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Physical and biological objectives in plan optimisation for hypofractionated stereotactic radiotherapy of liver patients including computerised, fully non-coplanar beam orientation selection

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Introduction

Treatment

- Hypofractionation: total dose delivered in 3 fractions
- Stereotactic body-frame with abdominal compression
- Residual tumor top-top respiratory motion < 0.5 cm, in all directions

Clinical planning:

- For each patient the plan has to strictly obey a set of hard constraints.
- Prescription isodose closely surrounds the PTV
- 65% strategy: prescription isodose is 65% of the isocenter dose

Study: compare 65% strategy (clinical planning) with planning based on:

1. 80% strategy: prescription isodose is 80% of the isocenter dose
2. gEUD-strategy: planning based on gEUD(a=-20) for tumor

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Methods (1)

- Use CT-data of 15 previously treated patients with 65% strategy

While strictly obeying the clinically applied constraints for organs at risk,

- 65% strategy: generate plan with the highest D_{isoc}
- 80% strategy: generate plan with the highest D_{isoc}
- gEUD strategy: generate plan with the highest gEUD(-20)

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Methods (2) – plan evaluation

All strategies

- PTV: gEUD(a) for different values of *a*: -1, -5, -10, -20, -50, -100
- Mean distance from the applied OAR constraint levels

Extra for 65%- and 80% strategies:

PTV voxels with a lower absolute dose in the 65% strategy than $D_{PTV,\ min}$ in the 80% strategy:

- Volume fraction of PTV?
- 3D-distance from PTV surface?

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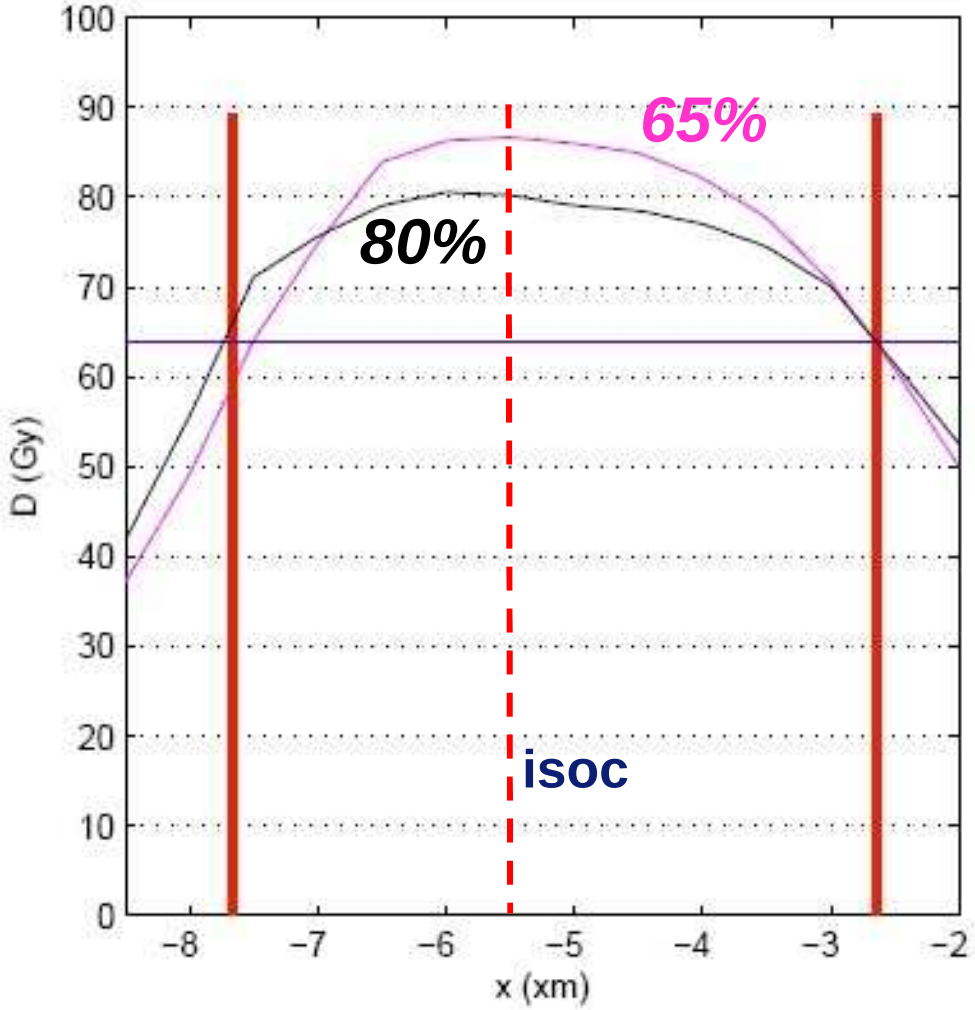

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Methods (3) – automated plan generation

- In-house developed algorithm: “Cycle”
  (de Pooter et al., IJROBP 2006, 66(3): 913-22)

- Automated selection of 10 beam directions from an input set of 252 non-coplanar beam directions (maximum angle with axial plane is 30^{o})

- Selected beams have an optimal weights and shapes

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Methods (4) – hard OAR constraints

Structure	Constraint
Normal Liver	$D_{33\%} < 21$ Gy
Normal Liver	$D_{50\%} < 15$ Gy
Spinal cord	$D_{max} < 15$ Gy
Bowel, duodenum, Stomach, Esophagus	$D_{5\ CC} < 21$ Gy
Heart, Aorta	$D_{5\ CC} < 21$ Gy
Kidney's	$D_{33\%} < 15$ Gy
R1	$D_{max} < D_{PTV,\ min} - 5$ Gy
R2	$D_{max} < 20$ Gy
Conformity Index	CI < 1.4

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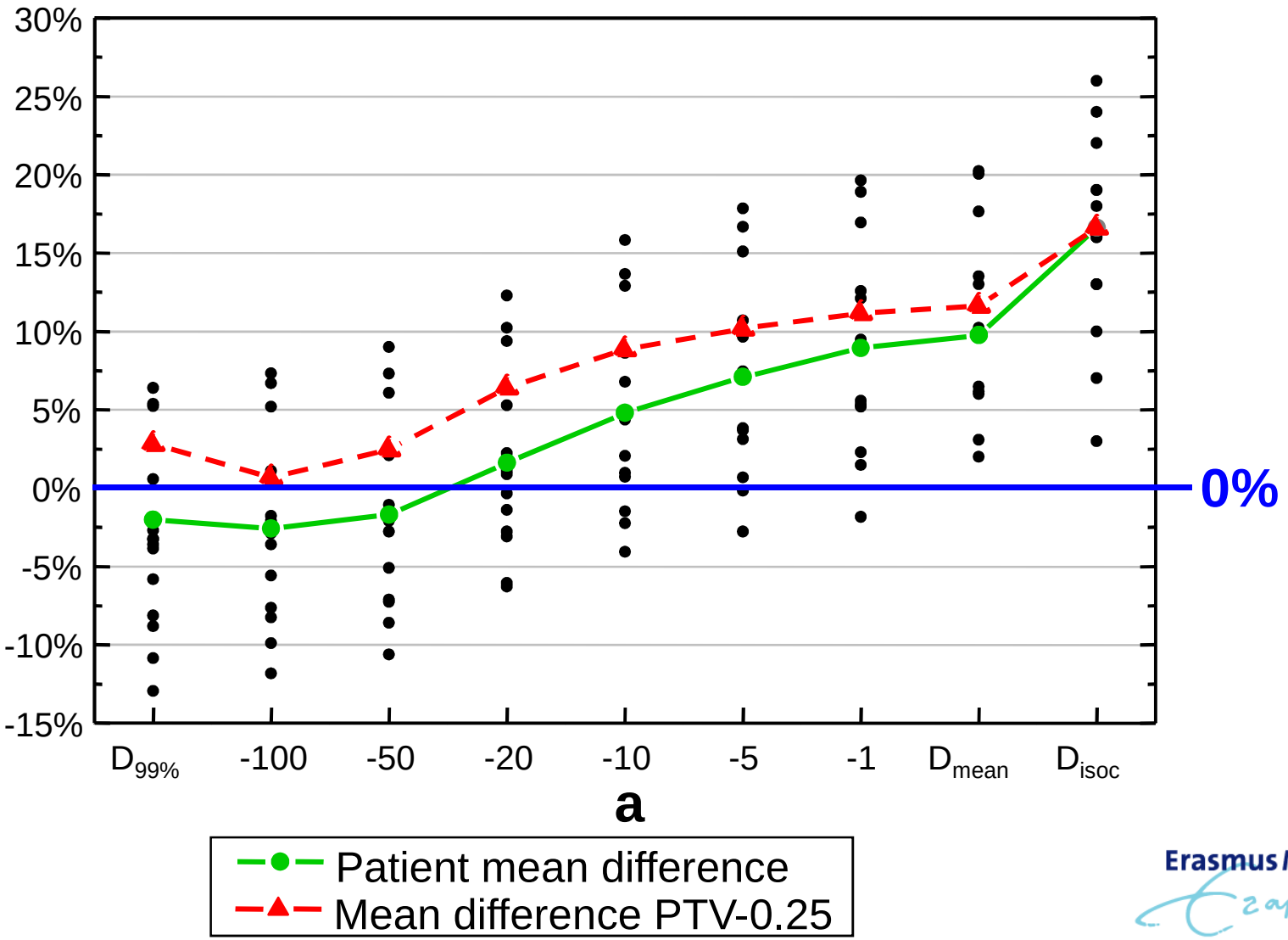
Results (1) – $gEUD^{65\%}(a)$ - $gEUD^{80\%}(a)$



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Results (2) – 65% vs. 80% strategy: voxels close to PTV surface

- PTV voxels with a lower absolute dose in the 65% strategy than the $D_{PTV,\ min}$ of the 80% strategy:
  - Volume on average **3%** (range 0 - 9%) of total PTV
  - On average, maximum distance to PTV surface: **0.16 cm**

  (average for 11/15 patients; for 4 patients the dose in all voxels for the 65% strategy was higher than the minimum dose in the 80% strategy)

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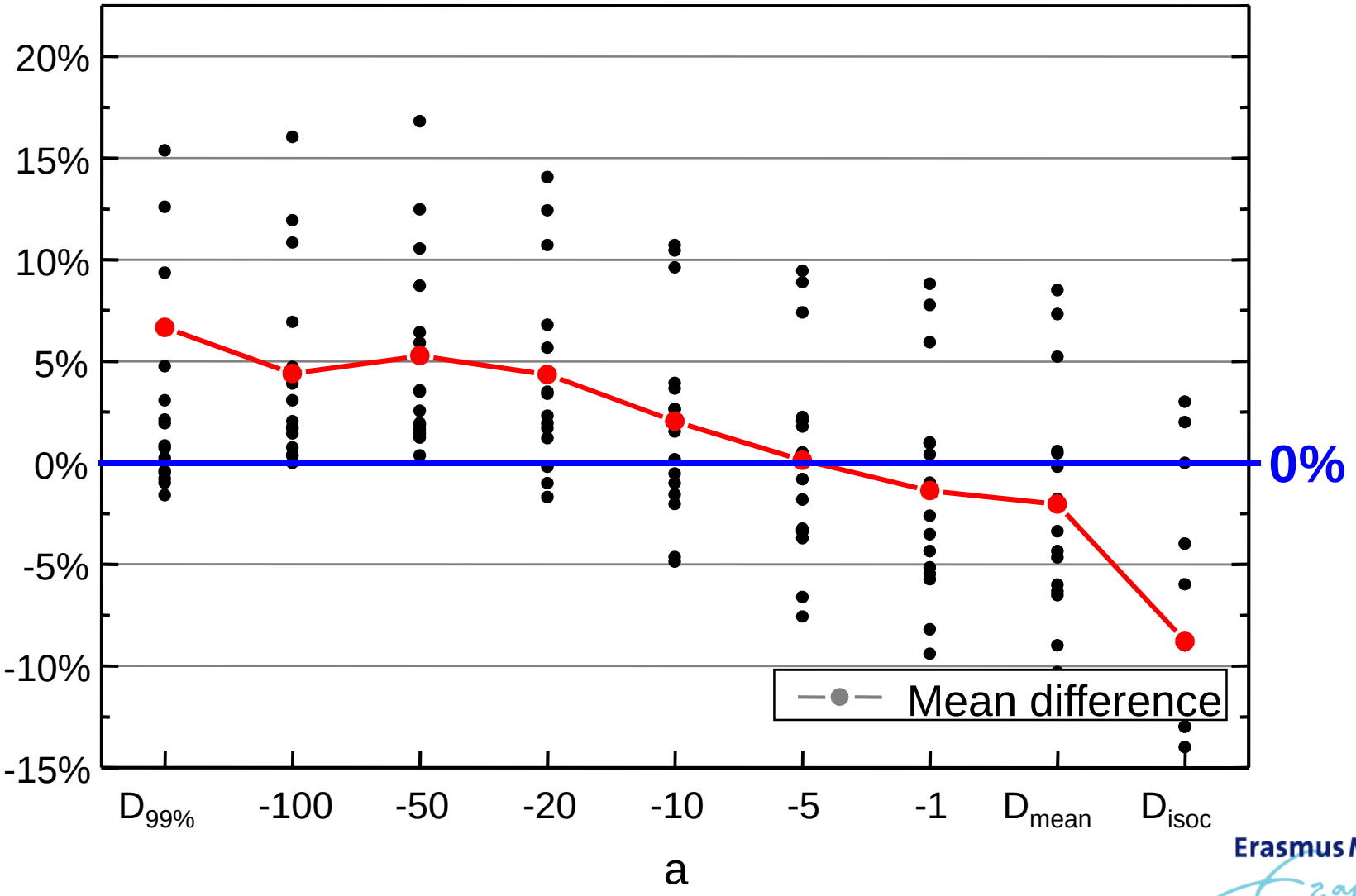
Results (3) – $gEUD^{gEUD(-20)}(a) - gEUD^{65\%}(a)$



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Conclusions (1)

- For relevant a, patient group means gEUD(*a*) are significantly higher for the 65% strategy than for the 80%. However, large inter-patient variations.

- The 65% strategy leads to treatment plans with a much higher isocenter dose than the 80% strategy (**17%**) at the cost of a slighly lower minimum dose (mean difference in $\mathbf{D_{PTV,\ 99\%}}$ **= 2%**)

- The lower dose part of the 65% strategy plans is on average within **0.16** cm from the PTV surface.

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Conclusions (2)

- Compared with the 65%- and 80 % strategies, for all relevant a, patient group means gEUD(*a*) are highest for the "biological" strategy, based on gEUD(-20). However, large inter-patient variations.

- The amount of increase in gEUD(a) depends on the *a*-value used for the evaluation. The appropriate a-value for the tumor is unknown.

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