

BALCERZYK-1: Quantification of boron compound concentration for BNCT in preclinical Positron Emission Tomography
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The quantification of boron concentration is essential in the planning of Boron Neutron Capture Therapy to reach the required 2 mM ^{10}B concentration in the tumour. The well-known BNCT patient treatment method using boronophenylalanine (BPA) as boron-carrying agent utilizes ^{18}F fluoroBPA (^{18}F FBPA) as an agent to qualify for treatment. Precisely, ^{18}F FBPA must have at least 3:1 tumour to background tissue ratio to qualify the patient for BNCT treatment.

To quantify boron concentration in the tumour, we have recalculated our old preclinical data of ^{18}F NaBF₄ PET study in thyroid and pituitary cancer and hyperplasia model in the rat (<http://doi.org/10.1093/jico/hyx189>). Thyroid and pituitary glands actively transport iodine into its cells using sodium-iodine symporter (NIS). Incorporated iodine is used to produce iodine-containing hormones in the thyroid.

The production of ^{18}F NaBF₄ PET tracer is based on isotope exchange in precursor ^{nat}F NaBF₄ which exchanges ^{nat}F with ^{18}F from proton-irradiated ^{18}O H₂O. In this case, the processing was heating at 120 deg. C for 10 min. Knowing the initial concentration of NaBF₄ and activity of ^{18}F NaBF₄ at the end of synthesis we can calculate the concentration of boron in the tumour from a PET study.

In preclinical case of rat thyroid hyperplasia 41 MBq, 41 pmol of ^{18}F NaBF₄ PET tracer was injected into the tail vein. After 17 min the peak activity in the thyroid reached 2.3 MBq/mL (9 SUV). Knowing that the injected dose contained 0.351 mM, 53 nmol of NaBF₄, we could calculate that the ^{nat}B concentration in the thyroid with hyperplasia reached 0.38 mM. Consequently, this incorporation would require additional 504 mg/kg dose of ^{10}B NaBF₄ to reach the necessary 2 mM ^{10}B concentration in the tumour. The transport through NIS is limited by IC₅₀ (half-maximal inhibitory concentration) of 1.6 μM of this symporter. This limiting factor of boron incorporation needs to be further studied to find the additional boron dose. 10 mM concentration of BF₄⁻ is not toxic to the cells. The activity ^{18}F NaBF₄ dropped to 70% in the thyroid after 90 min, which allows for BNCT treatment.

As a proposal, an immediate application of this method is in BNCT treatment of thyroid cancer. Contrary to ^{131}I used now, there is no post-treatment radioactive decay, the patient can be immediately discharged from hospital and there is no 6-month moratorium for pregnancy.

As a remote application, this method can be used for BNCT treatment compounds of the type R-BF_n where 1 ≤ n ≤ 3. They can be labelled with ^{18}F relatively easy as in our example. A patient may undergo injection of a mixture of non-radioactive R-BF_n to reach the required 2 mM ^{10}B concentration for BNCT treatment in the tumour together with ^{18}F R-BF_n for the last-minute update of the tumour state with PET to verify the extent.