



BRACHYTHERAPY

Editors' pick

Fast and fully-automated, multi-criterial treatment planning for adaptive HDR brachytherapy for locally advanced cervical cancer

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What was your motivation for initiating this study?

For external beam radiotherapy and prostate brachytherapy, it has been demonstrated that our in-house developed system for multi-criterial optimisation, Erasmus-iCycle, can automatically generate treatment plans with consistently high plan quality.

Treatment plan optimisation for cervical cancer high-dose-rate (HDR) brachytherapy is still performed through a manual trial-and-error approach at our institution. Dwell times are iteratively adjusted until a plan is clinically acceptable and cannot be further improved.

In this study, we explored the possibility of utilising Erasmus-iCycle to generate treatment plans automatically for HDR brachytherapy in cervical cancer. Using this approach, time-consuming, variable and suboptimal manual treatment planning could be avoided.

What were the main challenges during the work?

The main challenge was to translate clinical objectives into a mathematical form for optimisation. Two specific clinical objectives had to be taken into account:

- For brachytherapy for cervical cancer, we found that a fine trade-off was being made between target coverage and the near-maximum dose for organs at risk (OAR). This trade-off had to be reproduced carefully in the automatically generated treatment plans. For this purpose, a cost function based on a dose-volume histogram was implemented within our Erasmus-iCycle framework and the target coverage and OAR near-maximum doses were optimised in a step-wise manner.
- A clinical objective for the dose distribution is the so-called "pear shape". This is a high-dose volume that is not defined by OARs or other clinical structures. The pear shape originates from the historical loading of the applicator, when dwell times were not modulated. To reproduce the desired shape, we created artificial structures and used a smoothing objective. Again, the right trade-off had to be made between achievement of the correct shapes, maximisation of target coverage and minimisation of the dose to the OARs.

What are the most important findings of your study?

In a blind comparison study of plans by the physician, we observed that automatically generated plans for cervical cancer patients were superior to manually generated plans, while the total planning time for the automatic generation was only 20 seconds. Therefore, we found that fast and fully automated multi-criterial treatment planning for HDR brachytherapy of locally advanced cervical cancer was feasible.

What are the implications of this research?

This study demonstrated that the dose delivered to the target could be increased while keeping the doses to the OARs within limits. Due to the automated planning method, the tumour control could thus be increased if necessary, otherwise the OARs could be spared more.

Given this high plan quality and short planning times, the method is also suitable for online HDR brachytherapy applications.

Building on this work, we are currently investigating the potential of this approach for EMBRACE-II planning aims.

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