Clinical Experience with Automated Multicriteria Optimization

Ben Heijmen, Sebastiaan Breedveld

Joint AAPM-ESTRO Symposium: Automated Treatment Planning in Clinical Practice
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Disclosures

Erasmus MC Cancer Institute has research agreements with Elekta AB (Stockholm, Sweden) and Accuray Inc (Sunnyvale, USA).

Elekta AB is preparing commercialization of the Erasmus-iCycle approach for automated multi-objective planning.

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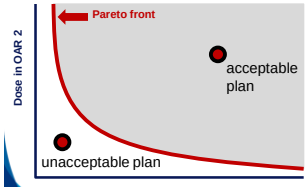
Outline

- ✓ Erasmus-iCycle
- ✓ Validation of automatic planning: comparison with manual
- ✓ Reduction of bias and enhancement of patient numbers in planning studies for treatment technique comparisons
- ✓ Challenges and Future

Erasmus-iCycle

Fully automated, multi-criterial optimization (MCO)

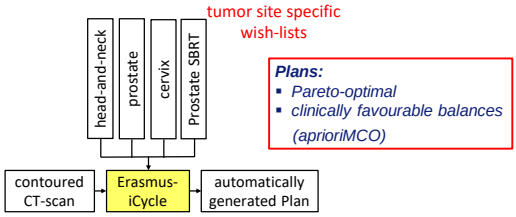


Craft et al.
- **a posteriori MCO**: user selects final, clinically favourable plan

Erasmus-iCycle
- **a priori MCO**: system automatically selects the final, clinically favourable plan on Pareto front

Erasmus-iCycle

Fully automated, multi-criterial optimization (MCO)



S. Breedveld et al. Med Phys. 2012; 39(2): 951-963

Constraints — wish-list for **prostate cancer**

	Volume	*Type*	*Limit*
	PTV	Max dose	105% of D_{Px}
	PTV	Mean dose	101% of D_{Px}
	Rectum & Anus	Max dose	102% of D_{Px}
	PTV Shell 50mm	Max dose	50% of D_{Px}
	Unspecified tissues	Max dose	105% of D_{Px}

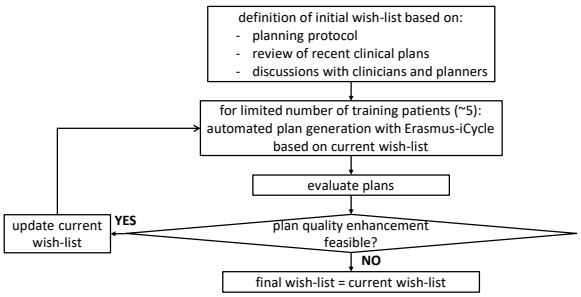
Objectives

Priority	*Volume*	*Type*	*Goal*	*Parameters*
1	PTV	↓LTCP	0.8	D_{Px} = 78 Gy, α = 0.8
2	Rectum	↓EUD	20 Gy	k = 12
3	Rectum	↓EUD	10 Gy	k = 8
4	PTV shell 5 mm	↓Max dose	80% of D_{Px}	
	Skin ring 20 mm	↓Max dose	20% of D_{Px}	
5	Rectum	↓Mean dose	5 Gy	
6	Anus	↓Mean dose	5 Gy	
7	Bladder	↓Mean dose	5 Gy	
8	PTV Shell 15 mm	↓Max dose	50% of D_{Px}	
	PTV Shell 25 mm	↓Max dose	30% of D_{Px}	
9	Left & Right Femoral Heads	↓Max dose	50% of D_{Px}	

S. Breedveld et al. Med Phys. 2012; 39(2): 951-963.

same wish-list used for all patients (no patient-specific tweaking)

Generation of wish-lists: improve on training plans

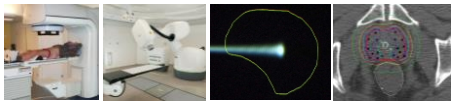


Highlights of Erasmus-iCycle:

- ✓ *automatically one Pareto-optimal plan, clinically favourable trade-offs, OAR doses as low as feasible*
- ✓ *no operator dependence of plan quality, consistently high*
- ✓ *huge reduction in planning workload*

Highlights of Erasmus-iCycle:

- ✓ *automated beam profile **and** beam angle optimization*
- ✓ *versions for IMRT/VMAT, Cyberknife and protons (version for BT being developed, AAPM 2018, Kolkman-Deurloo et al.)*
- ✓ *highly suited for 'unbiased' treatment technique comparisons; automated planning with same wish-list*



Erasmus-iCycle

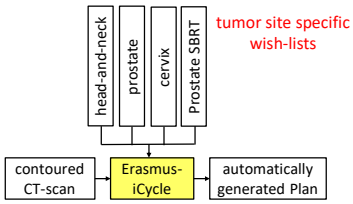
Fully automated, multi-criterial optimization (MCO)

Clinical implementation

Erasmus-iCycle

Fully automated, multi-criterial optimization (MCO)

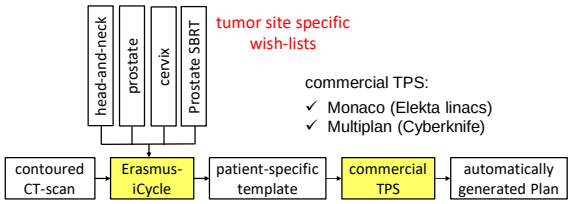
Clinical implementation



Erasmus-iCycle

Fully automated, multi-criterial optimization (MCO)

Clinical implementation



Erasmus-iCycle is **in routine clinical use** for VMAT and IMRT:

- Head-and-neck cancer
- Cervical cancer (Adaptive)
- Prostate cancer
- Advanced lung cancer

(~40% of curative patients)

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Validation of automated planning based on Erasmus-iCycle

- Head and neck cancer
- Prostate and seminal vesicles
- Prostate and vesicles and lymph nodes
- Prostate SBRT with Cyberknife
- Gastric cancer
- Spinal metastases
- Cervical cancer
- Advanced lung cancer

Pubmed: Heijmen b*

Head and Neck cancer

Toward Fully Automated Multicriterial Plan Generation: A Prospective Clinical Study

Peter W.J. Voet, RTT, Maarten L.P. Dirkx, PhD, Sebastiaan Breedveld, MSc, Dennie Fransen, RTT, Peter C. Levendag, MD, PhD, and Ben J.M. Heijmen, PhD

Int J Radiat Oncol Biol Phys. 2013; 85(3): 866-72.

in 97% of cases the automatic plan was selected by physician for treatment

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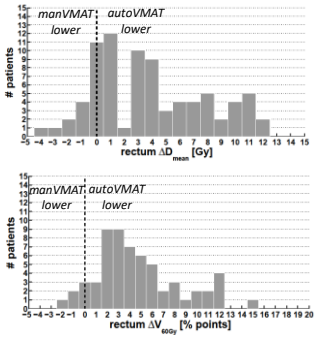


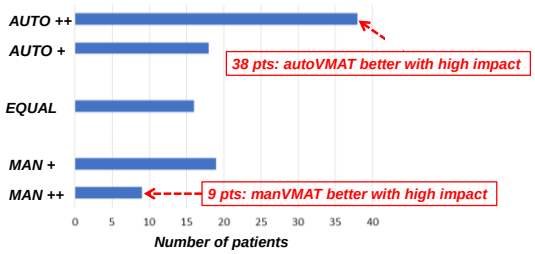
4 European centers

80 prostate patients (prostate + vesicles)

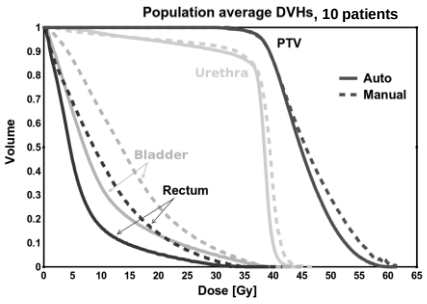
B. Heijmen et al. Radiother. Oncol. 2018 in press

AUTOplan vs. MANplan for prostate cancer

blinded clinician's side-by-side plan scoring



B. Heijmen et al. Radiother. Oncol. 2018 Jun 30, in press



Prostate SBRT Cyberknife

L. Rossi et al. Acta Oncol. 2018 July 2: published on-line, in press

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Issues with treatment planning studies for treatment technique comparisons

- ➢ Planning is manual, i.e. interactive, trial-and-error
- ➢ Different planning skills/experience for different treatment techniques
- ➢ Different TPSs for different techniques

⇨ ***bias in treatment technique comparisons***
⇨ ***low patient numbers***

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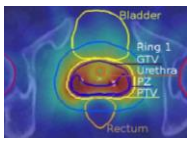
Reduce bias, enhance patient numbers with Erasmus-iCycle:

- ✓ Fully automated planning for all techniques
- ✓ Same TPS, same optimization engine/schedule (wish-list) for both techniques

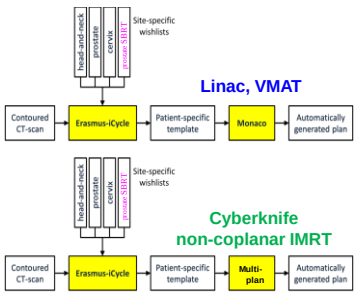
Prostate SBRT: VMAT vs. Cyberknife



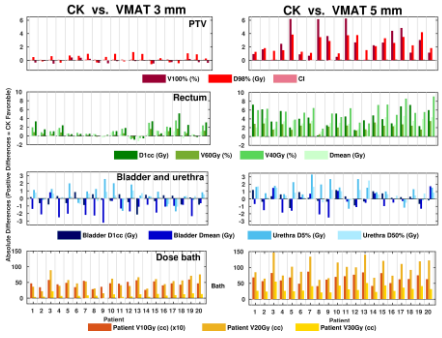
*Automatically generate **3 plans** for 20 patients:*

1. ***CK, 3 mm CTV-PTV margin** (as clinical, tumor tracking)*
2. ***VMAT, 5 mm margin** (no tracking, no rotation correction)*
3. ***VMAT, 3 mm margin** (clinically not feasible)*

L. Rossi et al. Acta Oncol. 2018, in press



Erasmus-iCycle: Breedveld, Heijmen, et al, Med Phys. 39(2), p 951-963, 2012



L. Rossi et al. Acta Oncol. 2018 July 2: published on-line

Blinded clinician's side-by-side plan comparisons

CK vs. $VMAT_{5mm}$

	CK better			Equal	VMAT better		
	😀	🙂	😐	😐	😐	🙂	😀
PTV	4	6	8	2			
Rectum	16	2	2				
Bladder		3	6	11			
Urethra	3	7	5	3	2		
Overall	11	8	1				

Contents lists available at ScienceDirect

Radiotherapy and Oncology

journal homepage: www.thegreenjournal.com

Original article

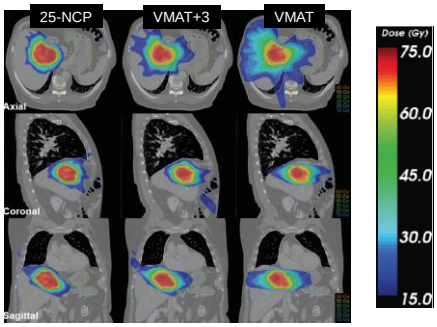
VMAT plus a few computer-optimized non-coplanar IMRT beams (VMAT+) tested for liver SBRT

Abdul Wahab M. Sharfo *, Maarten L.P. Dirkx, Sebastiaan Breedveld, Alejandra Méndez Romero, Ben J.M. Heijmen

Department of Radiation Oncology, Erasmus MC Cancer Institute, Rotterdam, The Netherlands

Radiother Oncol. 2017;123(1):49-56.

15 patients
- VMAT
- VMAT+1, VMAT+2,…VMAT+5
- NCP-15, NCP-25



29

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liver SBRT: IGRT vs. daily adaptive re-planning

Physics Contribution

Adaptive Liver Stereotactic Body Radiation Therapy: Automated Daily Plan Reoptimization Prevents Dose Delivery Degradation Caused by Anatomy Deformations

Suzanne M. Leinders, MSc,*,† Sebastiaan Breedveld, MSc,* Alejandra Méndez Romero, MD,* Dennis Schaart, PhD,† Yvette Seppenwoolde, PhD,* and Ben J.M. Heijmen, PhD*

*Erasmus Medical Center-Daniel den Hoed Cancer Center, Rotterdam, The Netherlands, and †Delft University of Technology, Delft, The Netherlands

Int J Radiat Oncol Biol Phys. 2013 Dec 1;87(5):1016-21

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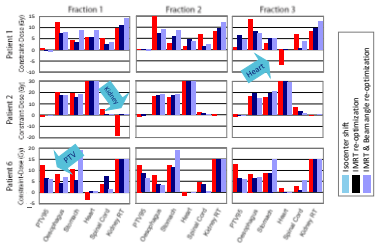
Results



Modest impact of daily beam angle re-optimization

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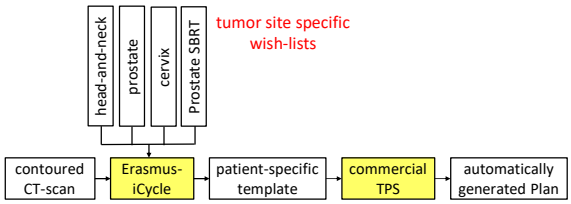

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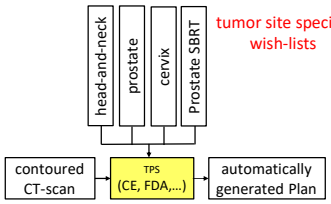

intensive upfront time investment of doctors

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automation
- **≠ no planning work**
- **≠ personnel reduction for planning**

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Erasmus MC contributors:

Sebastiaan Breedveld, Abdul Sharfo, Linda Rossi, Rens van Haveren, Bas Schipaanboord, Rik Bijman, Ybing Wang, Andras Zolnay, Erik-Jan Tromp Steven Habraken, Patricia Cambraia Lopes Ferreira, Maarten Dirkx, Wilco Schillemans, Joan Penninkhof, Steven Petit, Inger-Karine Kolkman, Mischa Hoogeman, Erica Venema, Christa Timmermans, Alejandra Mendez, Luca Incrocci, Jan-Willem Mens, Gerda Verduyn, Marjan van de Pol, Cecile Janus, Joost Nuyttens, Ben Heijmen

and many (inter)national collaborators


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Early registration:
21 August 2018
Late registration:
20 October 2018
No onsite registration.
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