Radiobiological method for the clinical validation of models dose-to-water (Dw) versus dose-to-medium (Dm) in radiotherapy

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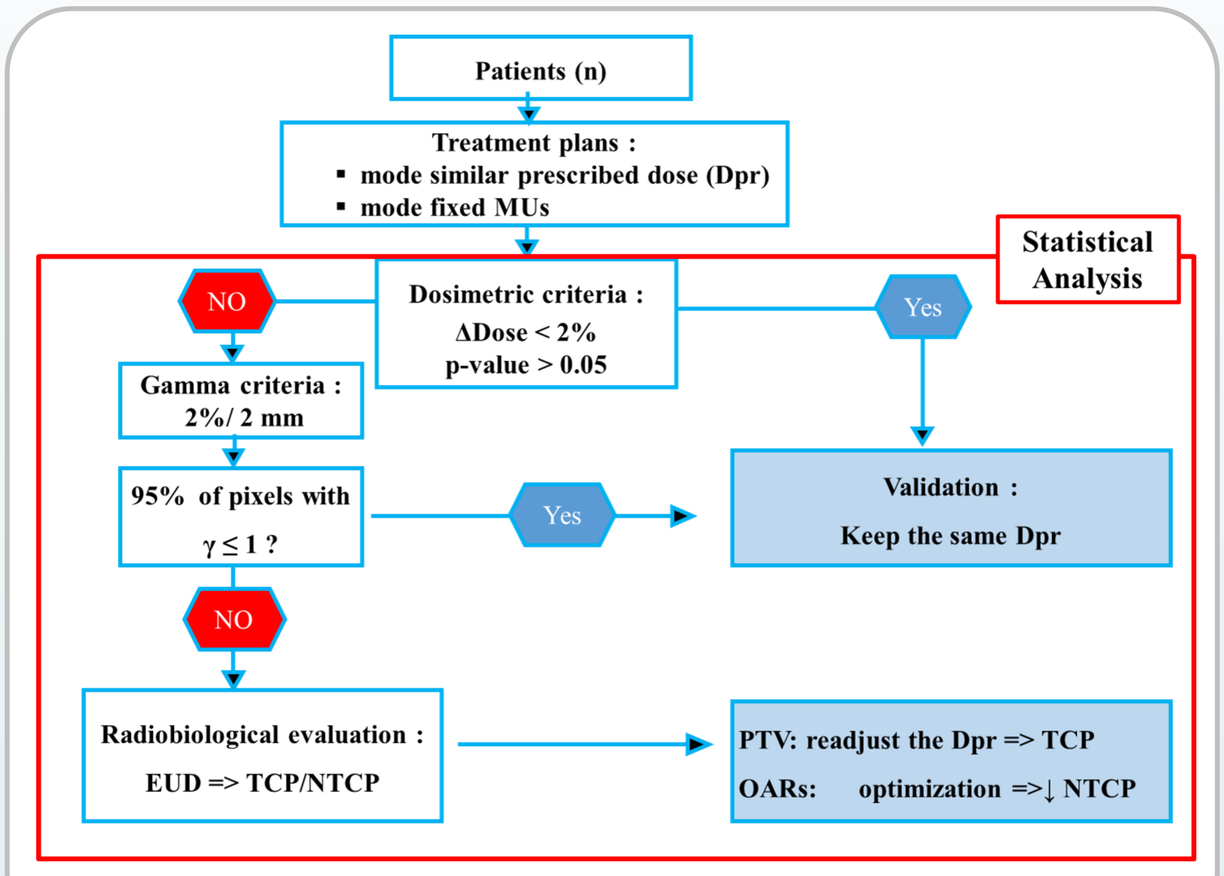
Purpose

A present challenge in medical physics is to implement the most accurate dose calculation algorithm, close to Monte Carlo simulations, with the highest safety to obtain the expected tumor control probability (TCP) and acceptable normal tissue complication probabilities (NTCP). The purpose is to propose dosimetric and radiobiological criteria to safely implement new algorithms/models in radiotherapy as the expected transition from Dw to Dm theoretically more accurate.

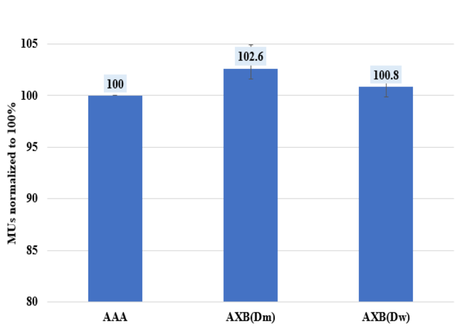
Methods

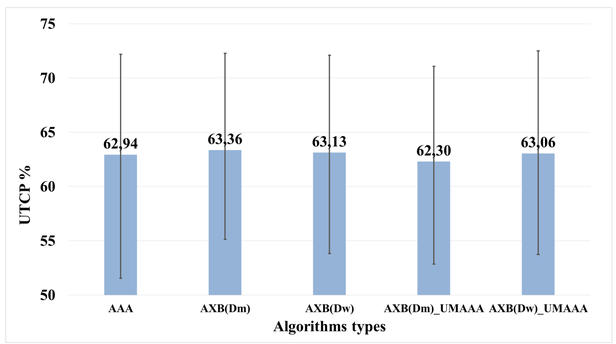
- **Lung tumors are taken as examples to demonstrate this transition.**
- **The doses were calculated using three types of algorithms [1,2]:**
  - **Type (a) : pencil beam kernels model, like PBC;**
  - **Type (b): point kernels model, like AAA;**
  - **Type (c): Acuros-XB based on the deterministic resolution of the Boltzmann linear transport equation. Acuros-XB proposes two options: dose to water (Dw) and dose to medium (Dm).**
- **The monitor units (MUs) are retrieved from the reference plan to recalculate the dose distribution with the new one.**
- **The dosimetric criteria include DVH data, D95%, MUs, dose at iso-centre (Diso) as well as gamma index (2%/2mm).**
- **The equivalent uniform dose (EUD), TCP, NTCP and Uncomplicated Tumor Control Probability (UTCP) were calculated to measure the clinical benefit – toxicity [3,4].**



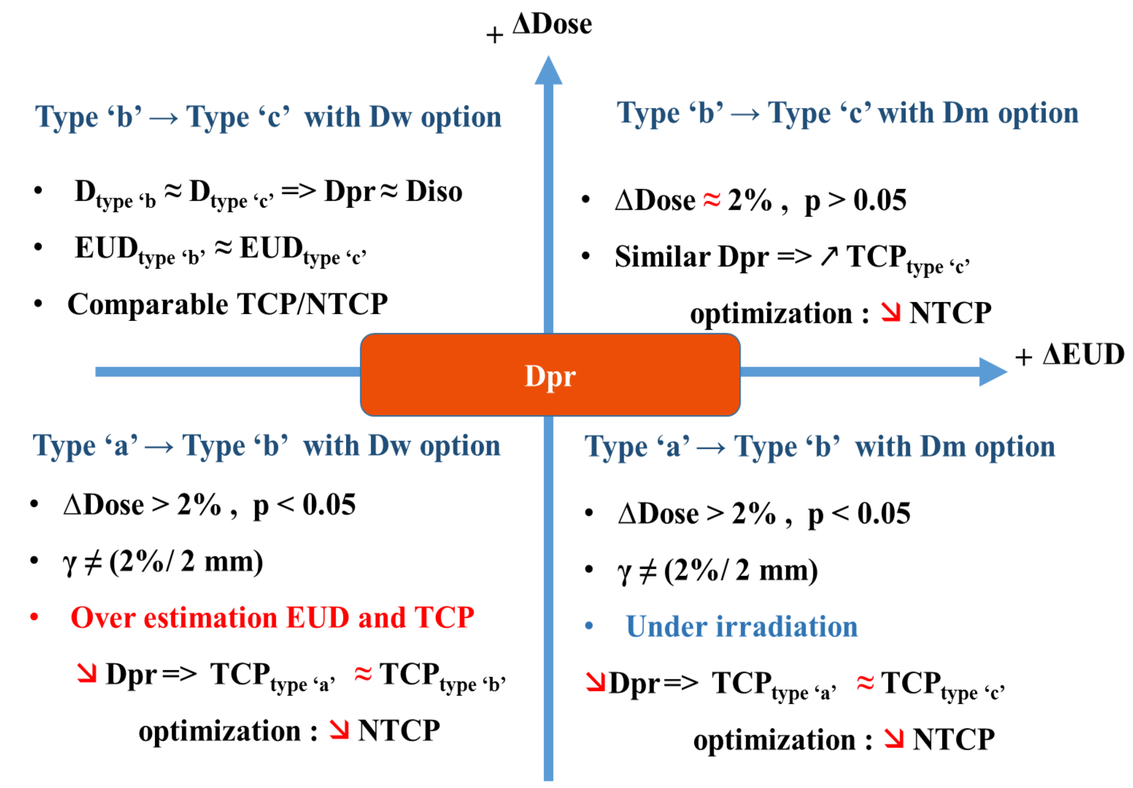
Results and discussion

A significant dose difference was obtained when moving from type 'a' to 'b' or 'c'. The former models overestimate Diso and require more MUs (2-5%) depending on transition type. In addition, the tolerance doses for OARs were impacted (e.g for lung : V20 and V30 Gy as well as mean lung dose).
EUDs for targets were significantly lower with more recent algorithms leading to that the former models overestimate the TCP prediction. A comparable EUD for lung was observed leading to comparable NTCP in absolute value.





Medical decision



Conclusion

Type (c) algorithms is known to provide improved calculation accuracy. Attention is required in order to safely implement the new generation in clinical use since these models require more MUs. The shift on dosimetric and radiobiological data depends on transition type, algorithm/model, the medium density, the irradiation technique and the treatment field size. A discussion between radiation-oncologists and medical physicists is necessary to define the attitude to be adopted regarding these dosimetric shifts. A reasonable approach would be to keep the same prescribed dose, increasing the TCP, but compensating by even more optimization for OARs sparing.

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