Clinical Experience with Varian RapidPlan™

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Disclosures

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What is knowledge-based planning (KBP)?

- Utilise prior knowledge and experience to predict an achievable dose in a new patient
- Use the predicted dose information to automatically generate patient-specific optimization objectives
- Different approaches for KBP

Zhu et al. *Med Phys* 2011;38:719
Yuan et al. *Med Phys* 2012;39:6868
McIntosh & Purdie. *Phys Med Biol* 2017;62:415–31.
Chanyavanich et al. *Med Phys* 2011;38:2515

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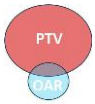
What is knowledge-based planning (KBP)?

- One approach is DVH prediction using a statistical model trained using information from geometrical anatomical, and dosimetric features



- Used in Varian RapidPlan™

Zhu et al. *Med Phys* 2011;38:719
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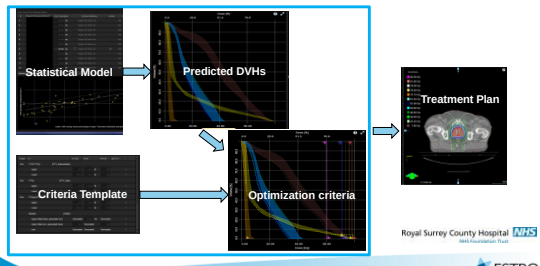
Varian RapidPlan™ workflow



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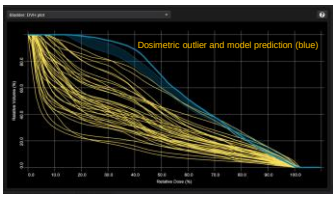
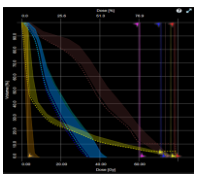
Model Evaluation: Outliers



Conversion from DVH prediction to optimisation criteria

- User defines PTVs and OARs of interest
- 'Out-of-the-box' default settings for criteria generation:
  - Auto generated criteria are min/max for PTVs, and optimisation line for OARs
  - Dose/volume objectives and priorities auto generated
  - Normal tissue objective set on Auto, (for IMRT, the fluence smoothing parameters are set to default software settings)
- User can add further critieria and manually set priorities and/or objectives



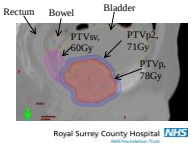
RapidPlan™ benchmarking questions

- What is the influence of statistical outliers on the model training and should they be excluded?
- How does plan quality depend on the methods used to convert predicted DVHs into plan optimisation criteria?
- How does RapidPlan™ perform when multiple dose levels are prescribed?
- How does RapidPlan™ perform when there are significant geometric variations in target volumes?

Hussein et al. ***Radiother Oncol Vol 120 p473-479***

RapidPlan™ benchmarking

- Started with 3 dose level prostate treatments
- 78Gy,71Gy,60Gy/37#
- 5-field IMRT
- Default RapidPlan™ settings



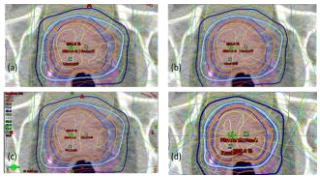
Influence of outliers?

Model 1: no outliers excluded

Model 2: extreme outliers excluded (e.g. hip prostheses)

Model 3: all statistical outliers excluded

Original Clinical Plan



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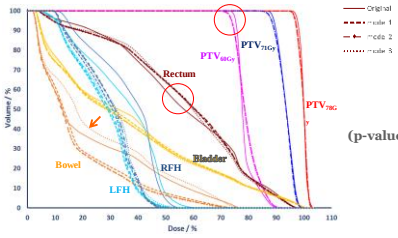
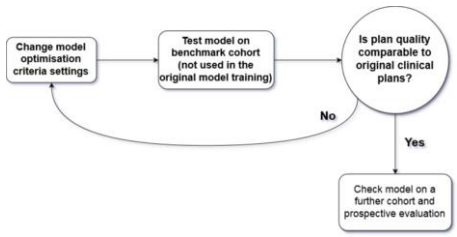
Influence of outliers?

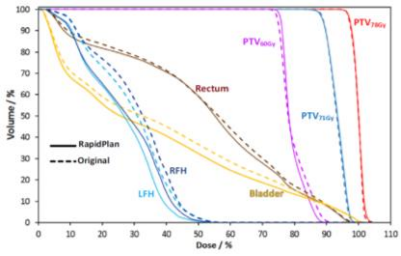


(p-value range 0.17-0.50)

Hussein et al. *Radiother Oncol Vol 120 p473-479*

Refinement of model process

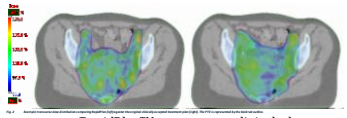




Hussein et al. *Radiother Oncol Vol 120 p473-479*

Cervix VMAT model

- Model found to generate plans which were more conformal with better OAR sparing than the original clinical plan, using a single optimisation (with subsequent modifications able to improve plans further)



RapidPlan™ clinical plan

Hussein et al. *Radiother Oncol Vol 120 p473-479*

Key findings from the benchmarking

- Generation of appropriate RP models is an iterative process
- Exclusion of statistical outliers appears to have less influence on plan quality than objective template (and other optimizer settings)
- Varian Model Analytica™

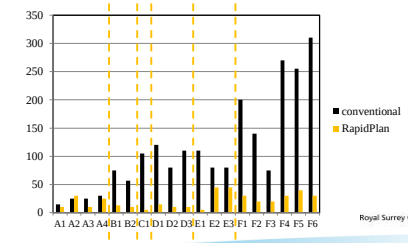
Prostate IMRT: prospective clinical evaluation

- Comparison of manual planning vs RapidPlan™
- 20 patients undergoing routine planning by planning team
- 6 planners of varying experience participated; same planner performed both optimisations for a patient

Prostate IMRT: prospective clinical evaluation

- Data recorded:
  - Time
  - Adjustments required
  - MU
  - Comparison of plan quality – based on DVH objectives

Prospective timing measurements (min)



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Prostate IMRT model prospective evaluation: key findings

- RapidPlan™ able to generate clinically acceptable plans with significant time saving compared to 'conventional' optimisation
- Average planning time reduced by 93min
- Spread on timings much smaller for RapidPlan™
- MU found to be slightly higher with RapidPlan™ (698 vs 668, p=0.03); not clinically significant

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Prostate IMRT model: continuing evaluation

- Model modifications based on feedback from planners
- Electronic feedback forms to monitor performance;
  - situations where RapidPlal™ unable to generate an acceptable distribution
  - allows further investigation and modification of model parameters as required
- Tested for situations outside the original scope
  - Different dose/fractionation
  - VMAT

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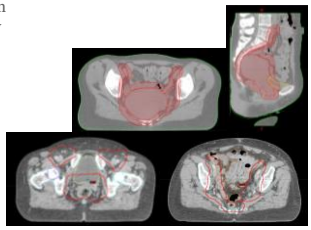
Cervix VMAT model

- Planning times reduced from ~1-1.5 day to around 0.5 day and more consistent between planners
- Gives very good starting point, but all cases need some adjustment



Cervix VMAT model

- Main issues in problem cases:
  - Homogeneity within PTV (small hot/cold spots)
  - Tendency to deposit more dose from the anterior/posterior direction
  - Currently adding dummy structures to address these

Cervix VMAT model

- Used successfully for single dose level pelvic sites;
- e.g. Pre-BXT prostate + nodes, endometrium, vulva+nodes

Cervix model: patient numbers

- Model initially based on 37 patients, but variable anatomy (hysterectomy/intact uterus, inguinal nodes):
- Tried doubling no. cervix patients – no impact

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Cervix model: effect of widening scope

- Preliminary investigation
- Compared a cervix-only model with a combined pelvic model (including other sites: endometrium, prostate, vagina, vulva & cervix)
- the combined pelvic model worked better for endometrium & nodes and PPN cases but slightly inferior to the cervix model for cervix cases

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Current clinical models

- Continuing evaluation of models in clinical use
  - Applicability to cases outside original scope
  - Identification and investigation of cases where model does not work
- Addition of more cases into model / widening of scope

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General challenges with KBP automated planning

Model refinement:

- For complex cases, no models are perfect after final optimisation
- give good starting points
- Can the configuration be pushed further?

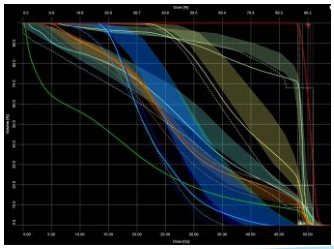
General challenges with KBP automated planning

- Behavior of optimizer with KBP is different to template-based optimization
  - Learning curve
  - Troubleshooting when it doesn't go right can be more difficult; e.g. Line objectives not editable
  - Sometimes becomes easier to abandon it and go back manual optimization!
- Solution - more training in how to manipulate the optimizer

General challenges with KBP automated planning

- Concerns about de-skilling in manual planning
  - Retain teaching on manual optimization for new staff
- Some sites already lend themselves to a well thought out class solution (e.g. prostate) and therefore for experienced planners the net benefit of KBP diminished

RapidPlan™ as a plan checking tool



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Models under investigation

- Lung SABR
- Prostate + pelvic nodes
- H&N
- Brain (GBM)
- Any other IMRT/RA site as it becomes standard treatment once sufficient patient numbers are available

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UK RapidPlan™ Consortium

- Growing consortium of UK centres who have either implemented/or are implementing RapidPlan™
- Aim is to facilitate sharing experience and models between interested centres
  - Including identifying the challenges involved in model sharing

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Summary (1)

- Generation of appropriate RapidPlan™ models is an iterative procedure
- Plans generated by RapidPlan™ still require some adjustments in some cases
  - May be able to improve models further by modification of constraints/addition of extra plans into model
  - Optimisation objectives different from those used in 'normal' IMRT/RA planning, hence learning curve of how to adjust
  - Model can never be perfect, especially in regions where conflicts exist

Summary (2)

- RapidPlan™ can be used to improve efficiency and consistency of planning
- Planning times can be significantly reduced, particularly for complex cases/less experienced planners
- Advantages to clinical service will depend on:
  - Experience of planners/complexity of cases
  - Re-learning how to manipulate plans when intervention required

Acknowledgements

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PHYSICS
workshop
Science
in development
26-27 October 2018
Malaga, Spain
REGISTRATION IS OPEN
DEADLINES
Contributions on ongoing research:
27 June 2018
Early registration:
21 August 2018
Late registration:
20 October 2018
No onsite registration.
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