The effect of field size on neutron dose equivalent around the target in proton beams

Maite Romero-Expósito[1,2], Alexandru Dasu[1,3]

[1]The Skandion Clinic, Uppsala, Sweden. [2]Oncology Pathology Department, Karolinska Institutet, Stockholm, Sweden. [3]Medical Radiation Sciences, Department of Immunology, Genetics and Pathology, Uppsala University, Uppsala, Sweden.

ESTRO 2023

Background

Neutrons are a concern for proton beam therapy (PT) due to their high radiobiological effectiveness and the risk for second cancer induction. Neutron dose calculation is not straightforward and therefore studies are carried out to find simple ways for calculating neutron production in PT. Simulations and measurements of proton beam scanning therapy have suggested a linear relation between H*(10) and the field for the neutron field around the patient (1).

Purpose

The objective of this work is to test the linearity assumption inside the patient as it could be useful to develop a simple general analytical model for the evaluation of the out-of-field internal neutron doses.

Materials and method

- ✓ A simple geometry, consisting of a proton field entering in a water tank, was modelled using the MCNP 6.2 code.
- ✓ A SOBP was created to cover different target volumes at the same depth in water and with the same modulation width, i.e., changing only the field (to maintain the same energy distribution of protons in the source).
- ✓ The field sizes considered were in the interval 5x5 to 15x15 cm^2.
- ✓ Neutron dose equivalent was evaluated around the target, at distances up to 40cm from the field edge.

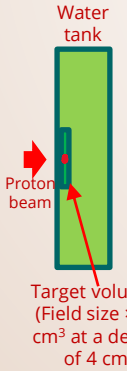

Figure 1. simulation geometry.

Results

- ✓ The effect of field size on neutron dose equivalent depends on the direction relative to the proton beam.

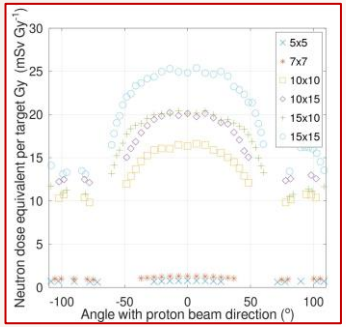

Figure 2. Neutron dose equivalent at 2 cm from field edge.

- ✓ At forward direction, 10x15 and 15x10 cm^2 fields are similar. Laterally, 10x**10** and 15x**10** cm^2 fields are similar, and, also, 10x**15** and 15x**15** cm^2.

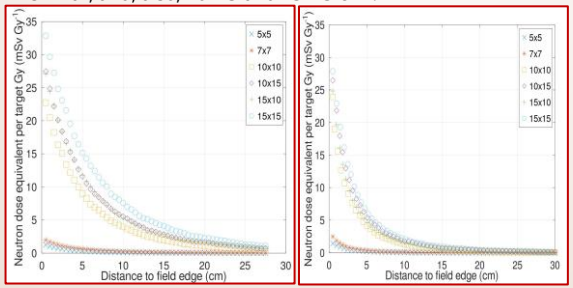

Figure 3. Neutron dose equivalent at 0º (left) and 90º (right) from beam direction.

- ✓ It´s not possible to apply a general normalization (dividing by field size) to all locations.
- ✓ Testing normalization by field projection: Dose divided by the field area seen from the location.

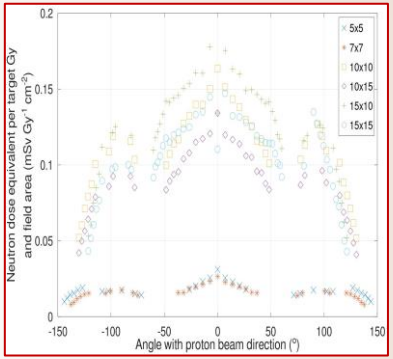

Figure 4. Neutron dose equivalent divided by field projection at 2 cm from field edge.

- ✓ Separation between 5x5 and 7x7 cm2 fields and the rest of fields is maintained.
- ✓ Relative deviation within 5x5 and 7x7 cm2 fields are below 20%.
- ✓ Relative deviation within 10x10, 10x15,15x10 and 15x15 cm2 fields are below 25%.

Conclusions

- ✓ The dependence with field is more complex than the linear dependence outside the body.
- ✓ Further studies are needed for finding a simple normalization to parametrize the field size in an analytical model.

Acknowledgments

This project has received funding from Euratom's research and innovation programme 2019-20 under grant agreement no. 945196. Radiumhemmets Forskningsfonder (Sweden) is acknowledged for financial support.

References 1. Front. Oncol. 2022;12:903537.