Clinical Experience with Varian RapidPlan™

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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
Chanyavanich et al. Med Phys 2011;38:2515

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;38:194
Yuan et al. Med Phys 2011;38:6868
Chanyavanich et al. Med Phys 2011;38:2515

Varian RapidPlan™ workflow
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 lines 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 criteria 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

Influence of outliers?

Hussein et al. Radiother Oncol Vol 120 p473-479

(p-value range 0.17-0.50)
Refinement of model process

- Change model optimisation criteria settings
- Test model on benchmark cohort (not used in the original model training)

In plan quality comparable to original clinical plans?

- Yes
- No

Check model on a further cohort and prospective evaluation

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)
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
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

Prostate IMRT model: continuing evaluation

- Model modifications based on feedback from planners
- Electronic feedback forms to monitor performance;
  - situations where RapidPlan™ 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
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

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

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

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

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
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-skill 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

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

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
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

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