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) **)**

COMMON TERMINOLOGY CRITERIA FOR ADVERSE EVENTS (CTCAE)

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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.

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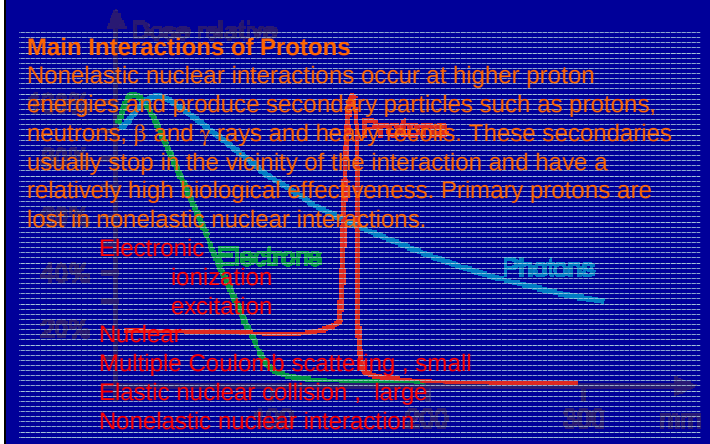
Main Interactions of Protons

Nonelastic nuclear interactions occur at higher proton energies and produce secondary particles such as protons, neutrons, β and γ rays and heavy fragments. These secondaries usually stop in the vicinity of the interaction and have a relatively high biological effectiveness. Primary protons are lost in nonelastic nuclear interactions.



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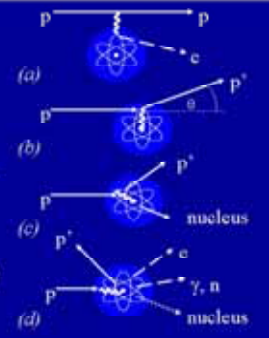
Main Interactions of Protons

- Electronic (*a*)
  - ionization
  - excitation
- Nuclear (*b-d*)
  - Multiple Coulomb scattering (*b*), small θ
  - Elastic nuclear collision (*c*), large θ
  - Nonelastic nuclear interaction (*d*)



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

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Protons

Dose distributions – nuclear interactions

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 tumour dose ratio is approximately one to four.

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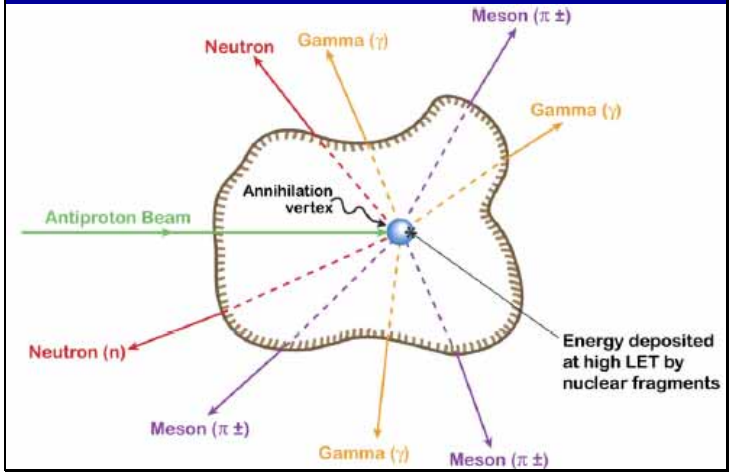
Antiprotons and secondary severe effects



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 .

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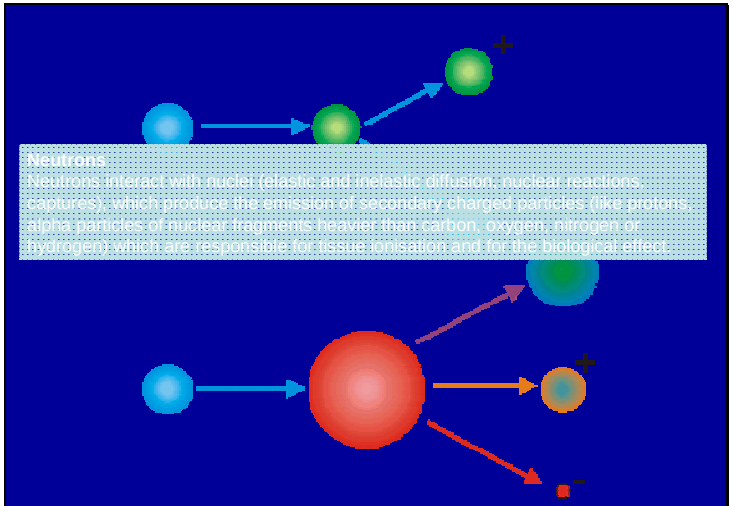

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OBSERVATIONS, CONCLUSIONS & PROPOSALS I

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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OBSERVATIONS, CONCLUSIONS & PROPOSALS I

Do not forget the basic principles of protection for medical exposures !

- Justification of medical exposures (BSS, para. II.4)
- Optimization of protection for medical exposures (BSS, paras II.16 (a) (ii), II.17 (a) (i) and II.18 (a))

PERIODIC EVALUATION AND FOLLOW-UP

1. Periodic follow-up examinations after treatment are critical, not only to evaluate the general condition of the patient and the tumour response but also to detect recurrences early, should they occur, and to observe the effects of irradiation on the normal tissues.
2. It has always been tried in radiation oncology to make the radiation fields conform to the tumour volume, in order to give the dose required for a cure to the tumour and to reduce the dose to normal tissue.
3. If better conformation to the target volume is achieved, it may be possible to increase the dose delivered to the tumour while keeping the side effects to normal tissue constant. Such dose escalation is usually only possible if the dose to normal tissue can be kept at its original level.

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