VITA™ Accelerator Neutron Sources: Capabilities and Research Results

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Background / Objective: To develop an accelerator neutron source suitable for boron neutron capture therapy – a new promising method for treating malignant tumors, and to develop dosimetry tools and methods.

Methods: Research into the transport and acceleration of a beam of charged particles, development and manufacture of an accelerator neutron source, and study of the radiation generated.

Results: A facility called VITA has been created, which includes a tandem electrostatic accelerator of an original design for producing a 2.3 MeV 10 mA proton beam, a lithium target for generating neutrons in the $^{7}Li(p,n)^{7}Be$ reaction, and a beam shaping assembly for forming a therapeutic neutron beam. Also, tools and methods for measuring the boron dose, γ-ray dose, and sum of the fast neutron dose and the nitrogen dose have been proposed and created. The conducted studies demonstrated the high efficiency of the VITA facility, the possibility of implementing the prompt γ-ray spectroscopy for boron imaging, the possibility of implementing lithium neutron capture therapy, which has advantages over BNCT, and also presented the results of the development of tools and methods for measuring the boron dose, γ-ray dose, and the sum of the fast neutron dose and the nitrogen dose.

Two VITA-II neutron sources made for oncology clinics. The first source (NeuPex; VITA-IIα) was delivered to the Xiamen Humanity Hospital (Xiamen, China) and is used for clinical trials. The second source VITA-IIβ was delivered to Blokhin National Medical Research Center of Oncology (Moscow, Russia), where clinical trials will soon begin. Experience gained from operating slightly different neutron sources has allowed the development of a third version VITA-III, which is distinguished by the use of a more compact gas stripper and the use of pre-decelaration instead of pre-acceleration of the injected ion beam. This will make it possible to obtain a parallel beam of protons and eliminate the need for a high-voltage platform, an isolating transformer, and a number of focusing devices.

Conclusion: The authors strongly recommend using the prompt γ-ray spectroscopy in treatment, developing lithium neutron capture therapy, including in combination with BNCT, and note the high efficiency, reliability and compactness of the VITA facility.

Keywords: Neutron capture therapy; charged particle accelerator; lithium target; neutron source