PAN-1: Feasibility Study of the First Boron Neutron Capture Therapy Centre in Canada Using Prototype Compact Accelerator-based Neutron Source

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Introduction: All our knowledge about Boron Neutron Capture Therapy (BNCT) in about 60 years since its hypothesis is from researches done in Nuclear Research Reactors (NRRs). The cost and scarcity of NRRs limited the conduction of large clinical trials. Accelerator-based BNCT (AB-BNCT) are needed to expand the research. Canada used to be the world leader in radiation technology when the world's first cancer treatment with Cobalt-60 took place in London, Ontario in 1951. It is time for us to rejoin the research in innovative radiation oncology by developing the first BNCT Centre in Canada. The purpose of this paper is to conduct a literature review and assess the current status of the BNCT technique around the world with emphasis on feasibility of BNCT using compact accelerator-based neutron source (CANS).

Prerequisites for building BNCT centre: Canada recently closed its major neutron source that was accessed by a community of about 800 researchers. A replacement prototype CANS has been planned for proposed research in materials development, Small-Angle Neutron Scattering (SANS) diffractometer, archaeology, and BNCT. The present proposal's precursor project was funded by the New Frontiers in Research Fund Exploration Grant (NFRFE-2018-00183). A team of national and international experts has been formed to conduct an extensive computational neutronic study exploring low-cost designs for a CANS target-moderator assembly. We have established cell lines and animal models to test Boron agents and then radiobiology of BNCT in preclinical trials in biochemical lab at University of Windsor (UWin). Radiation oncologist and biomedical scientist within Windsor Cancer Research Group (WCRG) have agreed to work together to evaluate in vitro and in vivo tumor response to BNCT, neutron dosimetry, and boron concentration measurement before we start phase I and phase II clinical trials for suitable cancer patients.

Facility design and treatment planning system (TPS): There are at least four companies marketing complete systems of AB-BNCT, i.e. Neutron Therapeutics (NT), Sumitomo Heavy Industries (SHI), TAE Life Sciences (TAE), and Neuboron Medtech Ltd. SHI's NeuCure is the first one to obtain approval from the Ministry of Health in Japan to start routine BNCT for head and neck cancer in March 2020. NT has constructed nuBeam in Finland and Japan and is expected to be approved as medical equipment as well. Both are supported by TPS from RayStation. At present, 14 AB-BNCT facilities in 8 countries are using cyclotrons, electromagnetic or electrostatic LINAC. Half of them are in Japan and most are still under construction.

Organization, operation and management of BNCT centre: Our prototype CANS will be located at UWin campus which is within 10-minute drive to Windsor Regional Hospital (WRH) with a large regional cancer program treating over 1600 new cancer patients with radiotherapy per year. The positron emission tomography (PET) scanner at WRH will help develop routine Boron concentration measurement protocol, using ^{18}F-BPA PET. Staff from both UWin and WRH will organize and manage the new BNCT centre. There is close collaboration between WRH and UWin after the formation of WCRG in 2011.

Funding: A NFRF-Transformation grant up to $24 million in 6 years is being applied to make CANS available within the next 2 to 4 years (NFRFT-2020-00021). This grant will cover all neutron applications including BNCT. It also covers the cost of preclinical and clinical trials. UWin will provide funding for the building that houses CANS up to another $10 million.

Conclusions: There is great interest to use CANS as the neutron source of BNCT and share it with Canadian neutron researchers for other studies. Good support from multiple institutions and universities across Canada has been well received. Neutron beam design activity will start as soon as the grant is available and be ready for pre-clinical use after CANS is developed in 2 to 4 years. It is feasible to build the first BNCT Centre in Canada using CANS. Our interdisciplinary research will help move BNCT toward approval as a clinical technique in Canada.