosthesis prostate cancer patients in proton therapy

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Abstract

Purpose: The main purpose of this study is to evaluate the clinical, dosimetric, and radiobiological results of three complex prostate cancer cases treated with uniform scanning proton therapy. All three prostate cancer patients had undergone metallic hip replacement prior to proton therapy. **Methods:** Each case was treated using three fields (2 oblique fields and 1 lateral or slightly angled field) for a total dose of 79.2 Gy (RBE), and proton beam through the metallic prosthesis was avoided. Normal tissue toxicities were assessed per the Common Terminology Criteria for Adverse Events (CTCAE) v4.0. Dosimetric results were analyzed based on the dose-volume histograms (DVH). Radiobiological modeling response evaluation of normal tissues was done by calculating tissue complication probability (NTCP) based on equivalent uniform dose (EUD). The average follow-up was 18.2 months. **Results:** All three patients experienced acute Grade 2 urinary toxicity, with bladder NTCP of 0.88%, 0.15%, and 0.36% and bladder V_{70} of 14.8% (15.8 cc), 7.1% (31.1 cc), and 14.3% (10.3 cc) in the first, second, and third cases, respectively. For the bladder, the V_{50} ranged from 13.7 to 38.7%, and the EUD ranged from 48.84 to 57.65 Gy (RBE). One patient (case 1) experienced acute Grade 1 rectal toxicity with rectal NTCP of 0.67%, whereas the other two cases did not experience any gastrointestinal toxicity (rectal NTCPs of case 2 and 3 were 0.08% and 0.06%, respectively). Additionally, the rectal EUD was higher in case 1 (50.34 Gy (RBE)) when compared to the results in cases without the incidence of gastrointestinal toxicity (41.38 Gy (RBE) in case 2 and 40.10 Gy (RBE) in case 2). The rectal V_{70} was about 11% in case 1, whereas it was less than 4% in cases 2 and 3. Cases 1 and 3 developed Grade 1 hip toxicity (pain) with femoral NTCPs of both the cases below 0.01%. The mean femoral doses were 30.49, 33.68, and 13.22 Gy (RBE), and the femoral EUDs were 18.43, 18.69, and 14.37 Gy (RBE) for cases 1, 2, and 3, respectively. One patient (case 1) experienced acute Grade 2 erectile dysfunction. None of three cases evaluated in this study experienced Grade ≥ 2 gastrointestinal toxicity, Grade ≥ 3 urinary toxicity, and hip fracture. **Conclusion:** The uniform scanning proton therapy can be used to treat the prostate cancer patients who have undergone metallic hip replacement. Both the dosimetric results and normal tissue toxicities were found to be acceptable. The EUD and NTCP parameters can potentially be correlated to the normal tissue toxicities by including clinical data from a large number of cases. The preliminary results from this study indicate that the rectal NTCP $\geq 0.67\%$ can develop acute Grade ≥ 1 rectal toxicity. The bladder NTCP $\geq 0.15\%$ will most likely cause acute urinary toxicity.

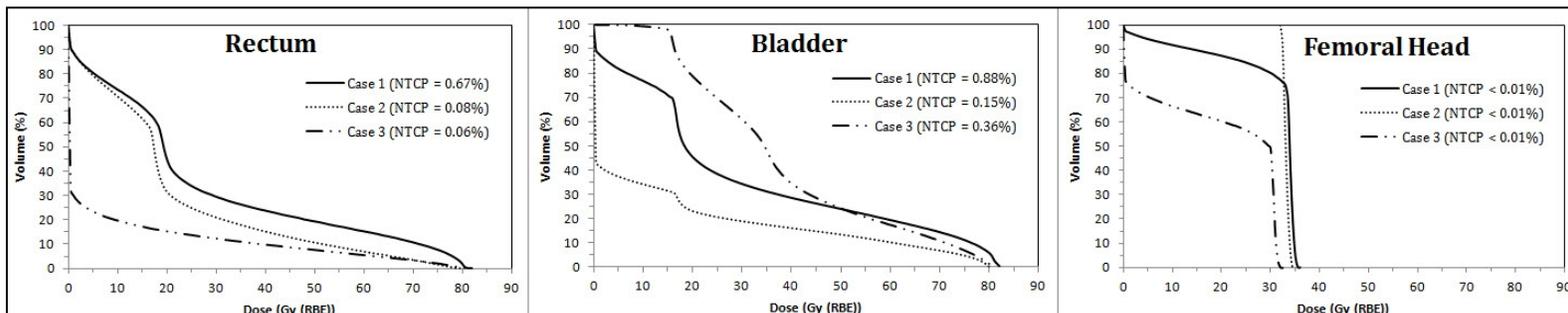


Figure 1: DVHs and NTCPs of the rectum, bladder, and femoral head in 3 unilateral metal hip prosthesis prostate cancer patients.