Dose painting

Why paint dose?

Local regional control for locally advanced tumours leaves room for improvement

Tumours recur most likely in high-risk subvolumes
- hypoxic subvolumes
- subvolumes with highly proliferating clonogens
- subvolumes with high tumour burden

Dose painting focuses on high-risk subvolumes using some kind of functional imaging

Aerts et al. R&O 2009
How?

- dose painting by contours
- dose painting by numbers

Intensity

- $D_{max}$
- $D_{min}$

Frederic Duprez et al. (IJROBP 2010)

How?

- dose painting by contours
- dose painting by numbers

- standard software
- allows for margin expansion
- based on thresholding
- evaluation based on DVHs

- research software
- no margins
- ‘no’ thresholding
- evaluation based on new descriptors

How?

- dose painting by contours
- dose painting by numbers

- functional dataset
- prescribed dose
- dose painted plan
- voxel to dose
- voxel volume
- regular DVH objectives
- thresholding
- dose painted plan
- functional dataset
- prescribed dose grid
- voxel based objective
How?

- **dose painting by contours**
  - standard software
  - allows for margin expansion
  - based on thresholding
  - evaluation based on DVHs

- **dose painting by numbers**
  - research software
  - no margins
  - ‘no’ thresholding
  - evaluation based on new descriptors

Thresholding might be tricky

\[Q_{\text{VH}} = \frac{n}{D_{\text{max}}} \sum |D_i - 1|\]

Treatment plan evaluation

\[\Delta V_H = \frac{D_{\text{max}} - D_{\text{min}}}{D_{\text{max}}}\]

\[Q_{\text{VH}} = \frac{D_{\text{max}} - D_{\text{min}}}{D_{\text{max}}}\]
But maybe we should strive for some kind of TCP estimator…..

"Tumours are ultimate parallel structures and therefore a tumour is controlled if, and only if, all tumour subvolumes are controlled"

Munro and Gilbert Br. J. Radiol. 1961

\[ TCP = \prod VCP \]

\[ VCP = \text{voxel control probability} \]

\[ TCP = 0.99^{20} = 0.82 \quad TCP = 0.99^{16} \times 0.8^4 = 0.35 \]

So for homogeneous tumours isodose lines coincide with iso-VCP lines

For inhomogeneous tumours this is not the case and maybe we should define

\[ ESD = \text{Equivalent SUV corrected dose} = \text{the local dose that yields an identical local effect as if the local SUV is 1} \]

Conclusions

- dose painting is feasible
  - highly conformal delivery technique
  - functional imaging (robust in time and geometry)
  - a sensible relationship between image intensity and high-risk tumor characteristics
- dose painting by contours can be done using conventional treatment planning systems
- for dose painting by numbers you’ll need to have access to dedicated software tools
- [potential benefit of dose painting techniques should be examined in clinical studies!]