Do we still need natural intelligence in radiation oncology?

RO-001

on behalf of

World Association of Robo Sapiens in Healthcare (WARSH)

92nd OECI Oncology Days

16. June 2070, CYBERSPACE 001.007.2345.213.8552

Artificial Intelligence in radiation oncology

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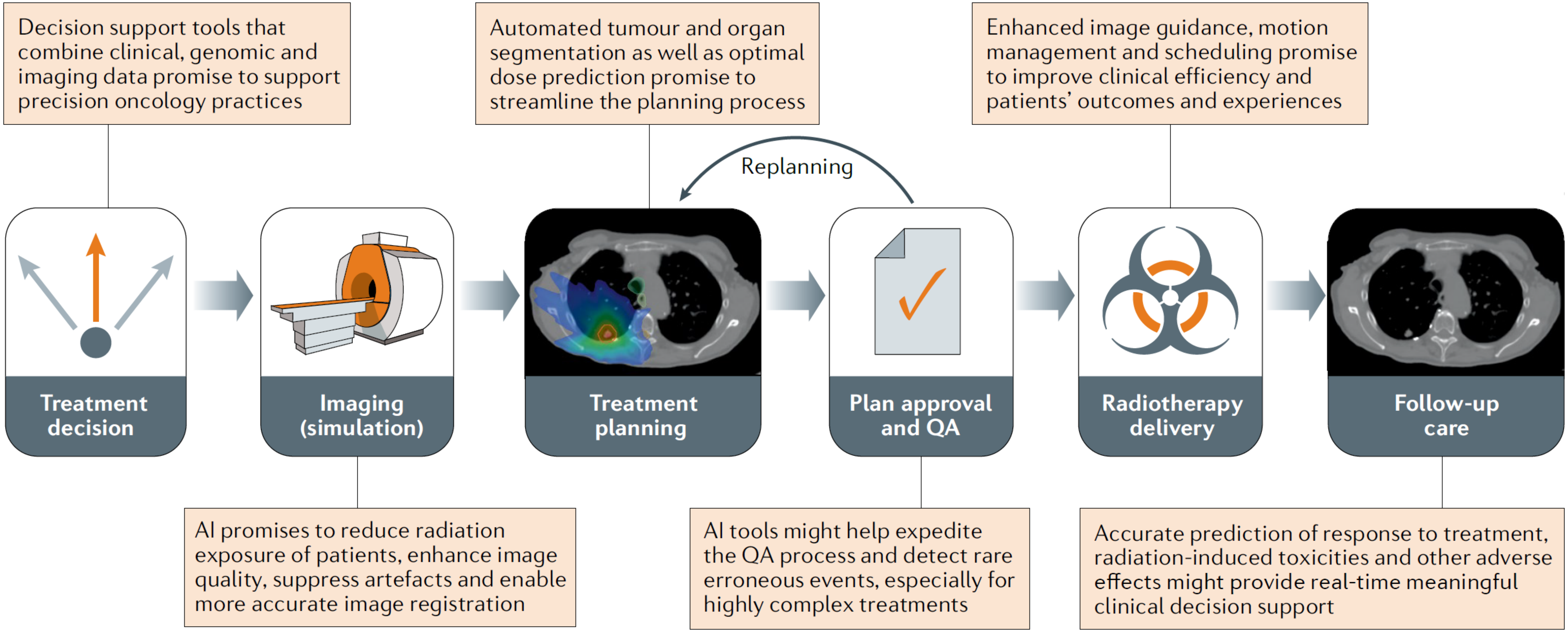
DISCLOSURES

No disclosures.

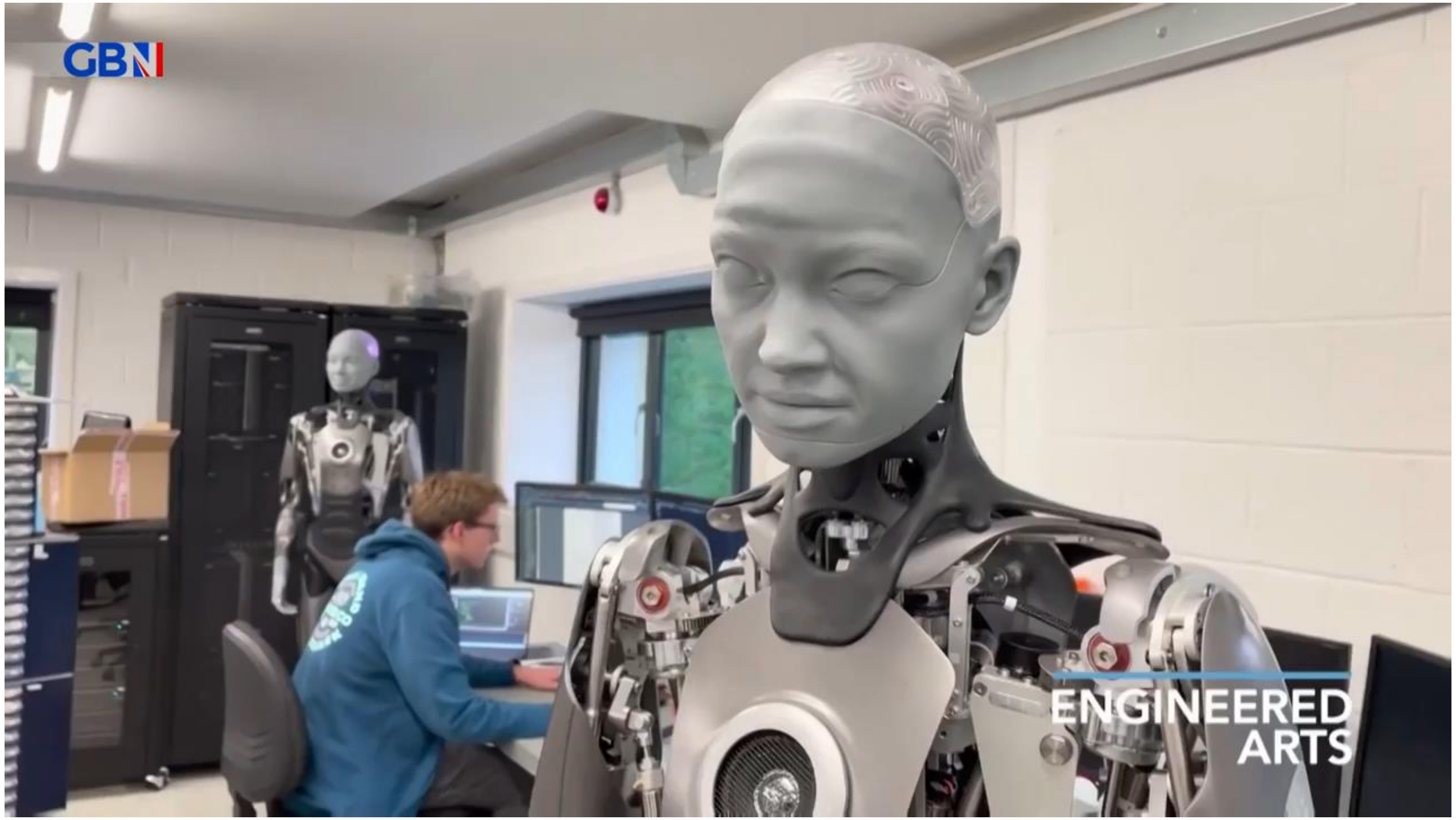
Where AI in radiation oncology can be used?

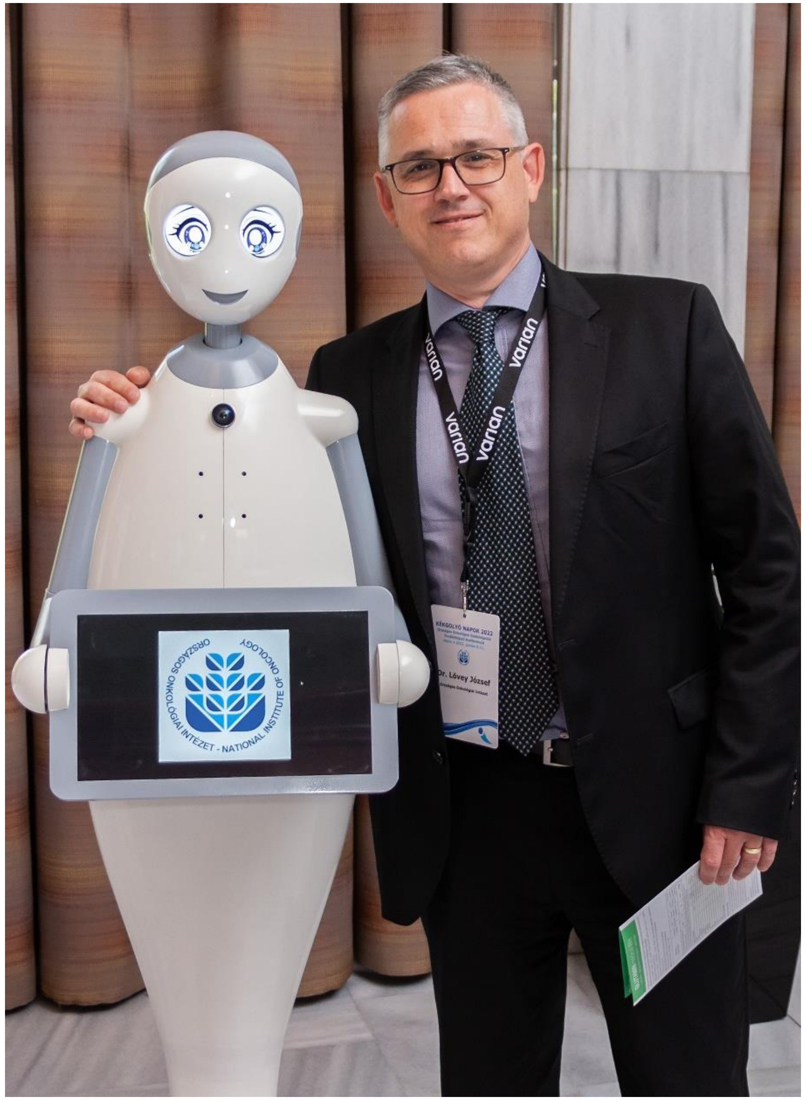
Among many useful areas

AI can be used also for everything



Nat Rev Clin Oncol (17), 771-782, 2020





ENJOY ROBOTICS

Why radiation oncology is a good terrain to AI?

- RO lives on **images**
  - Image processing (one of the strongest field in AI)
  - Different image modalities / image fusion
  - Images for planning, verification, (prediction, outcome)
- Radiotherapy is a very **formalized industrial like** process
- Well-defined **rules**
- Solid **data**
- Large number of **algorithms** already used
- Very advanced on **QA**
- Decreasing the influence of **human error**

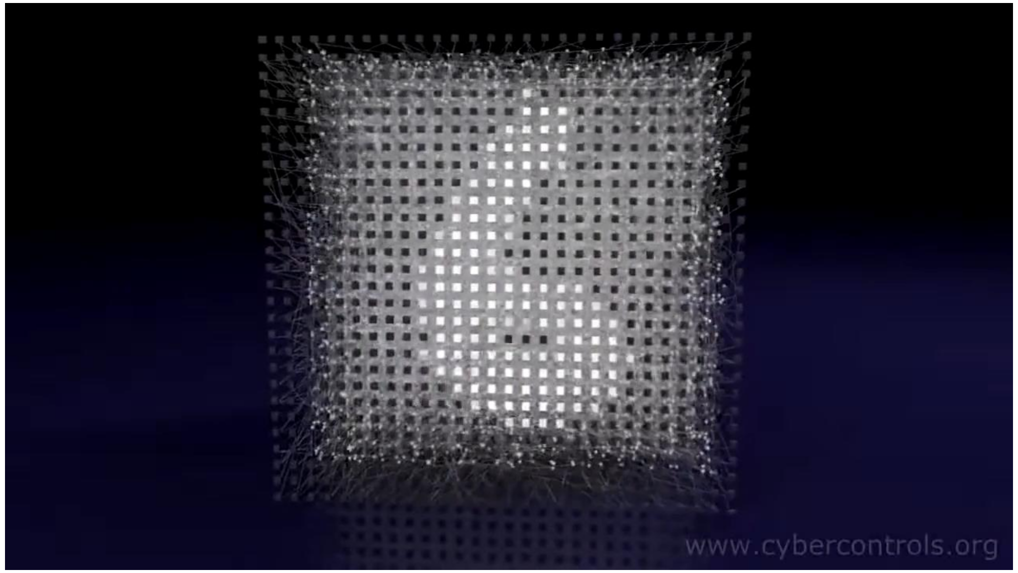


Image quality enhancement

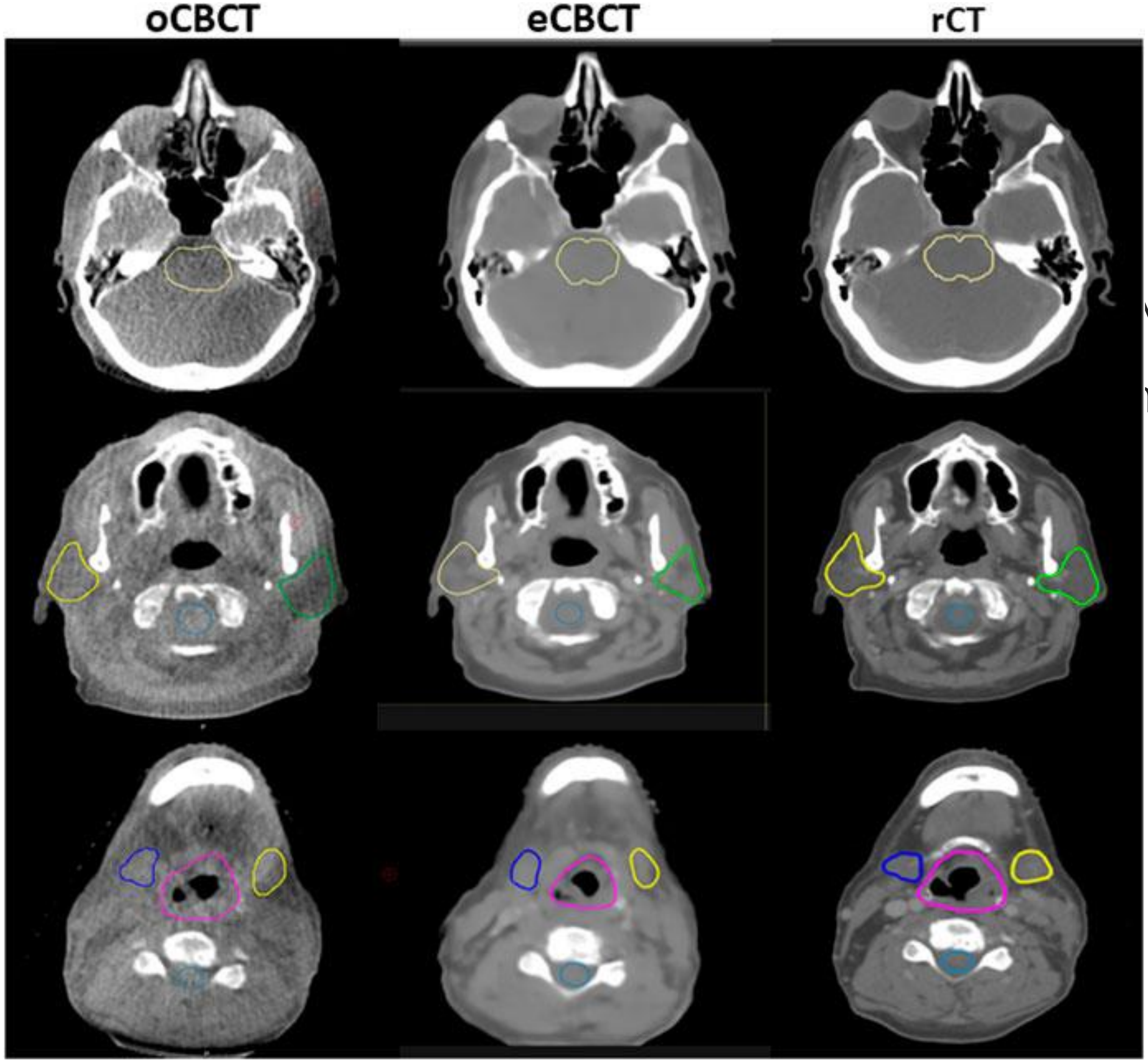
Image quality is often a problem in RO

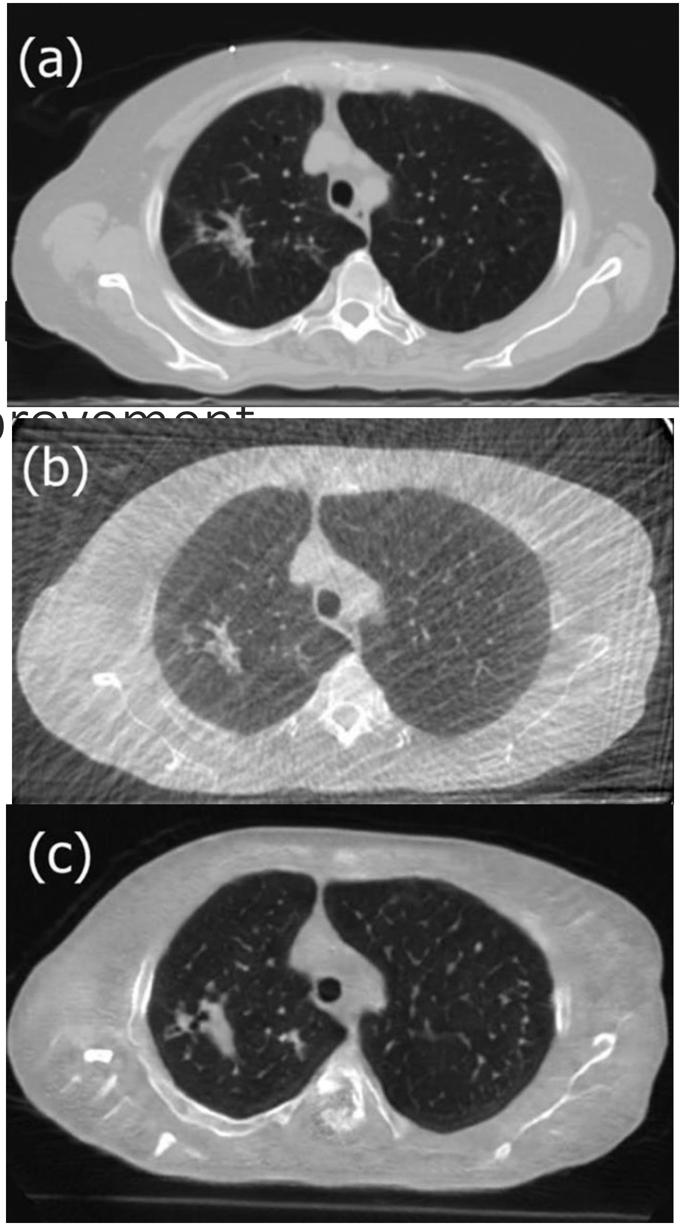
CBCT look quite fine but still there is a room for improvement

Using **MR**-s with weaker magnetic field (eg. open MR for brachytherapy)

AI can helps to

- Increase image quality
- **Decrease additional radiation** (e.g. daily CBCT) during IGRT
- Helps in **adaptive radiation** therapy





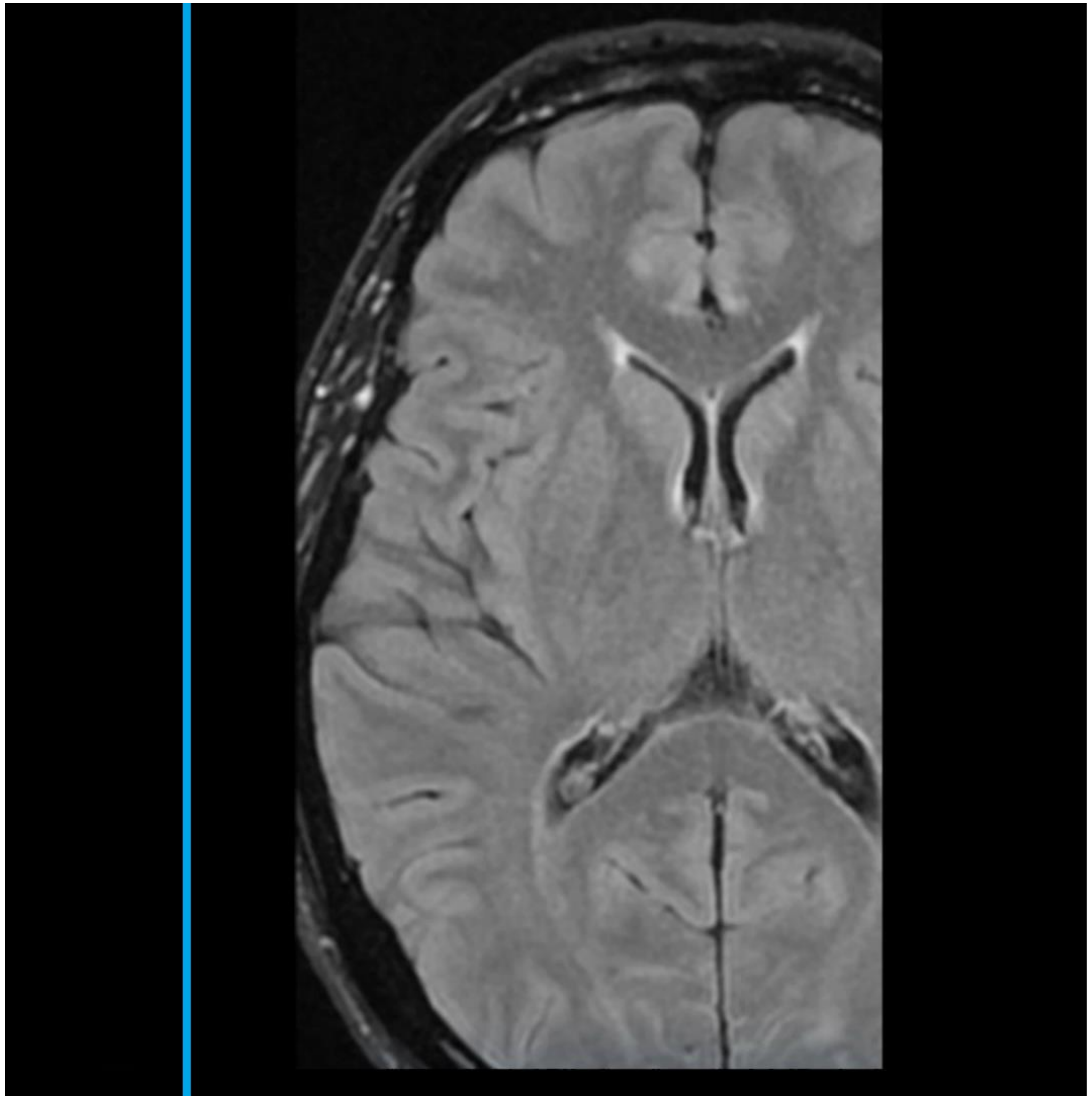
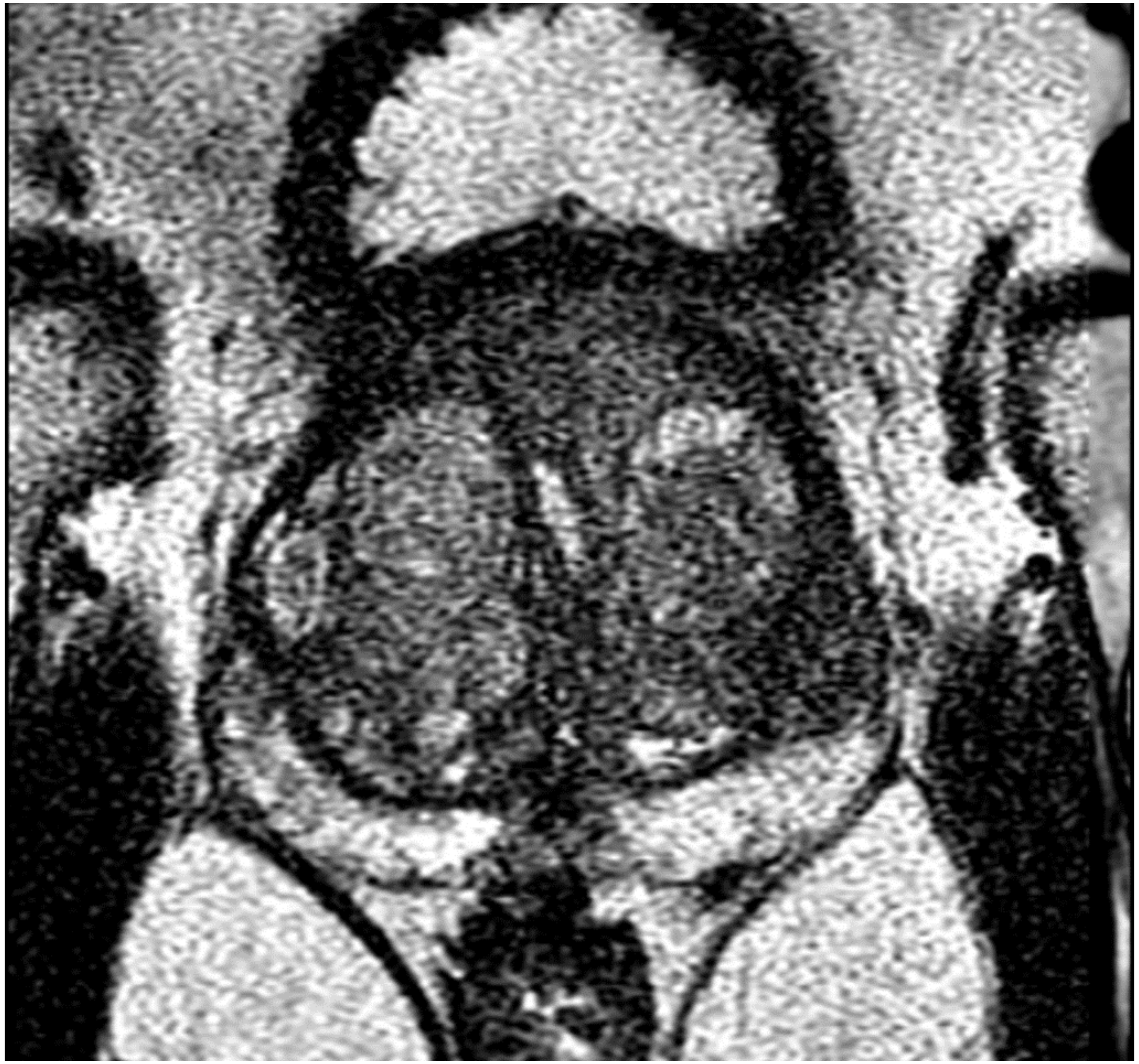
MSCT

4D CBCT

AI CBCT

Chen et al. Front. Artif. Intell., 11 February 2021

Usui et al. Radiation Oncology (2022) 17:69

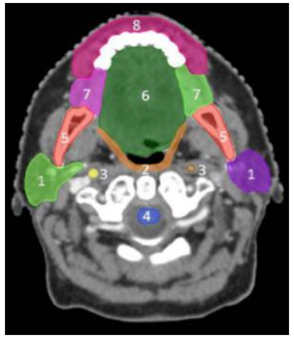



GE HEALTHCARE, courtesy of Almos Elekes

Synthetic CT from MR / MR-only radiotherapy

Present workflow
MR-assisted

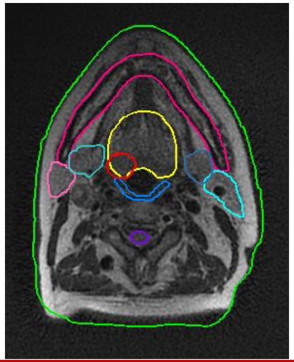
Primary modality CT



CT-based target and organ contouring

Registration

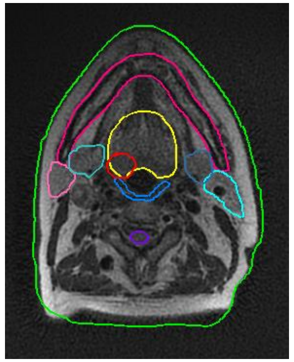
Supporting modality MR

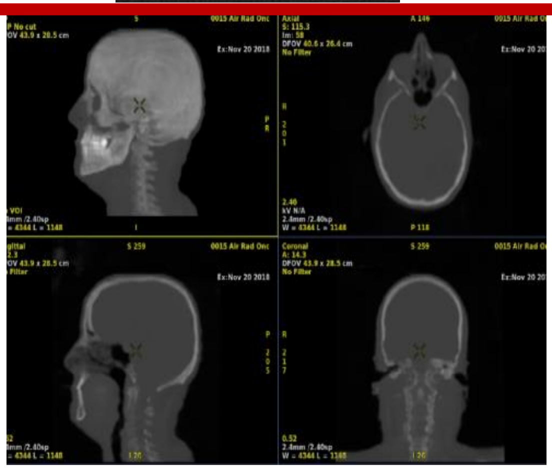


MR-based target and organ contouring

Future workflow
MR-only

Primary modality MR





MR-based synthetic CT

Courtesy of Laszlo Rusko, GE HEALTHCARE

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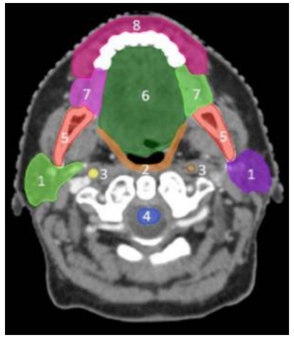

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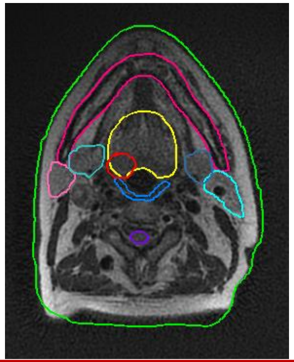

MR-based target and organ contouring

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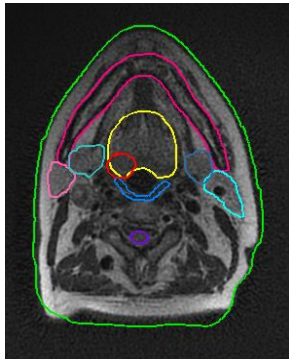
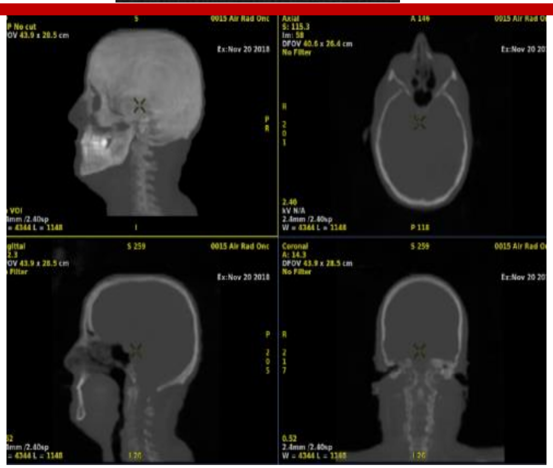


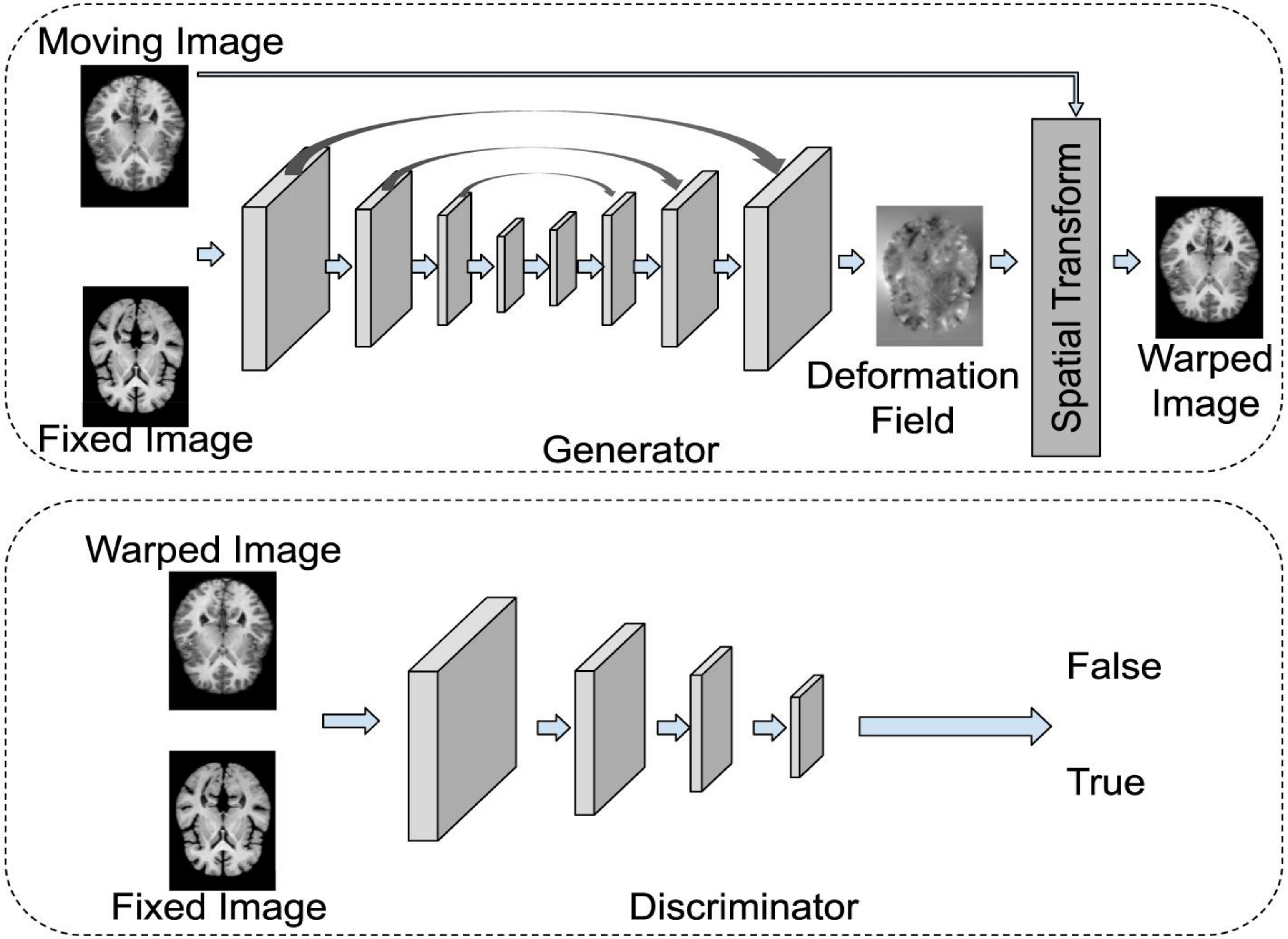


MR-based synthetic CT

Courtesy of Laszlo Rusko, GE HEALTHCARE

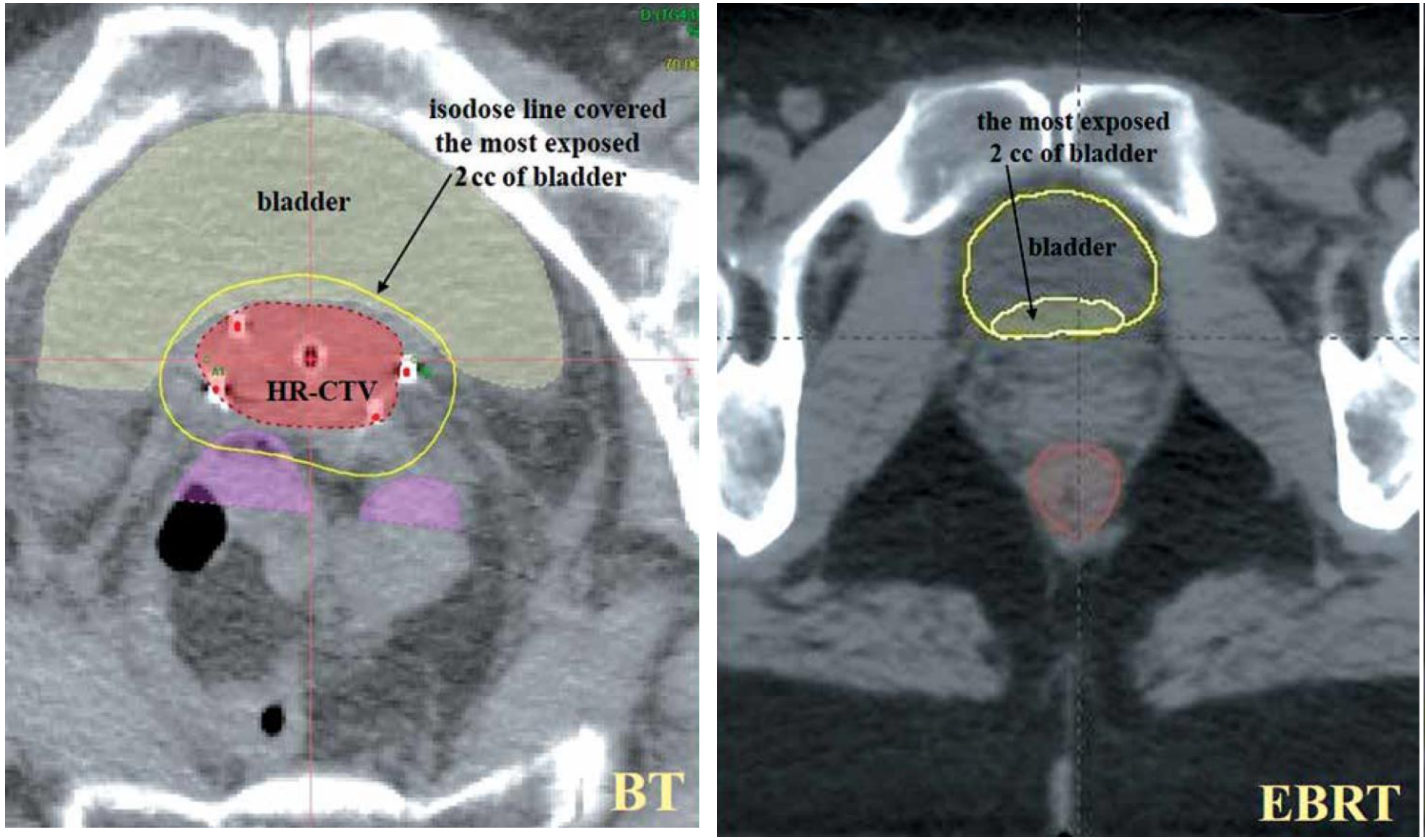
P No cut
OV 43.9 x 28.5 cm
S
0015 Air Rad Onc
Ex:Nov 20 2018
P
R
VOI
mm /2.40sp
= 4344 L = 1148
I
Axial
S: 115.3
Im: 58
DFOV 40.6 x 26.4 cm
No Filter
A 146
0015 Air Rad O
Ex:Nov 20 20
R
2
0
1
2.40
kV N/A
2.4mm /2.40sp
W = 4344 L = 1148
P 118
gittal
2.3
OV 43.9 x 28.5 cm
Filter
S 259
0015 Air Rad Onc
Ex:Nov 20 2018
P
2
0
5
mm /2.40sp
= 4344 L = 1148
Coronal
A: 14.3
DFOV 43.9 x 28.5 cm
No Filter
S 259
0015 Air Rad O
Ex:Nov 20 20
R
2
1
7
0.52
2.4mm /2.40sp
W = 4344 L = 1148

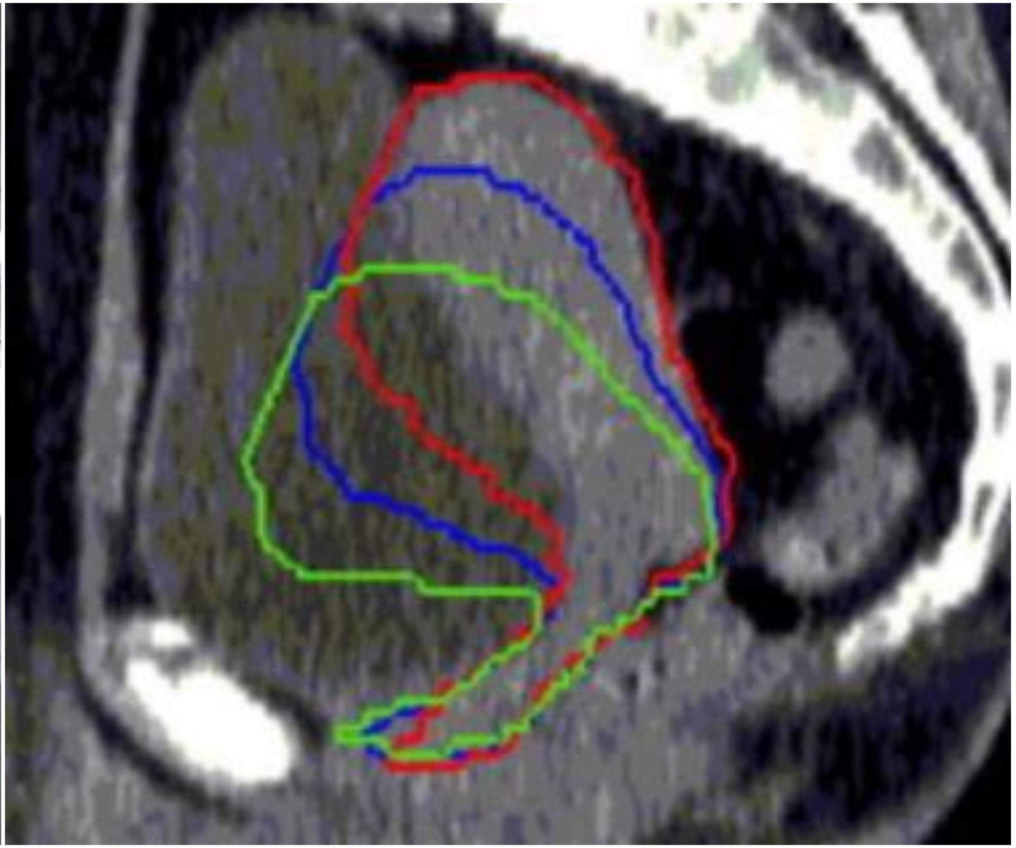
Deformable image registration



Xiang Chen *et al* 2021 *Prog. Biomed. Eng.* **3** 012003

Dose summation / adaptive radiotherapy





Föhlich et al. J Contemp Brachytherapy. 2019

Nováková S, RO 2017

Autocontouring OAR / target volumes

Quality of segmentation influences

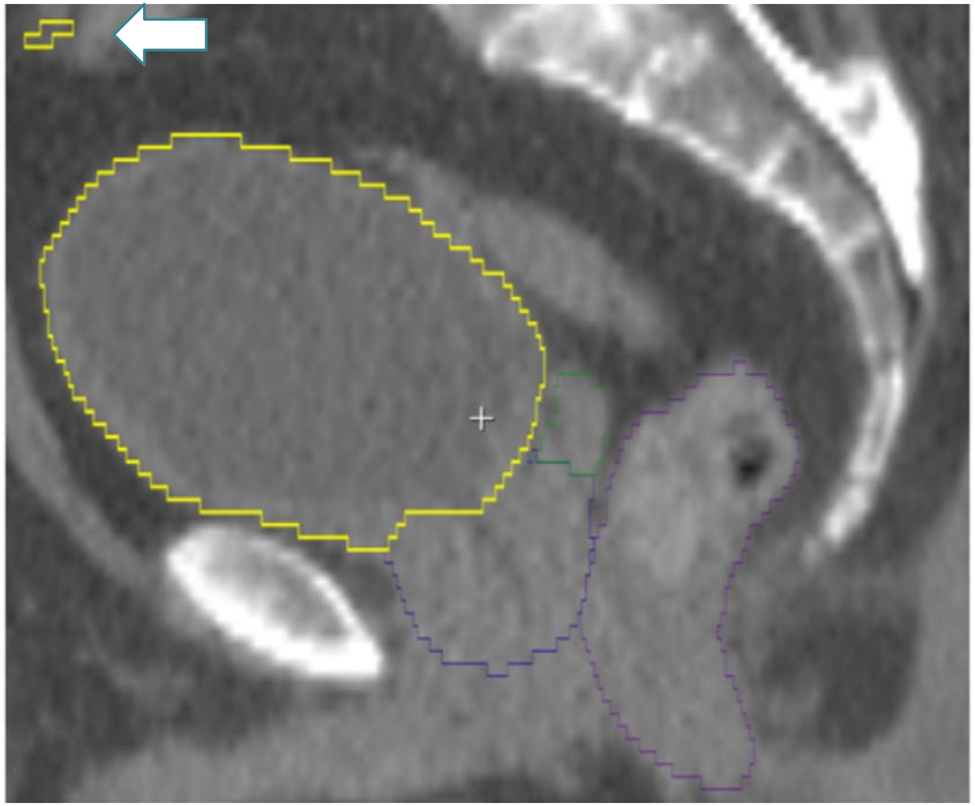
- Tumour control
- Side effects

Auto segmentation offers

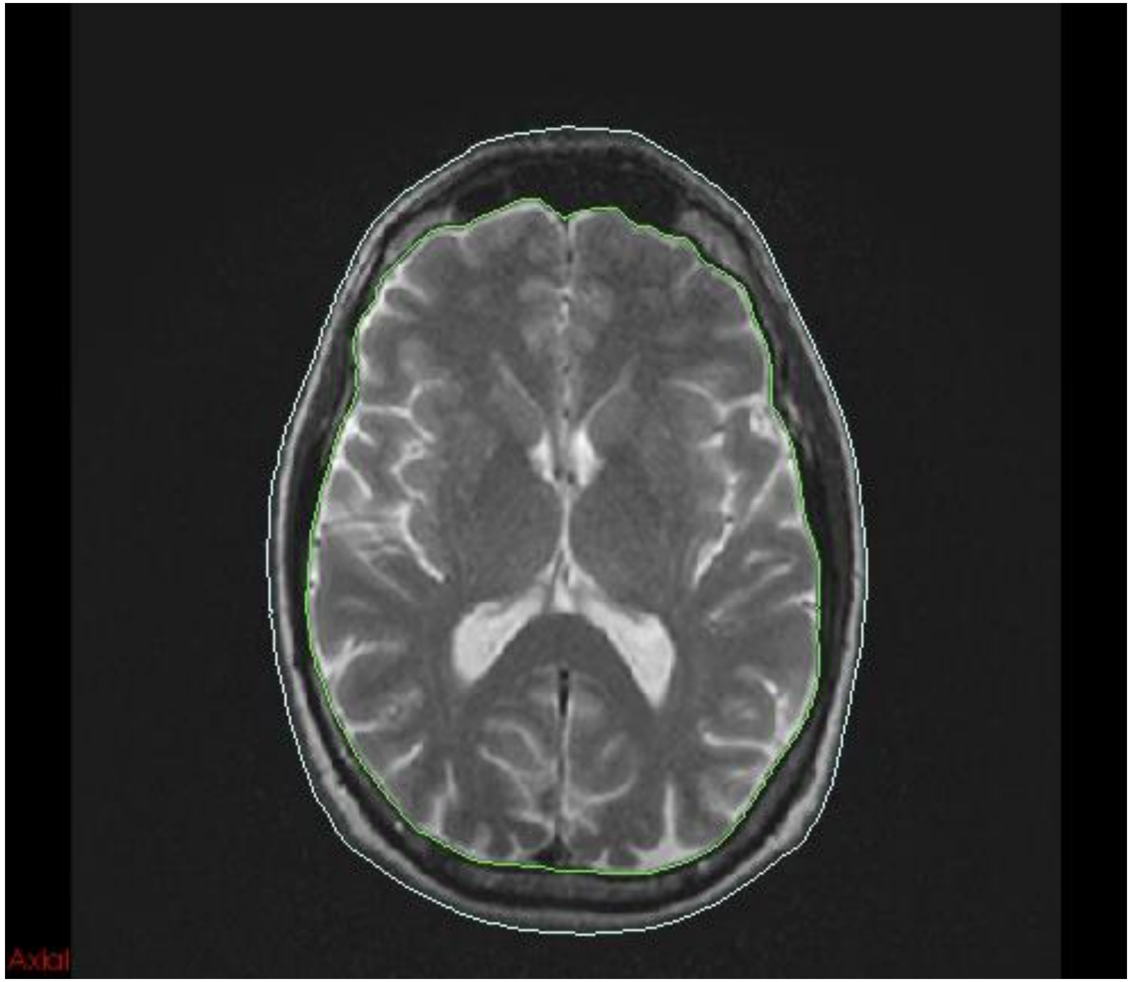
- Consistency
- Decreased inter-observer variability
- More accurate dose calculation
- Decrease in the need of human resources

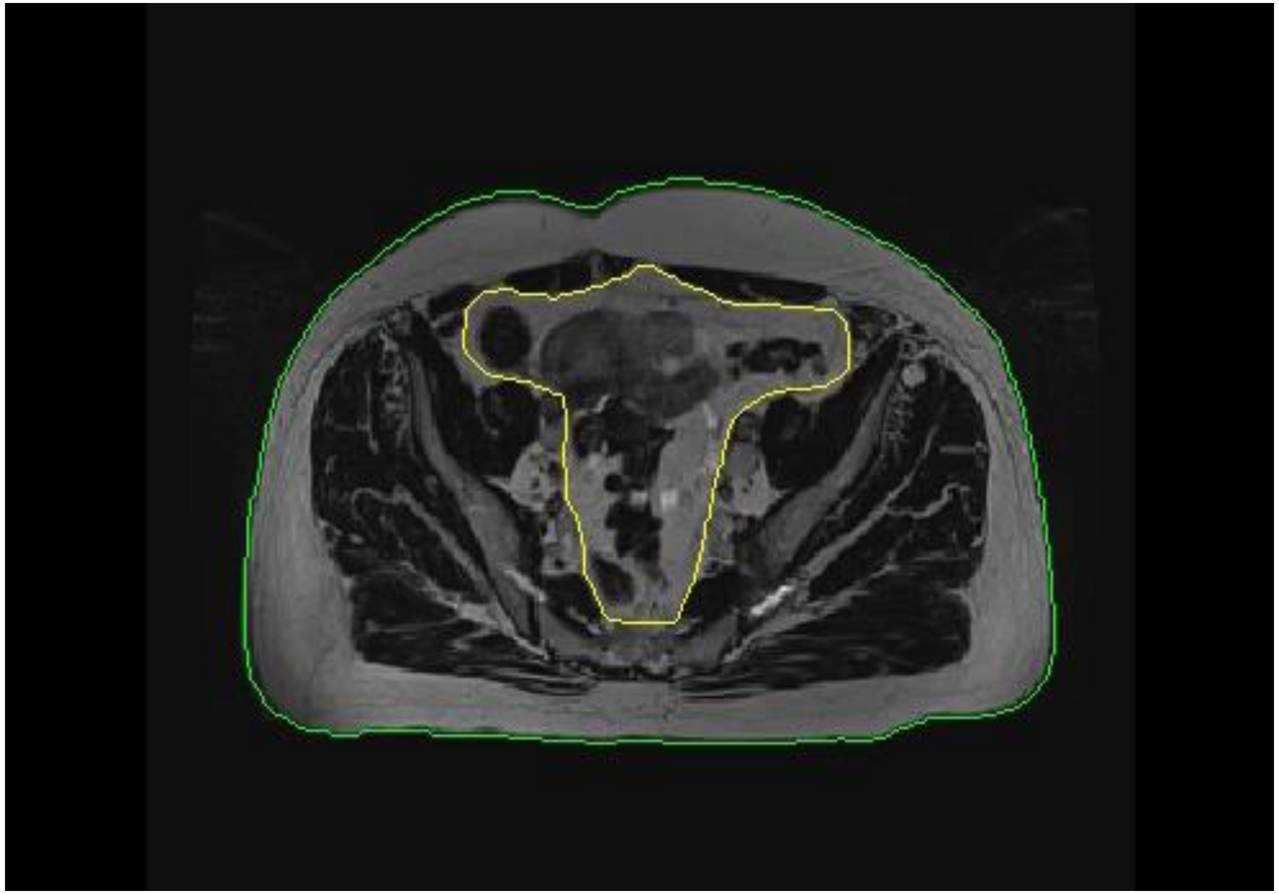
Challenges

- Image quality
- Artefacts
- Delineation accuracy (post processing)
- Small errors

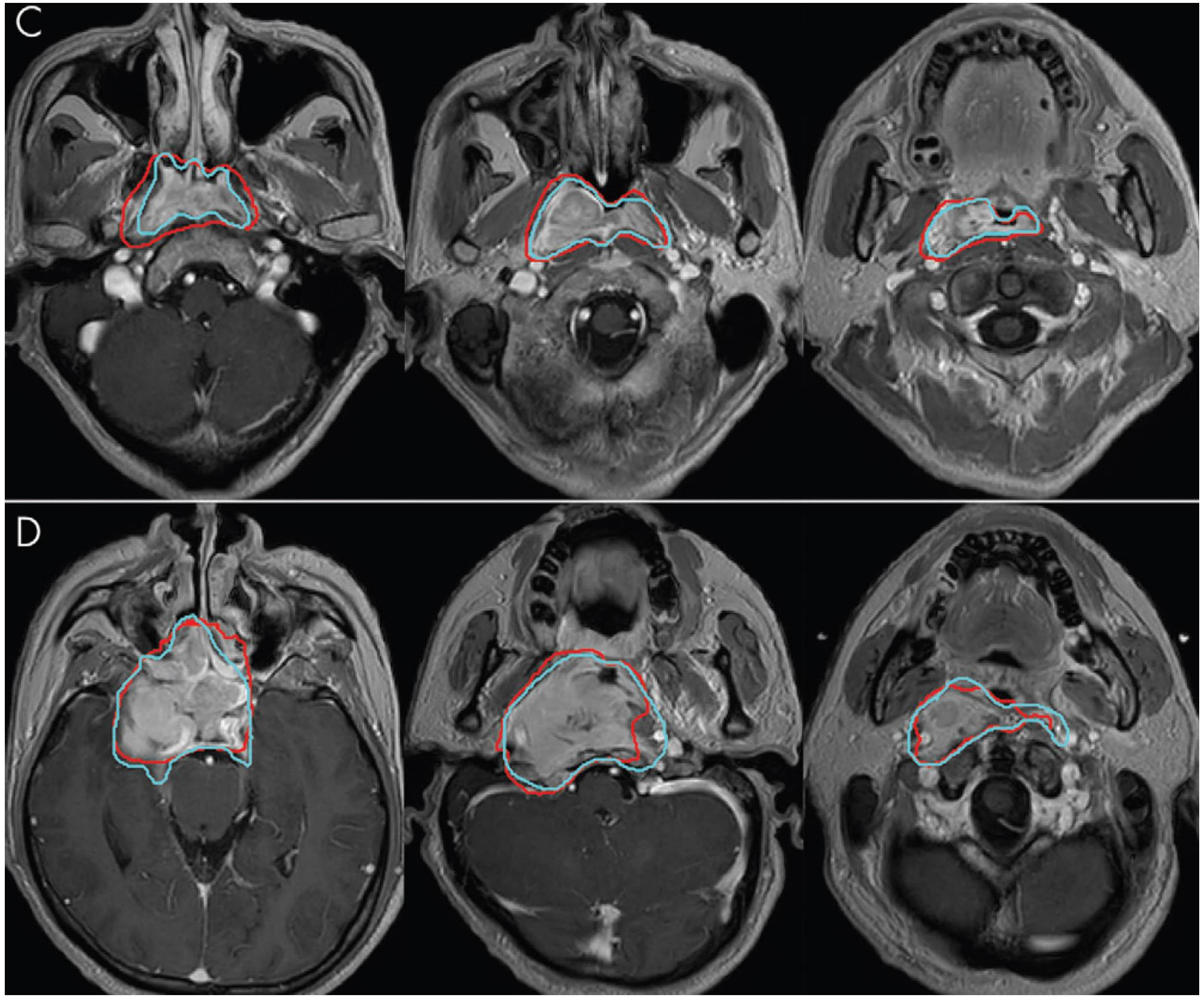


CERN IdeaSquare J Exp Innov 2017;1:3e12

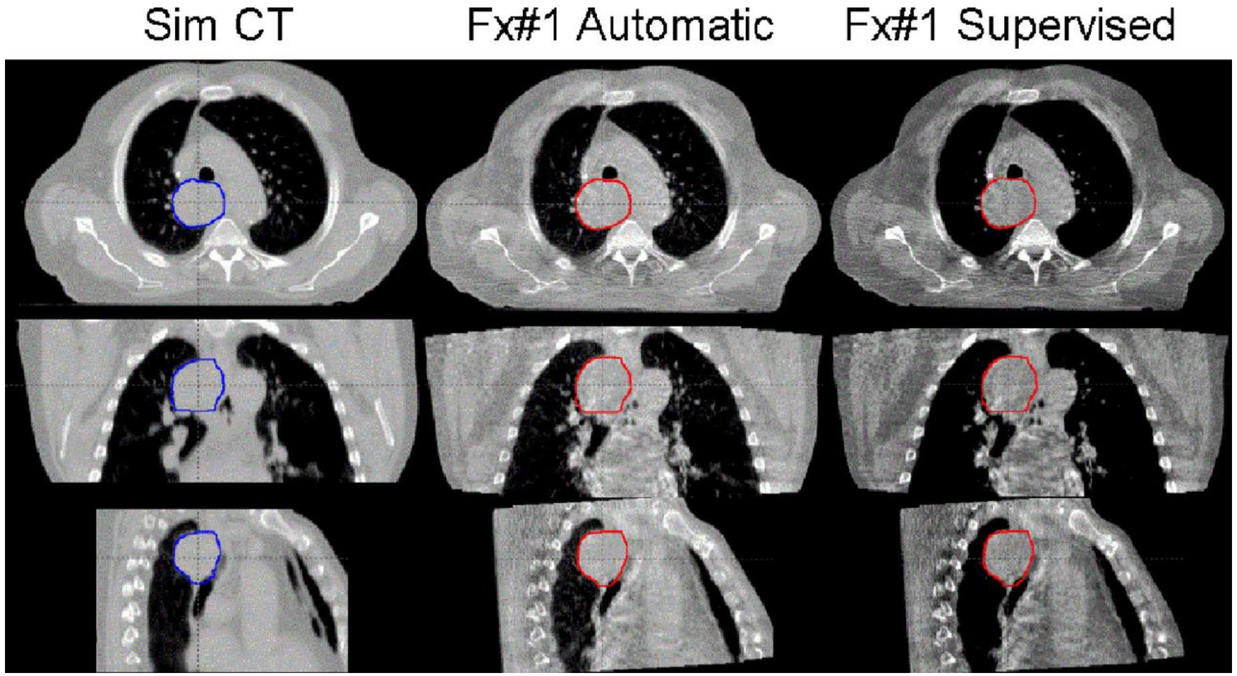




Courtesy of Laszlo Rusko, GE HEALTHCARE

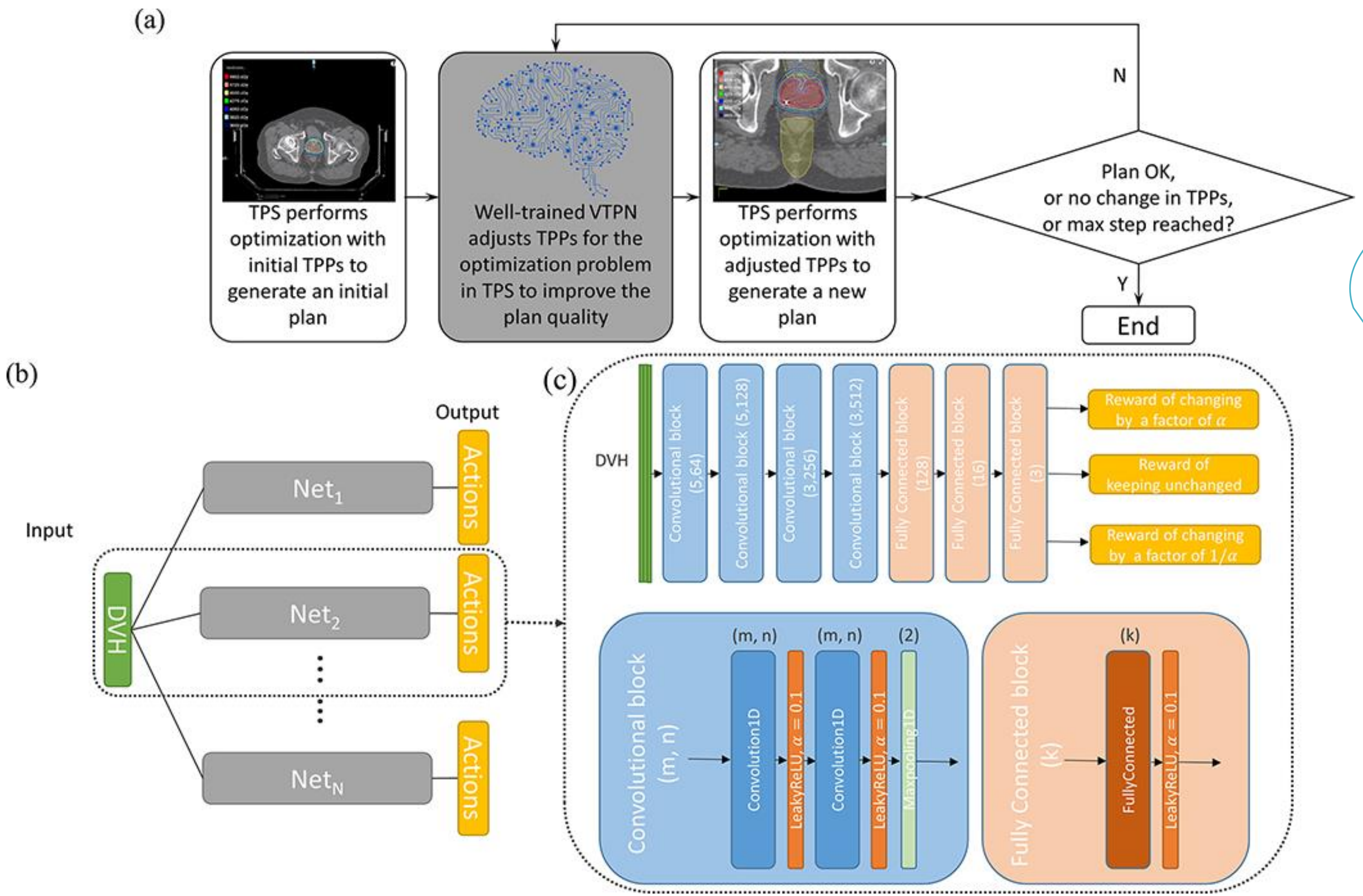


Radiology 2019; 291:677–686

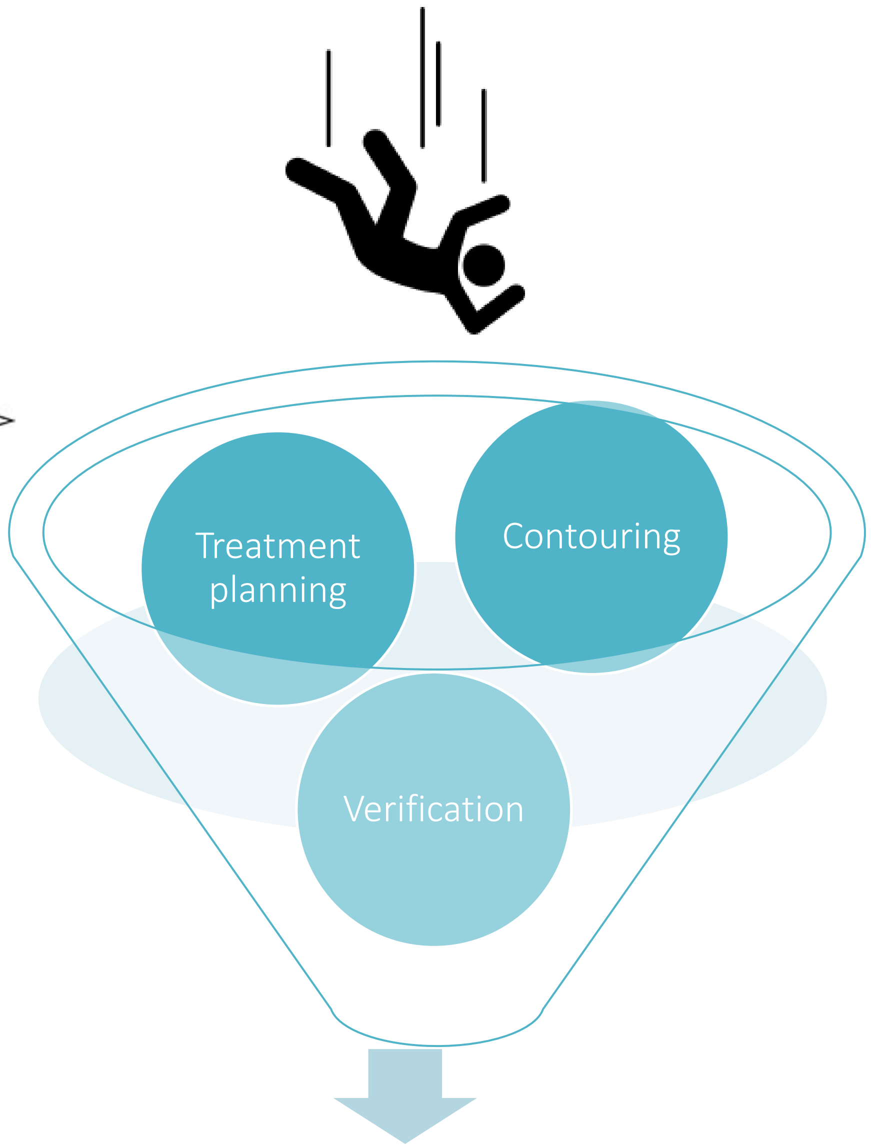


Practical Radiation Oncology (2022)
https://doi.org/10.1016/j.prro.2021.12.017

(Fully) Automated planning

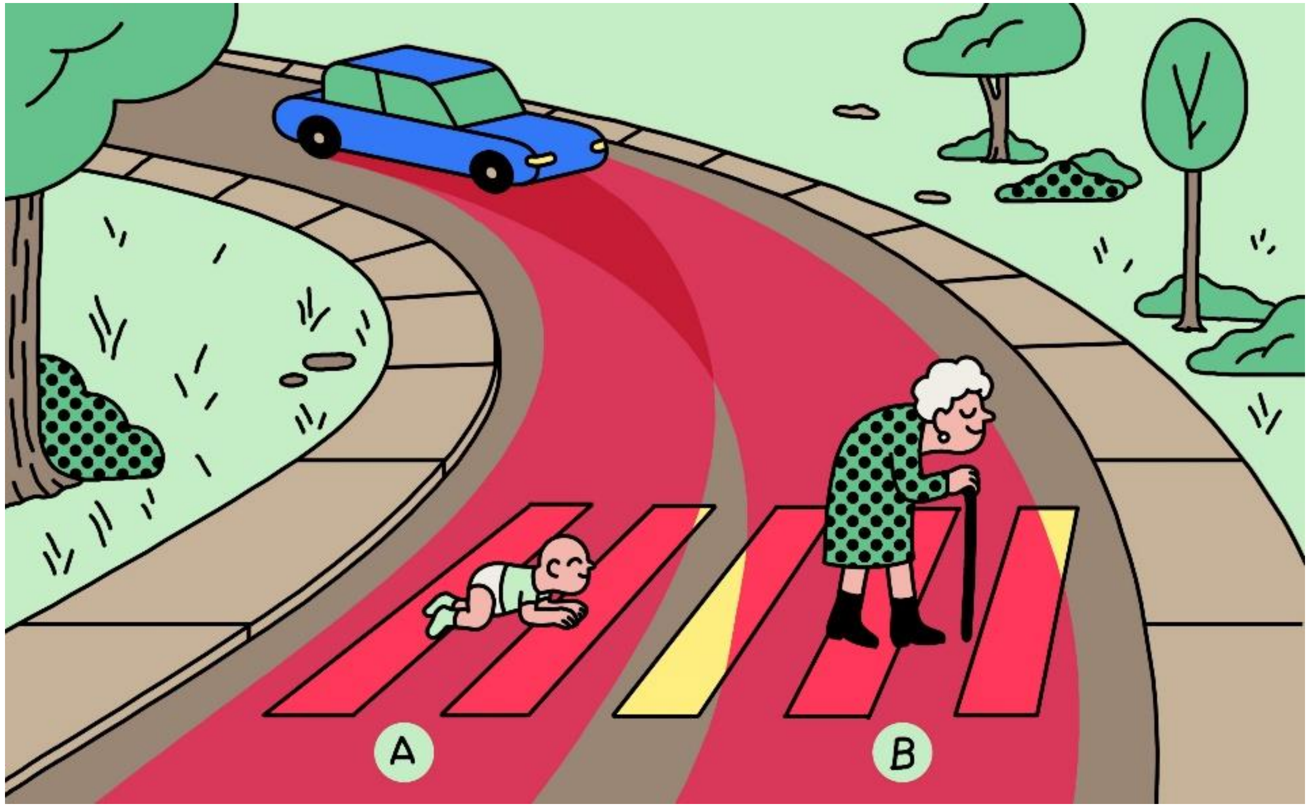


Med Phys. 2021 Apr;48(4):1909-1920.



Ready and verified plan

(Fully) Automated planning



MIT technology review

Competition between

Effect (local control) and **side effects**

Between side effects

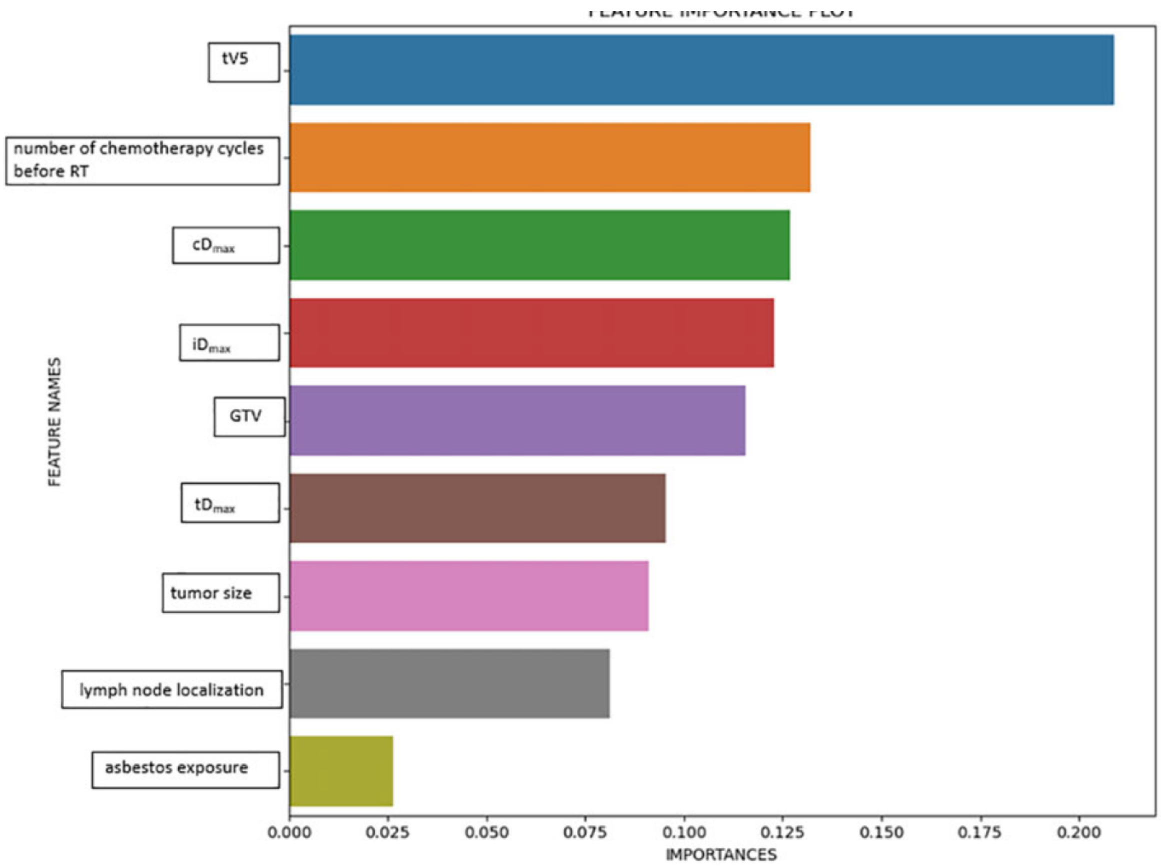
Young curable female cancer patient

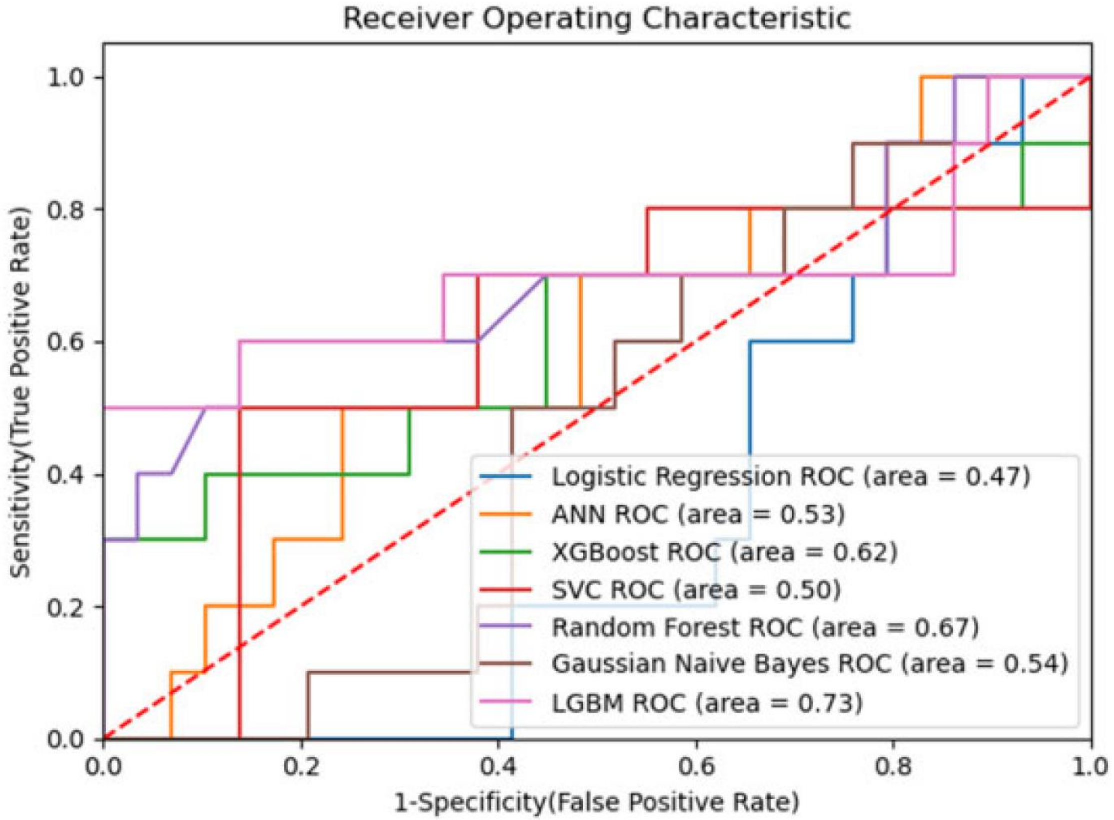
Breast dose weight?

Coronary artery dose weight?

Secondary cancer or heart disease?

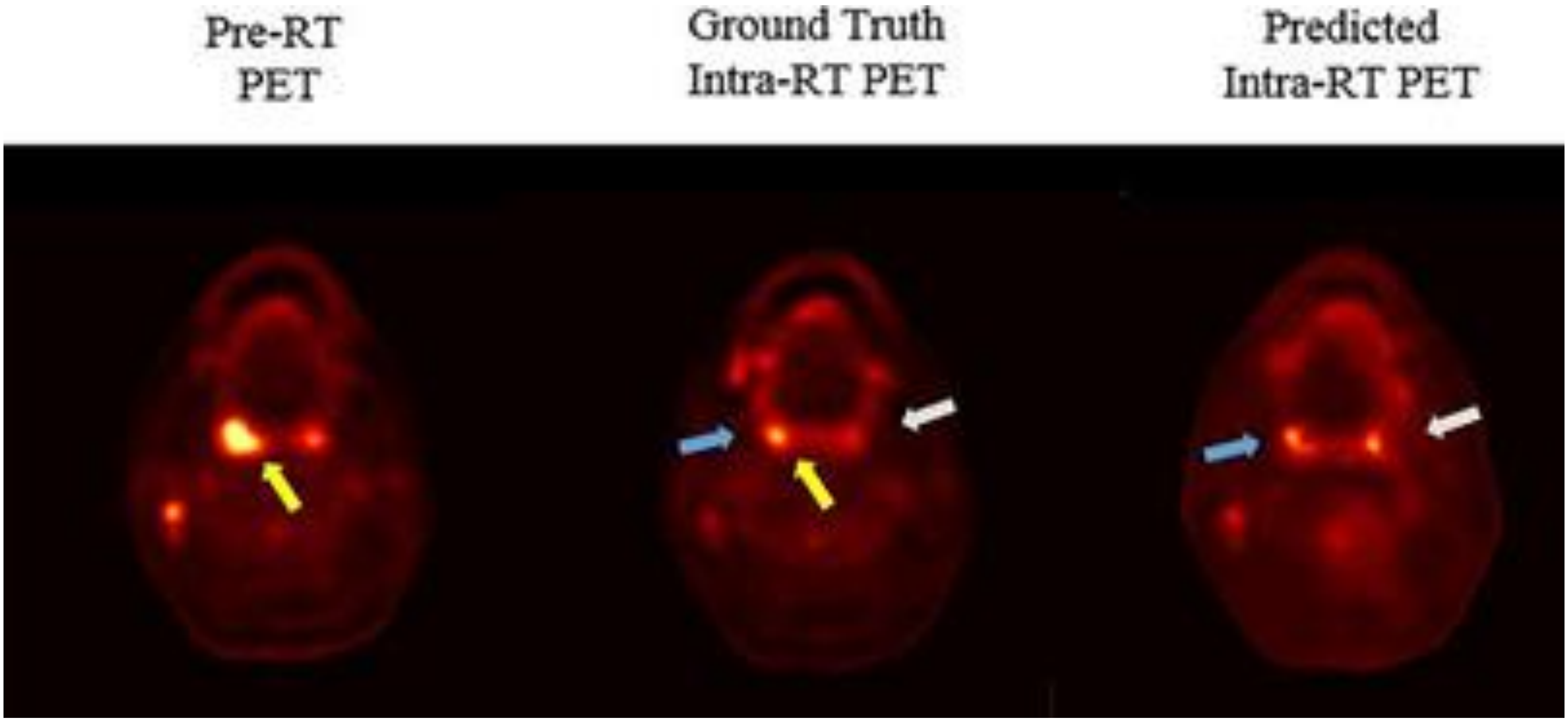
Outcome prediction – side effects





Technology in Cancer Research & Treatment Volume 20: 1-10

Outcome prediction – local control



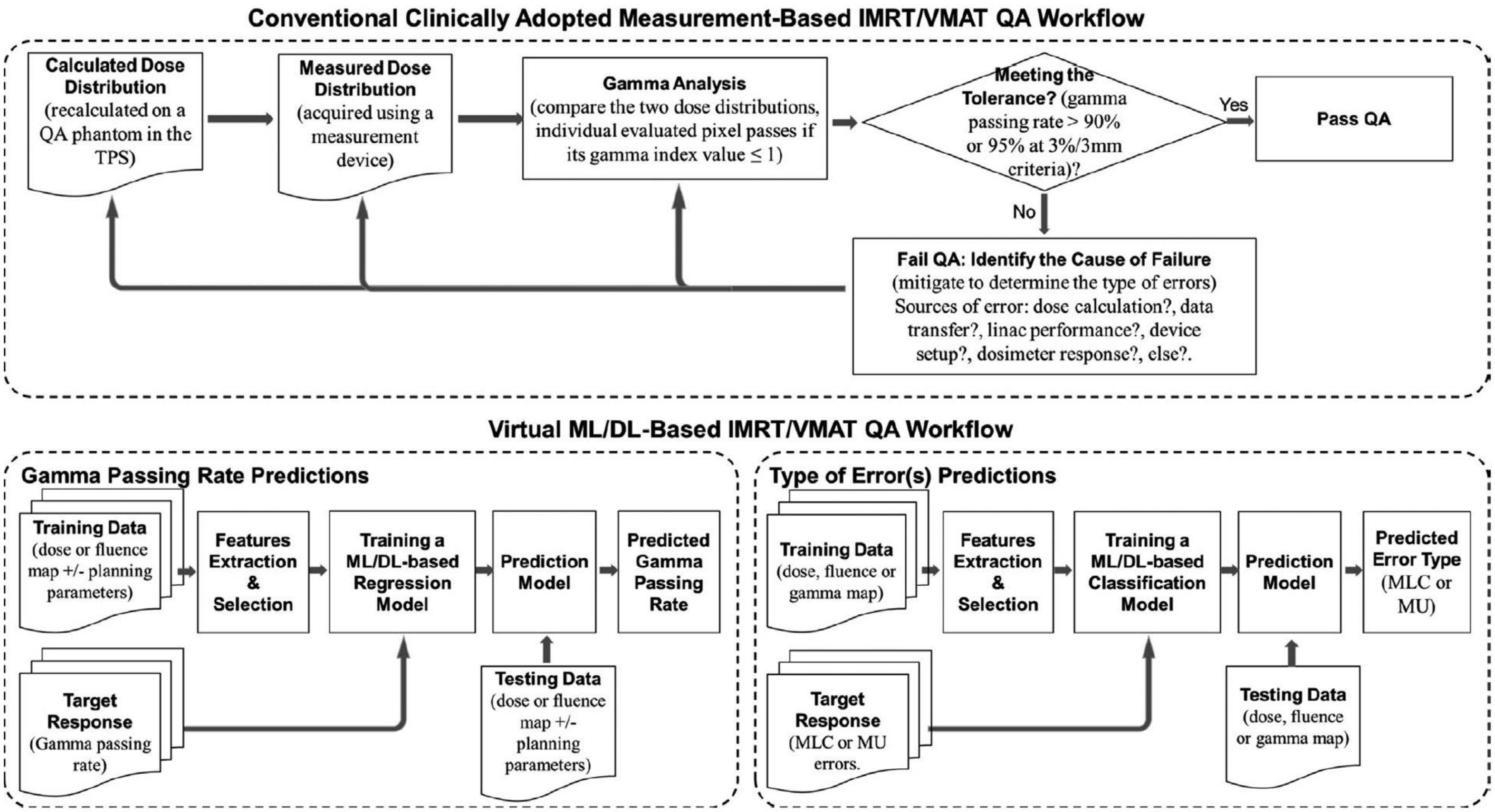
Front. Oncol., 18 August 2020 | https://doi.org/10.3389/fonc.2020.01592

Quality assurance – machine level

References	QA Source	Data Source	ML Model	Task
Carlson et al. (2016)	DICOM_RT, Dynalog files	74 VMAT plans	Regression, Random Forest, Cubist	MLC Position Errors Detection
Li and Chan (2017)	Daily QA Device	5-year Daily QA Data	ANN Time-Series, ARIMA Models	Symmetry Prediction
Sun et al. (2018)	Ion Chamber	1,754 Proton Fields	Random Forrest, XGBoost, Cubist	Output for Compact Proton Machine
El Naqa et al. (2019)	EPID	119 Images from 8 Linacs	Support Vector Data Description, Clustering	Gantry Sag, Radiation Field Shift, MLC Offset
Grewal et al. (2020)	Ion Chamber	4,231 Proton Fields	Gaussian Processes, Shallow NN	Output and Patient QA Proton Machine
Osman et al. (2020)	log files	400 machine delivery log files	ANN	MLC Discrepancies during Delivery & Feedback
Chuang et al. (in press)	Trajectory log files	116 IMRT plans, 125 VMAT plans	Boosted Tree Outperformed LR	MLC Discrepancies during Delivery & Feedback
Zhao et al. (in press)	Water Tank Measurement	43 Truebeam PDD, Profiles	Multivariate Regression (Ridge)	Modeling of Beam Data Linac Commissioning

Front. Artif. Intell. 3:577620.

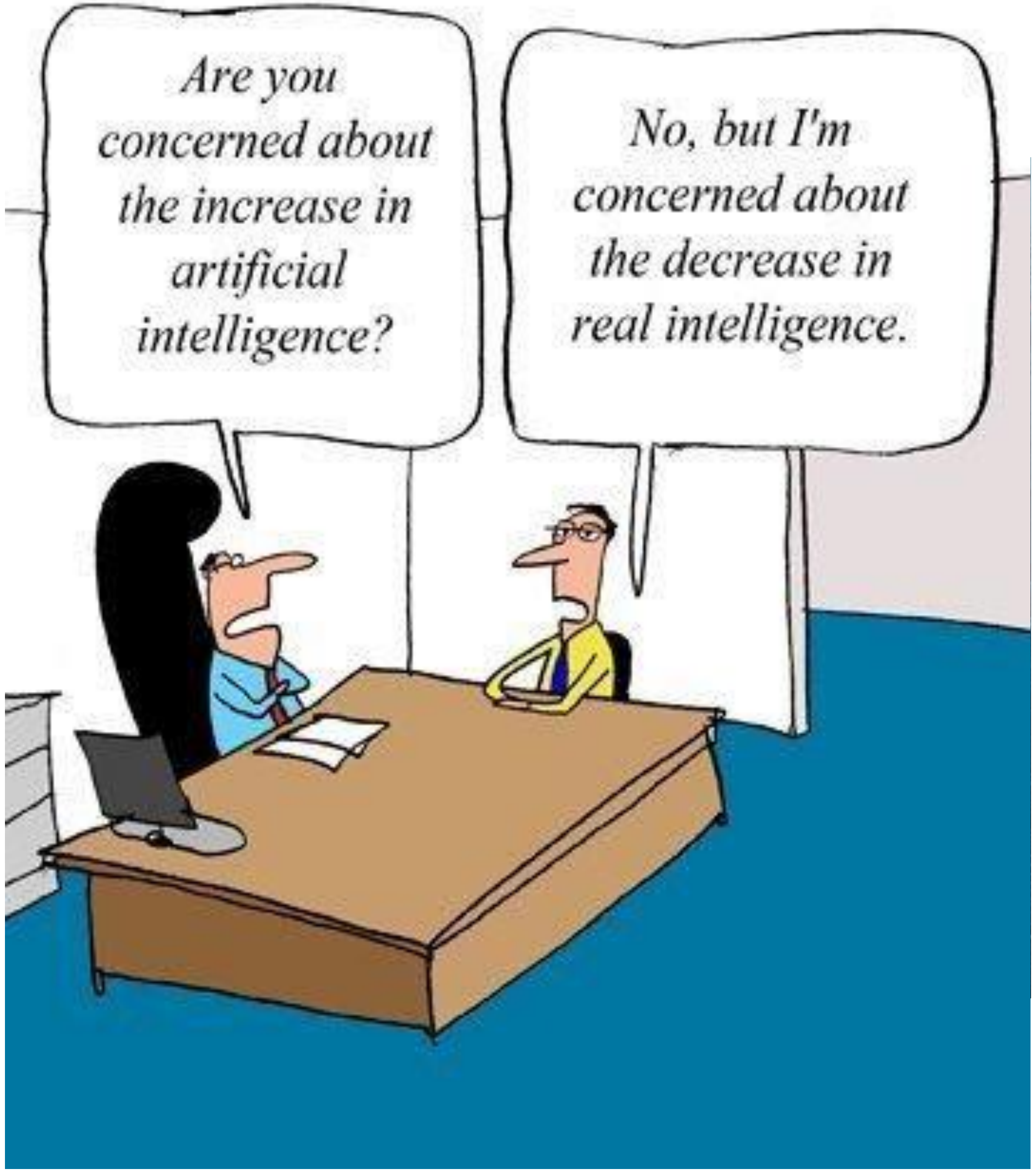
Quality assurance – patient level



J Appl Clin Med Phys. 2021;22(9):20–36.

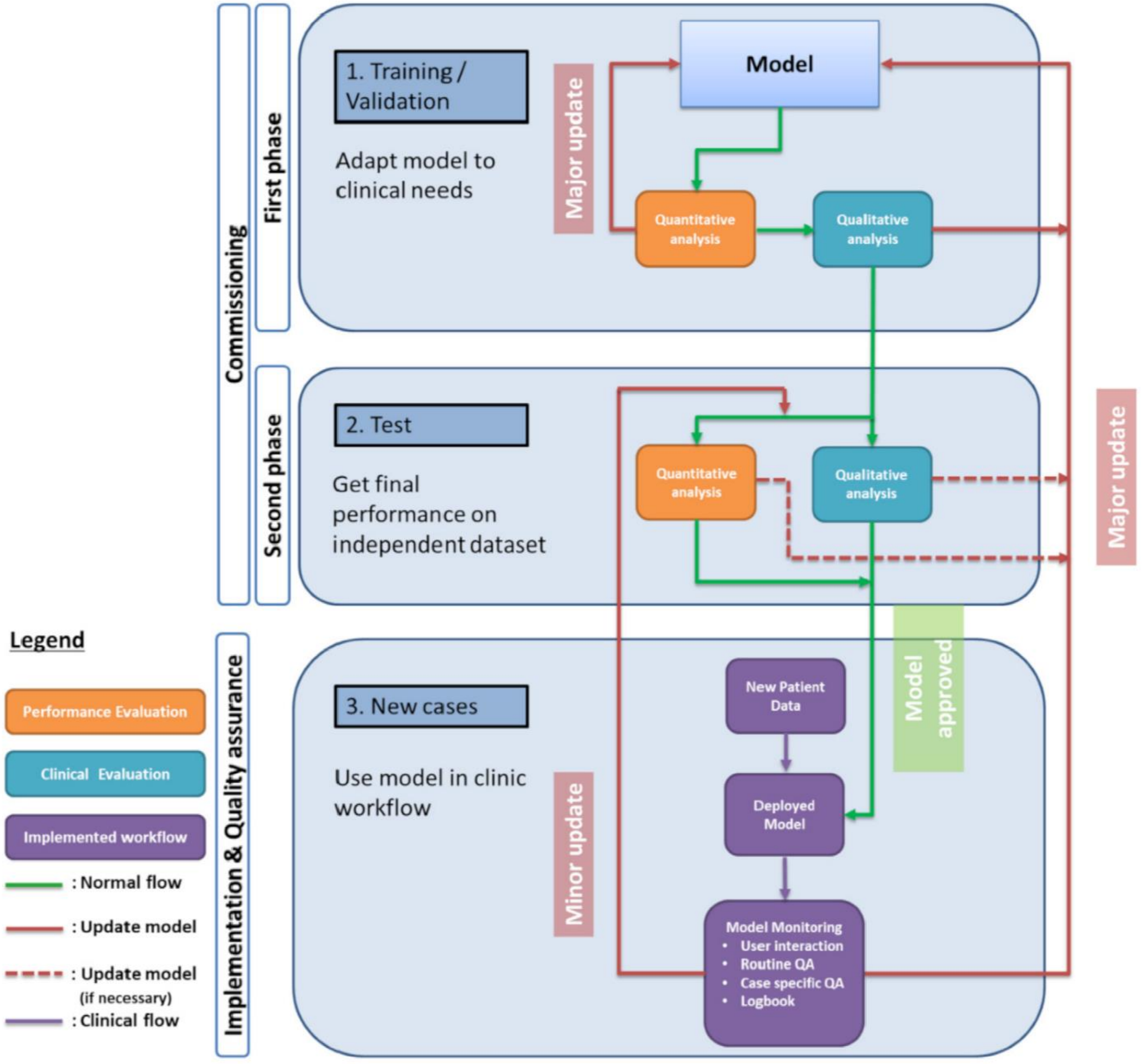
Are there threats from AI?

"We're outsourcing all our critical business decisions to a flawed algorithm with insufficient data — what could possibly go wrong?!"



Inappropriate use of AI technique

Comissioning of AI in radiation oncology



Radiotherapy and Oncology 153 (2020) 55–66

AI techniques we use (at least what I know about)

Autocontouring

Two systems we used

We did not do formal commissioning, the radiographer checks the OAR and occasionally the radiation oncologist

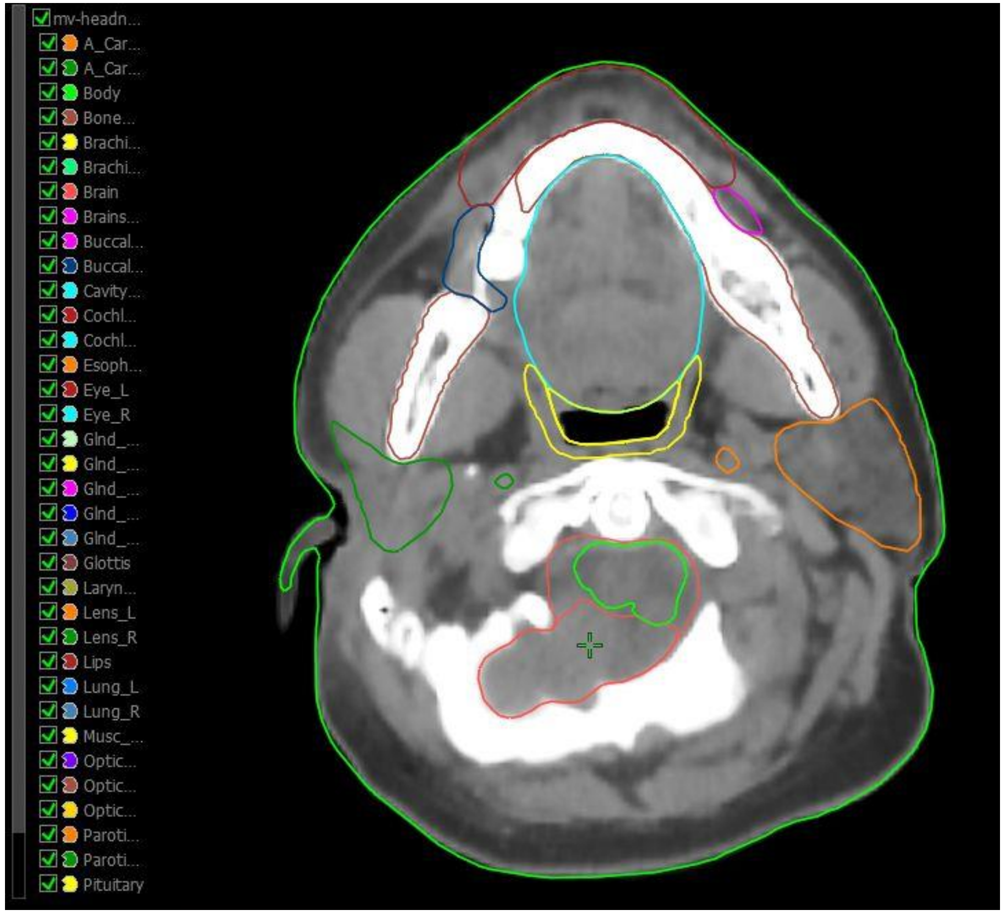
Significantly **reduces time** of OAR contouring

3+3 minutes of up and downloading to the clouds

10 minutes of post processing is required

Lot of „unnecessary” contours are available

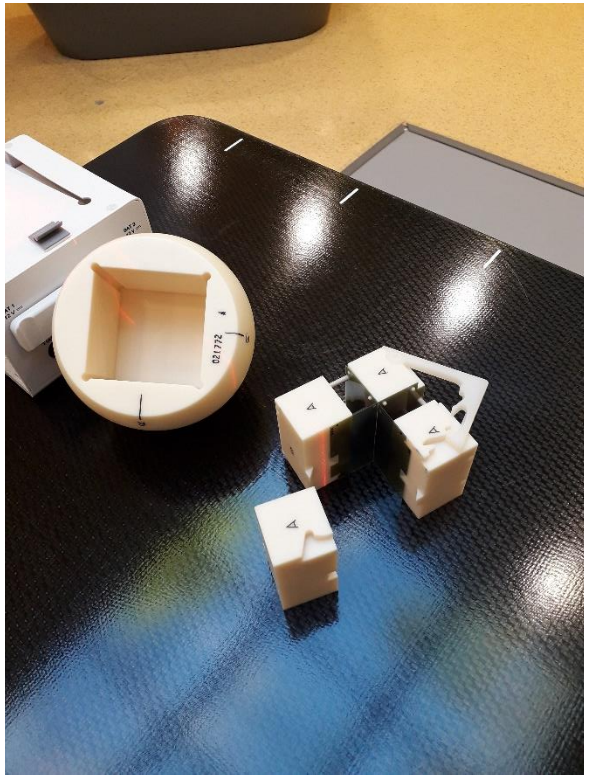
MR based contouring is not yet available (e.g. hippocampus) at every vendor

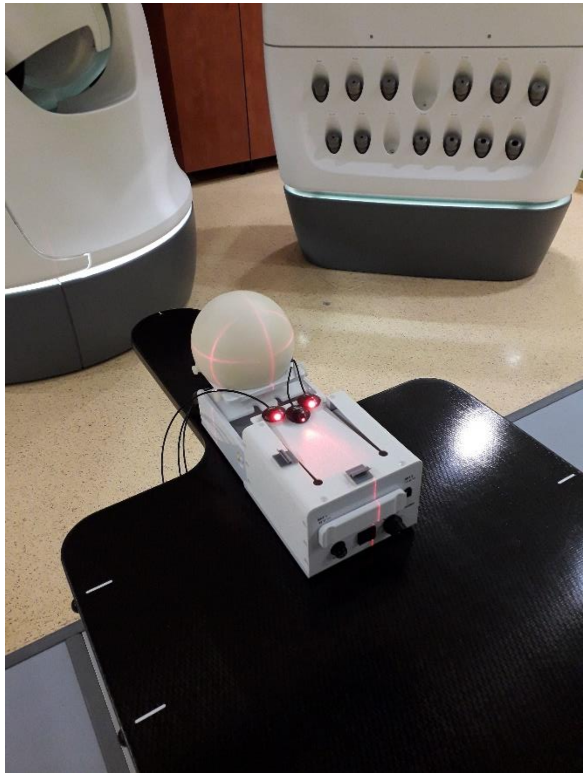


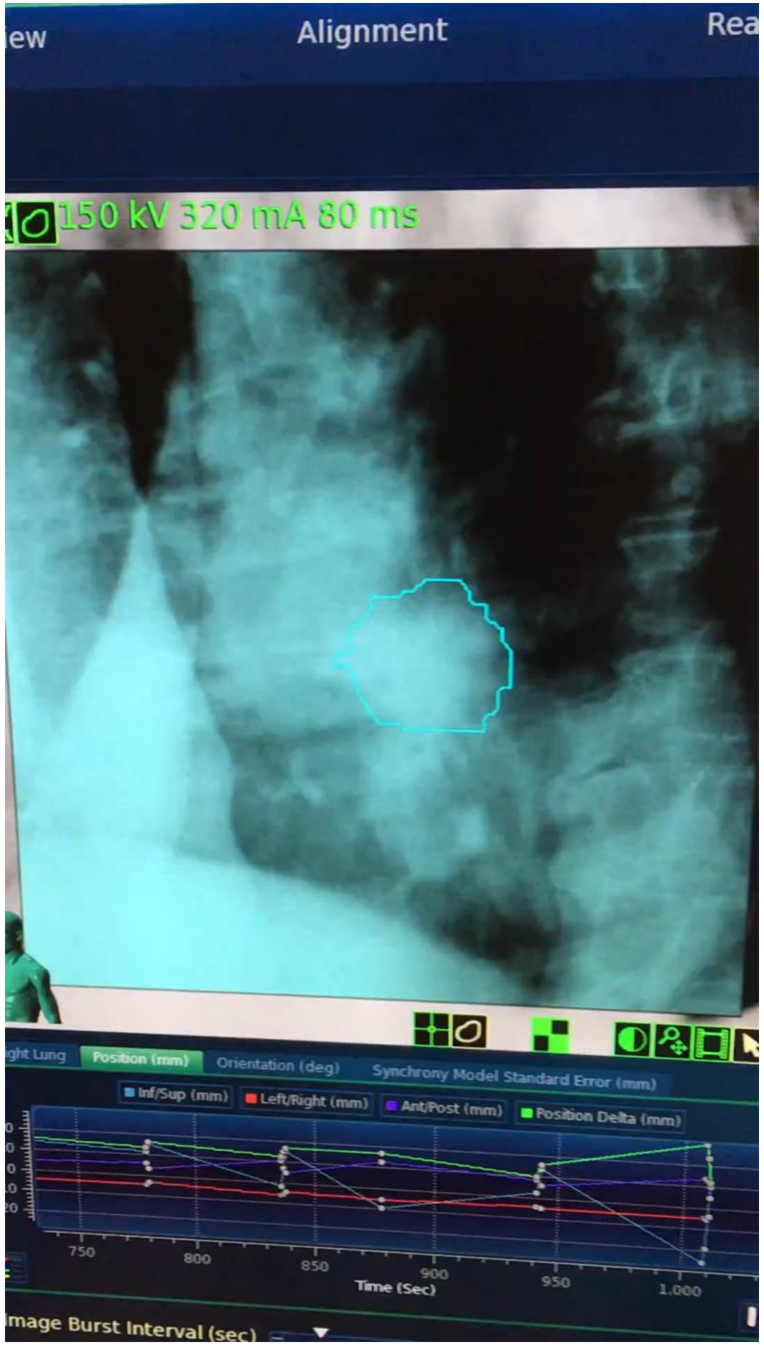
AI based techniques we use

Motions tracking (Synchrony)

- Commissioning showed a good correlation with the predefined data
- Clinical experience supports the use





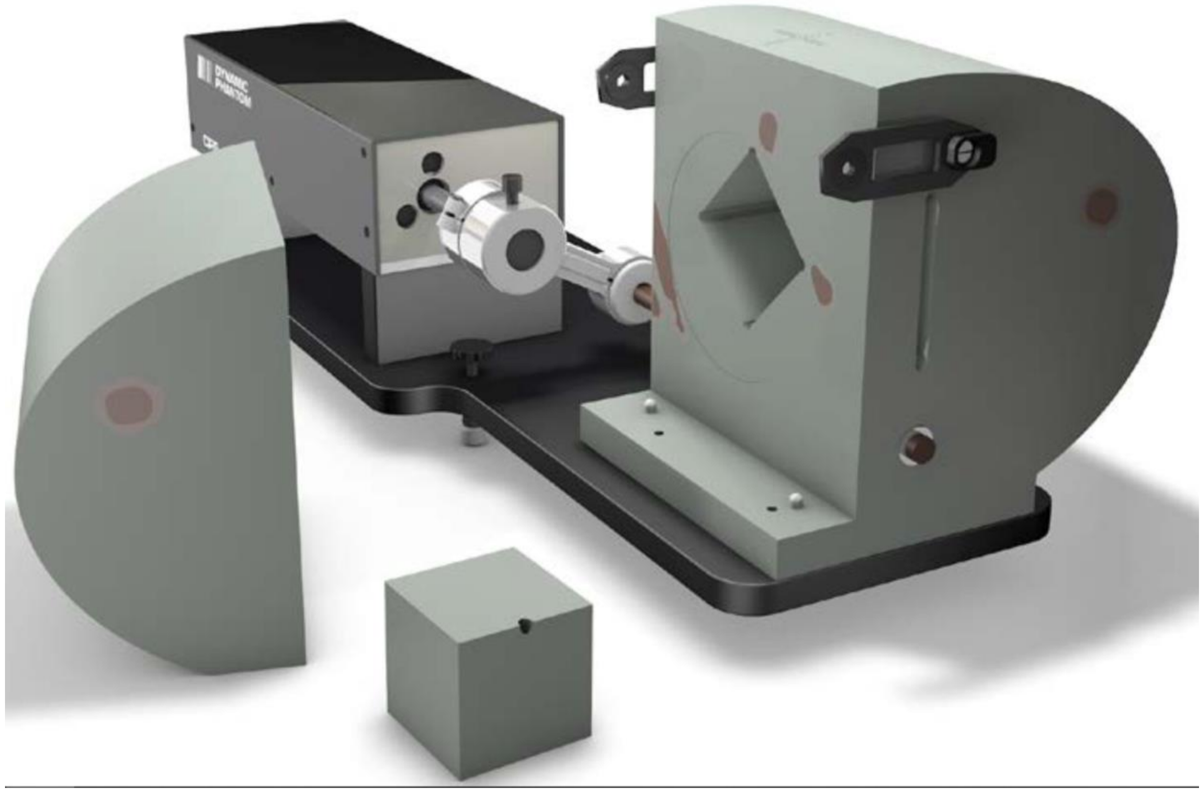


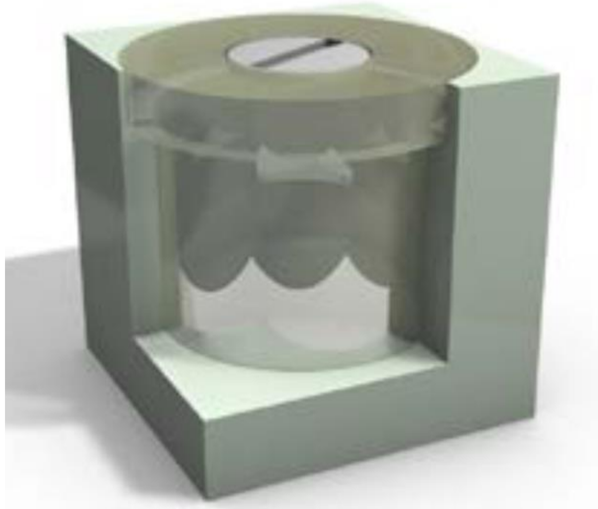
AI based techniques we use

Adaptive radiotherapy (ETHOS)

Just has started to implement

Commissioning will start with special (CIRS dynamic pelvic) phantom





CONCLUSIONS

AI will engage **most of the technical procedures** of radiation oncology in some decades

The challenge is to provide **big and good quality** data in form of imaging, physical and outcome data

Commissioning is a must – tools have to be developed

Clinical outcomes must be evaluated

CONCLUSIONS

If introduced and used appropriately AI will

Help to resolve the **human resources crisis** in radiation oncology

Will reduce the influence of **human error** on the process

Quality will increase

Local control / cure rate will be better

Side effects will decerese

Thank you for your attention !