Monte Carlo Simulations for Stereotactic Radiotherapy System with Various Kilo Voltage X-ray Energy

HM Deloar[1,2)], E Kunieda[1)], T Kawase[1)], H Saitoh[3)], M Ozaki[4)], T Fujisaki[5)], A. Myojoyama[3)], K. Saito[6)], S Takagi[7)], O. Sato[7)], and Atsushi Kubo[1)]

1) Department of Radiology, Keio University, Tokyo, Japan
2) CREST, Japan Science and Technology Agency, Tokyo, Japan
3) Department of Radiological Sciences, Tokyo Metropolitan University of Health Sciences, Tokyo, Japan
4) CT Systems Division, TOSHIBA MEDICAL SYSTEMS CORPORATION, Japan
5) Department of Radiological Sciences, Ibaraki Prefectural University of Health Sciences, Ibaraki, Japan
6) Center for Promotion of Computational Science and Engineering, Japan Atomic Energy Research Institute
7) Safety Engineering and Technology Department, Mitsubishi Research Institute, INC, Japan

Abstract

Stereotactic Radiotherapy (SRT) of lung tumors with a narrow and precise medium energy x-ray beam where the homogeneous high dose area will be confined within the tumors are desirable. A conventional x-ray CT with medium energy x-ray has been modified to develop a radiotherapy system for lung SRT. A cylindrical collimator (0.3 cmϕ) made of tungsten was introduced to collimate the X-ray beam. The system was simulated with BEAMnrc(EGS4) Monte Carlo code and various x-ray energy spectra were generated to investigate the dose distributions with our kilo-voltage SRT system. Experiments were performed to acquire the energy spectra of 100, 120 and 135 kV from CT measurements and those results were compared with the spectra obtained from Monte Carlo simulations. Verifications of percentage of dose depth (PDD) for 120 and 147.5 kV were investigated in a water phantom with experiments and Monte Carlo simulations. Finally dose distributions of 120, 135, 147.5, 200, 250, 300, 350, 400, 500 kV spectra were investigated with lung phantom and human lung. The Percentage of Depth Dose (PDD) in the water phantom calculated from the experimental and simulated spectra of 120 and 147.5 kV show good agreement with each other. The PDD of 147.5 and 120 kV spectra at 9 cm depth was approximately 10% and 9%, respectively. Dose distributions around the lung tumor in the phantom and human for all x-ray energies were almost uniform but in the case of the human lung absorptions of dose at ribs for the energy lower than 135kV was more than 35% and those absorptions for the energy spectra of 147.5 kV and above was less than 30%. This absorption gradually decreases with increasing x-ray energies. Uniform dose distributions in the lung region of human and thorax phantom demonstrated the possibility of SRT system with medium energy X-ray. A detail performance of this system as a kilo-voltage conformal radiotherapy is under investigations.