Impact of Automatic Planning From the Clinician's Perspective

Abstract

Recent advances in optimization and machine learning methods, it is now conceivable that the design of an individual treatment plan can be made with little, if any, human intervention. Adding autosegmentation processes to automated planning will result in dramatic increase in the efficiency and consistency of individual plans. Once the anatomic information, through imaging, is acquired for planning purposes, the majority of the steps required for the generation of the optimal plan could be automated. Such efforts are already being pursued at many institutions. However, since treatment plan design is one of the most important steps affecting the quality of a delivered treatment, human intervention, or at least supervision, will be crucial for the gradual development of confidence in these automated processes. In this talk, I will provide my insights on the aspects of automated treatment planning that would be addressed for this practice to become an integral part of the future practice of radiation therapy.Learning Objectives:1. Understand the concerns related to the implementation and practice of automated treatment planning from a clinician's perspective.2. Understand the impact of automated treatment planning on improving quality and consistence of radiation therapy from a clinician's perspective.

Objectives

1. Understand the concerns related to the implementation and practice of automated treatment planning from a clinician's perspective.

2. Understand the impact of automated treatment planning on improving quality and consistency of radiation therapy delivery from a clinician's perspective.

Important Disclosures

Research grants / Honoraria / Advisory Board:

Accuray
Bayer Healthcare
Elekta
Varian Medical
Viewray Inc.

Automated Treatment Planning

Elements:

- Autosegmentation
- Autoplan –
  - Margins
  - Priorities
  - Etc
- Auto-reports
- Libraries – Local / Other (expert users)
- Registry data

Outline

1. Clinical context – Background
Problems that can be addressed with automated planning

2. Concerns
Potential problems associated with automated planning

3. Possible first clinical applications
Practical steps

4. New Opportunities
Novel applications for automated planning

Objectives

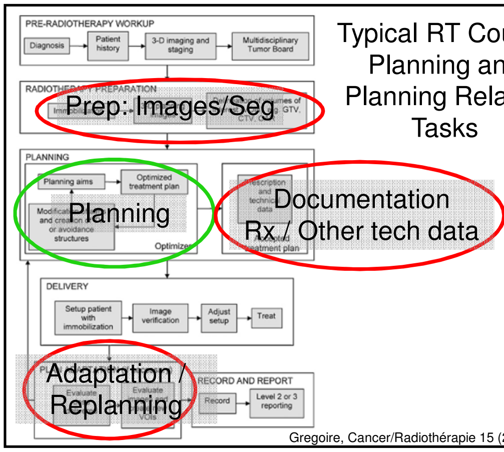
1. Clinical context – Background
Problems that can be addressed with automated planning

2. Concerns
Potential problems associated with automated planning

3. Possible first clinical applications
Practical steps / opportunities

4. New Opportunities
Novel applications for automated planning

Typical RT Course Planning and Planning Related Tasks



Gregoire, Cancer/Radiothérapie 15 (2011) 555–559

Automated Treatment Planning

Shift focus from actual planning to overall process supervision

Benefits:
- Expediency / Efficiency
  - e.g. H&N planning turnaround
- Standardization
  - e.g. Breast planning, identifying outliers
- Learning
  - e.g. Improvement of plans, training
- Automated documentation:
  - e.g. Automated report generation
- Safety:
  - e.g. Standardization, guidelines, etc
- Culture change:
  - Change planning mentality from an “optimizer” to a “supervisor”

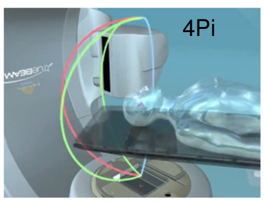
Automated Treatment Planning

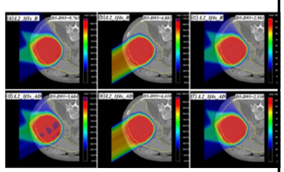
Not a new thing

Many aspects already automated

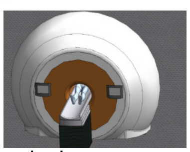
Automated Treatment Planning

A Necessity in the future?





Proton Therapy / IMPT



More complex devices

Objectives

1. Clinical context – Background
Problems that can be addressed with automated planning

**2. Concerns
Potential problems associated with automated planning**

3. Possible first clinical applications
Practical steps

4. New Opportunities
Novel applications for automated planning

Concerns

- Too much automation?
  Auto-segmentation
- Differences in different platforms
- Errors – systematic errors
- Cutting dosimetrist jobs? No!
  New challenges:
    Oversee entire process
    More complex deliveries
    Oversee dose accumulation processes
    ADAPTIVE RT

Objectives

1. Clinical context – Background
Problems that can be addressed with automated planning

2. Concerns
Potential problems associated with automated planning

3. Possible first clinical applications
Practical steps / opportunities

4. New Opportunities
Novel applications for automated planning

Possible first clinical applications
Practical steps

- Clinical cases; Palliative
  Whole brain
  Prostate
- Planning – Structure Naming Standardization
- Automatic generation of plan quality reports
- Building of case libraries
- Plan quality data collection / Registry data

Simulation + (Near) Automated Planning

McIntosh A, Dunlap N, Sheng K, et al. University of Virginia
Med Dosim. 2010;35 (4): 280-6.
Helical tomotherapy-based STAT RT: Dosimetric evaluation for clinical implementation of a rapid radiation palliation program.

CT simulation, treatment planning, and treatment delivery in one session

- Whole brain
- Central obstructive lung mass
- Multilevel spine disease
- Hip metastasis

Clinically acceptable dosimetry:
conformality and homogeneity superior to standard 3D plans

Nomenclature Standardization

Physics Contribution

Standardizing Naming Conventions in Radiation Oncology

Lakshmi Santanam, Ph.D.,* Coen Hurkmans, Ph.D.,[†] Sasa Mutic, Ph.D.,* Corine van Vliet-Vroegindeweij, Ph.D.,[‡] Scott Brame, Ph.D.,* William Straube, M.S.,* James Galvin, D.Sc.,[‡] Prabhakar Tripuraneni, M.D.,[§] Jeff Michalski, M.D.,* and Walter Bosch, D.Sc.*,[¶]

**Department of Radiation Oncology, Washington University School of Medicine, St. Louis, MO; [†]Department of Radiation Oncology, Catharina Hospital, Eindhoven, The Netherlands; [‡]Department of Radiation Oncology, Thomas Jefferson University Hospital, Philadelphia, PA; [§]Department of Radiation Oncology, Scripps Clinic, LaJolla, CA; and [¶]Advanced Technology Consortium, Image-guided Therapy QA Center, St. Louis, MO*

Received May 23, 2011, and in revised form Sep 17, 2011. Accepted for publication Nov 21, 2011

Santanam L, IJROBP, 15;83(4):1344-9, 2012

Nomenclature Standardization

Table 1 Examples of target volume (TV) names

TV ICRU name	Primary/node	Single/multiple	Number	Prescription dose (cGy)	Proposed name
PTV	Primary	Single	N/A	5000	PTV_5000
PTV	Node	Multiple	1	5000	PTVn1_5000
CTV	Node	Multiple	2	4000	CTVn2_4000
PTV	Node	Multiple	2	4000	PTVn2_4000
PTV	Primary	Multiple	1	5000	PTVp1_5000

Abbreviation: ICRU = International Commission on Radiation Units and Measurements.

Table 2 Planning organs at risk volumes

Organ at risk name	Left/right	Margin (mm)	Proposed name
SpinalCord	N/A	Nonuniform	SpinalCord_PRV
SpinalCord PRV	N/A	5	SpinalCord _05
Parotid	Left	0	Parotid_L
Parotid	Right	0	Parotid_R
Total parotid	Left+Right	0	Parotids
Kidney	Left	10	Kidney_L_10

Santanam L, IJROBP, 15;83(4):1344-9, 2012

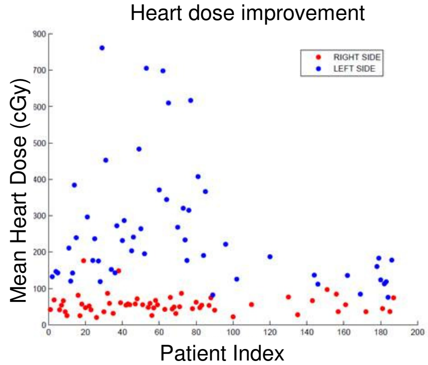
Nomenclature Standardization

Table 3a Standardized organ at risk names

Standard names	Description	Standard names	Description
AnalCanal	Anal Canal	**Esophagus_Middle**	**Middle Esophagus**
A_Pulmonary	**Pulmonary Artery**	External	Skin
A_Carotid	**Carotid Artery**	**Eye**	**Eye**
A_Brachiocephali	**Brachiocephalic Artery**	Femur	Femur
A_Coronary	**Coronary Artery**	**FemoralJoint**	**Femoral Joint**
A_Subclavicular	**Subclavicular Artery**	**FrontalLobe**	**Frontal Lobe**
A_Hypophyseal	**Hypophyseal Artery**	**GHJoint**	**Glenohumeral Joint**
Aorta	**Aorta**	Globe	Eye Globe
AnalSphincter	**Anal Sphincter**	Glottis	Glottis
Atrium	**Atrium**	GreatVessel	Great Vessel
Bladder	Bladder	Heart	Heart
BladderWall	**Bladder Wall**	**Hippocampus**	**Hippocampus**
BrachialPlexus	Brachial Plexus	**Hypothalamus**	**Hypothalamus**
Brain	Brain	Kidney	Kidney
BrainStem	Brain Stem	LargeBowel	Large Bowel
Breast	Breast	Larynx	Larynx
BronchialTree	Bronchial Tree	LacrimalGland	Lacrimal Gland
BaseOfTongue	**Base of Tongue**	Lens	Eye Lens
Carina	Carina	Lips	Lips
CaudaEquina	Cauda Equina	Liver	Liver
Cerebellum	Cerebellum	Lung	Lung
Cerebrum	Cerebrum	Mandible	Mandible
Chiasm	Optic Chiasm	**MassMuscle**	**Masseter Muscle**
CN_VII	Seventh Cranial Nerve	**Mediastinum**	**Mediastinum**
CN_VIII	Eighth Cranial Nerve	MainBronchus	Main Bronchus
Cervix	**Cervix**	**OccipitalLobe**	**Occipital Lobe**
Cochlea	Cochlea	OpticNerve	Optic Nerve
Colon	**Colon**	OralCavity	Oral Cavity
ConstrMuscle	**Constrictor Muscle**	Ovary	Ovary
Cornea	Cornea	**Parametrium**	**Parametrium**
Duodenum	Duodenum	**ParietalLobe**	**Parietal Lobe**
Ear_Middle	Middle Ear	**Pancreas**	**Pancreas**
Ear_External	External Ear	Parotid	Parotid
Esophagus	Esophagus	**PelvicBones**	**Pelvic Bones**
Esophagus_Upper	**Upper Esophagus**	PenileBulb	Penile Bulb
Esophagus_Lower	**Lower Esophagus**	**Penis**	**Penis**

Santanam L, IJROBP, 15;83(4):1344-9, 2012

Case Libraries – Learning
UCLA – Breast case library
Heart dose improvement



Objectives

1. Clinical context – Background
Problems that can be addressed with automated planning

2. Concerns
Potential problems associated with automated planning

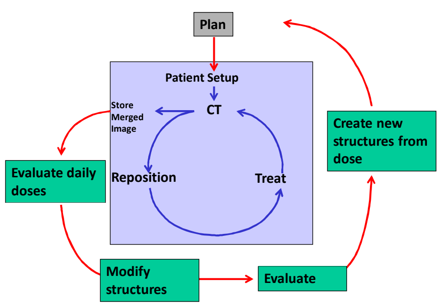
3. Possible first clinical applications
Practical steps

4. New Opportunities
Novel applications for automated planning

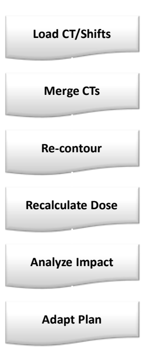
New Opportunities:
Novel Applications for
Automated Planning

Off-line Adaptive Radiotherapy

Off-line Adaptive Radiotherapy:



Adaptive Radiotherapy (ART) Workflow



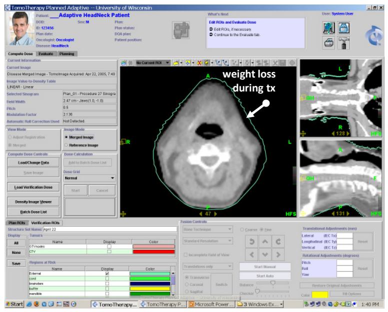
- Use CT of the day
- Estimate actual dose on CT of the day: Recalculate dose
- Adjust contours of the day
- Identify new hot/cold spots
- Adjust according to hot/cold spots
- Prospective daily dose calculation

Image and Contour Review

Compute Dose

•Adjust contours based on changes in anatomy

•Calculate dose on the daily CT (Verification Dose)

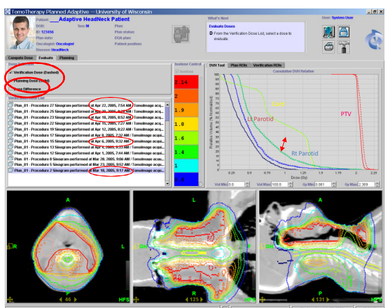


Treatment evaluation

Evaluate

Evaluate individual treatment fractions

Verification Dose vs. Planned Dose

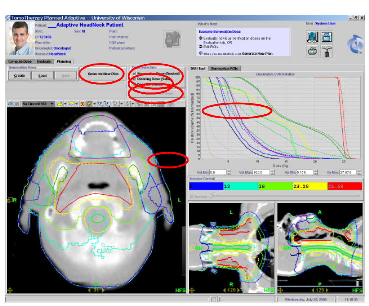


Dose Review – Replanning?

Planning

Work with a single fraction or the sum of multiple verification doses

Create contours from hot or cold spots in a particular structure



New Opportunities:
Novel Applications for
Automated Planning

On-line Adaptive Radiotherapy / Real-Time Radiotherapy

(IMAGINE THE FUTURE)

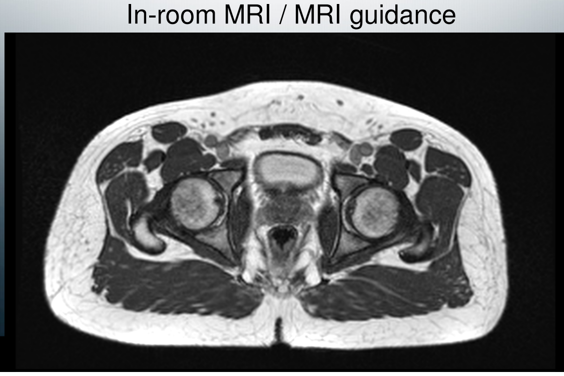
Real-Time Radiotherapy

Initial treatment plan generated automatically using prior knowledge – Best plan of the day

Assessment and adjustments:
- Daily (all fractions) with good in-room images
- On-line
- Intra-fraction variations included
- Deformable registration
- Dose accumulation (inter/intrafraction)
- Real-time automated (re)planning
- In-vivo dosimetry

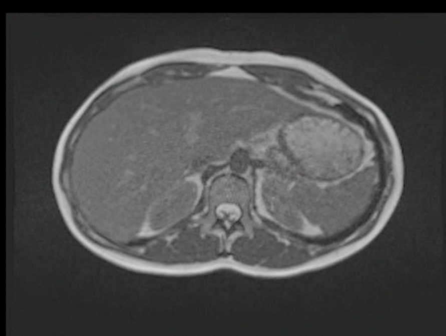
Continuous soft-tissue imaging with automated plannning / delivery

In-room MRI / MRI guidance



Pilot (Navigation) Scans

20 sec Pilot Scan

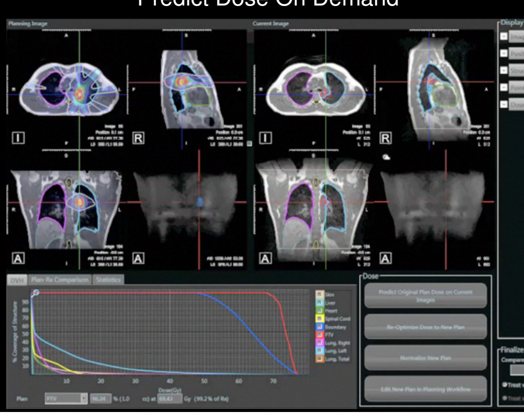


Automatically Identify & Locate Tissues

Automatically Identify & Locate Tissues

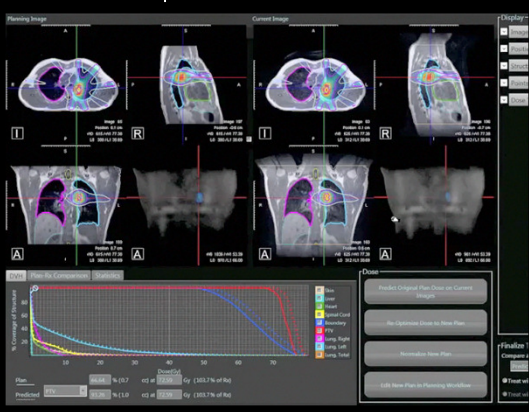
Predict Dose On Demand

Predict Dose On Demand



Optimize On Demand

Optimize On Demand

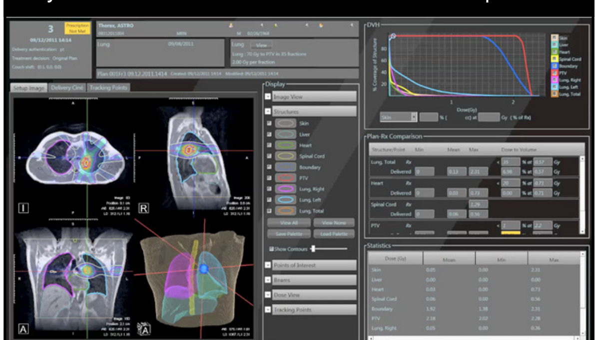


Track Tissues & Control Therapy

Track Tissues & Control Therapy

Physician Review

Physician Workstation: Overall review and supervision



Automated Planning - Conclusions

Automated treatment planning has many potential advantages from improving throughput to improving safety.

Automated treatment planning will still require significant supervision. (No change in the physician approval process for initial plans).

Simple cases (simple geometries) can be ideal first clinical applications for automated planning, but complex deliveries will require it.

In the future, automated planning will increasingly be part of our routine in generating initial plans, and/or in the context of adaptive RT.