Assessment of secondary cancer risk for patients treated with BNCT

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Boron neutron capture therapy (BNCT) has advantages in the treatment of head and neck tumors, and is based on the nuclear reaction of boron-10 nuclei delivered to tumor cells and neutrons giving rise to high-LET alpha particles and lithium ions whose path length is approximately one cell diameter [1]. Besides the dose deposited in tumor, BNCT also deposite dose in healthy organs, which may lead to secondary cancer. With more and more attention are paid to the side effects caused by radiotherapy, for cancer survivors, especially for adolescents with long life expectancy, the secondary cancer risk in organs cannot be ignored. This paper mainly investigates the secondary cancer risk in healthy organs when adolescent brain tumor patients is treated with BNCT. The concerned organs are the organs with high cancer incidence in China. The equivalent dose of tumors and organs were obtained by the Monte Carlo method and the radiation computational phantom with Chinese physiological characteristics [2]. The secondary cancer risk in organs was assessed according to the Lifetime Attributable Risk (LAR) factor in the BEIR VII report [3]. Three irradiation geometries are adopted, i.e., RLAT (right lateral), TOP and PA. For the RLAT geometry, the beam is located 10 cm right from the head. For the TOP geometry, the beam is located 10 cm above the head. For the PA geometry, the beam is located 10 cm behind the head. Based on these, the effects of neutron irradiation geometry (RLAT/TOP/PA), tumor depth (3/4/5/6 cm) and patient age and gender (10- and 15-year-old male and female patients) on the secondary cancer risk are explored in this study. The tumor was located on the right side of brain with 2 cm diameter and 6 cm depth. The dose to 95% of tumor volume is 20 Gy, and the maximum dose of organs at risk cannot exceed the dose limitation. The results showed that the risk of secondary cancer in most concerned organs of TOP geometry was higher than the two other geometries. This is because most organs are directly exposed to the incident neutron beam under TOP geometry, and the equivalent doses are higher. The total risk of secondary cancer is the lowest under the PA geometry. Under the PA geometry, the results showed that as the tumor depth increased, the equivalent dose and risk of secondary cancer of the organs will increased since the prelonged treatment time. The risk of secondary cancer in healthy organs of both male and female patients would decrease with the age, which may be related to the shorter life expectancy of the older patients. The risk of secondary cancer in most organs of female patients is higher than that of male patients of the same age, it is mainly because the β values in the LAR formula is higher in female patients than male patients, and can also be related to the height and the body thickness of the patients. From the perspective of secondary cancer, these findings provide reference about the secondary cancer risk for the clinical application of BNCT.

References

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