Secondary effects in hadrontherapy - N. Verga, Radu Mitrică
SECONDARY EFFECTS IN HADRONTHERAPY
- Protons & Neutrons-

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What is Secondary Effect?
Multiple clinical terms are used to convey ‘Adverse Event‘ including secondary
effect, side effect, acute or late effect, complication, toxicity, morbidity, etc.—all
essentially pointing to a change possibly caused by treatment.

What is an Adverse Event?
Any unfavourable symptom, sign, or disease (including an abnormal
laboratory finding) associated with the use of a medical treatment or procedure
that may or may not be considered related to or caused by the medical treatment
or procedure. (The National Cancer Institute [NCI].)

EARLY AND LATE SIDE EFFECTS

Tissue/organ response
- Acute effects ("early side effects")
- Sub-acute effects
- Late effects
- Generic
- Consequential

Hazards of radiation exposure
- Somatic effects
- Genetic effects
- Stochastic effects
- Deterministic (non-stochastic) effects

Different types of ionizing radiation produce a different
biological effect especially to the surrounding normal tissue.
Main Interactions of Protons

Nonelastic nuclear interactions occur at higher proton energies and produce secondary particles such as protons, neutrons, and beta and gamma rays. These secondaries usually arise from the result of the interaction and have a relatively high biological effectiveness. Primary protons are lost in nonelastic nuclear interactions.

Non negligible percentage of primary protons in proton therapy undergo nuclear interactions resulting in various secondary particles!

Absorbed energy (150MeV primary protons) due to products of nuclear inelastic interactions:

- Muscle adult: 6.0%
- Skeleton adult: 6.4%
- Soft tissue M: 5.9%
- Water: 5.8%

The skin dose to tumor dose ratio is approximately one to four.

Antiprotons and secondary severe effects
The patient will receive a total body dose of pions and neutrons which have a high RBE for radiation carcinogenesis and will contribute to the induction of second cancers.

There is not much data available at present concerning the magnitude of this total body dose but it tends to negate the putative advantage of antiprotons, namely to concentrate dose in the tumor and minimize the exposure of normal tissues.

**OBSERVATIONS, CONCLUSIONS & PROPOSALS I**

**Second cancer and other late side effects**
- The patients receive the treatment not only with hadrontherapy, with chemotherapy and photons and electrons radiotherapy too
- It is possible to increase the risk to develop a second cancer when the patients receive chemotherapy and photons and electrons radiotherapy
- The increasing of the survival rate of the treated hadrontherapy patients is a reality
- This long time of survival offers the possibility to observe the developing of second cancer, especially for the paediatric cases (ex.: the long-term incidence of non-ocular primary tumors following treatment of retinoblastoma)

**RISK**
Risk estimates are, however, subject to large uncertainties. The major sources of uncertainty come indeed from the lack of detailed knowledge of the biological effects of energetic heavy ions, especially at the effects of secondary particles appeared in normal tissue surrounding the tumor.

*We must pay attention and follow-up the treated cancer patients!*
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