Evaluation of dose perturbations for metal stent in photon and proton radiotherapy planning for hepatocellular carcinoma

Hyeyoung Kim, Boram Lee, Sungkoo Cho, Sang Hoon Jung, Youngwhi Lim, Do Hoon Lim, Hee Chul Park

Department of Radiation Oncology, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, South Korea

Purposes & Objectives

This study was conducted to evaluate and apply dose influence of metal stent in photon and proton radiotherapy planning for hepatocellular carcinoma.

Methods

Dose perturbations were evaluated by Monte Carlo simulation and Planning system in photon and proton. Computed tomography (CT) data sets of 1.25 mm slice thickness were obtained with containing metal stent in water equivalent solid phantom. The plan with and without metal stent consisting of nickel and titanium base alloys (Nitinol) was performed. We used Truebeam (Varian Medical System) and of Pinnacle³ (Version 9.10, Philips Medical System) treatment planning system in photon and proton therapy system of Sumitomo Heavy Industries Ltd., and RayStation (Version 6, RaySearch Laboratories) treatment planning system in proton for dose calculation. The photon plan test are designed in an anterior-posterior/posterior-anterior (AP/PA) field technique using 6MV energy and proton plan are designed in an anterior-posterior/posterior-anterior (AP/PA) field of Wobbling beam using 150 MeV energy and 10 cm ridge filter. The Monte Carlo simulation was programed under same conditions for beam parameters, solid water phantom and metal stent of radiotherapy planning system and we compared the calculated dose distribution effects as with and without metal stent. The Monte Carlo was calculated using Geant4(v10.3) and GATE(v8.1).

The two types of stents were used for bile ducts and intestinal tract in order to confirm the effect of size on the stent. And the stents were compared at 0°, 45° and 90° in order to apply the angular effect.

Results

The thickness of the metal stent is about 0.1 mm. The stent appears blurred in the image because the stent is smaller than the size of the detector used in CT. In RTP, it was confirmed uncertainty for dose calculation that the image blurring of stent in CT can reconstruct the density of 1.08 ~ 1.3 g/cm3, which is much smaller than the actual density of 6.8 g/cm3. The treatment planning system cannot calculate dose perturbations due to stents. In the calculation of dose using Monte Carlo, dose enhance effect of photon was ~0.3 ~ 3.7 % depending on the stent size due to multi scatter. In the proton, a dose increase of 0.7 ~ 4.3% was observed depending on the position of the stent. The above results were analyzed based on the maximum dose. It was also analyzed that the minimum dose was reduced by the dose shadow effect in the proton.

Conclusion

Our study was performed to evaluate the uncertainty of dose calculations that could be caused by stents in radiotherapy planning and to apply them in clinical practice. In the Monte Carlo calculation, dose perturbations of 3.7% and 4.3% were observed with the use of metal stents in photons and proton. We confirmed the effect of dose change by metal stent through dose calculation and simulation. In case of RTP used in clinical practice, we can recommend to replace stent density to the average HU value of the surrounding normal tissue considering dose uncertainty by image blurring of stent that metal stent is not reflected in the planning system.