Artificial Intelligence as a Transformative Tool in Radiotherapy Planning: Enhancing Precision and Efficiency in Cancer Treatment.

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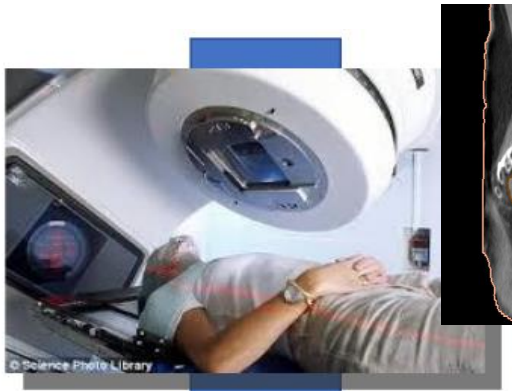
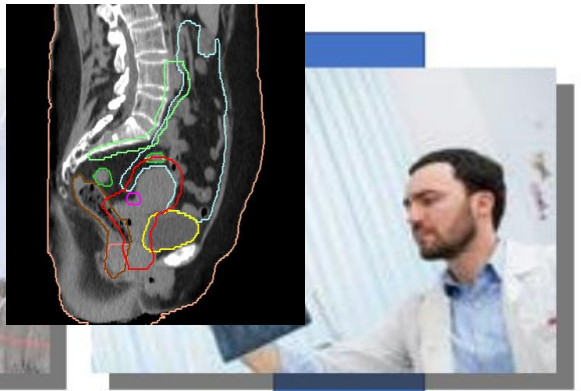
Radiotherapy Steps

- Diagnosis
- Staging

- Planning CT
- Target contouring
- OARs contouring
- Treatment plan
- Linac data transfer



- RT plan implementation

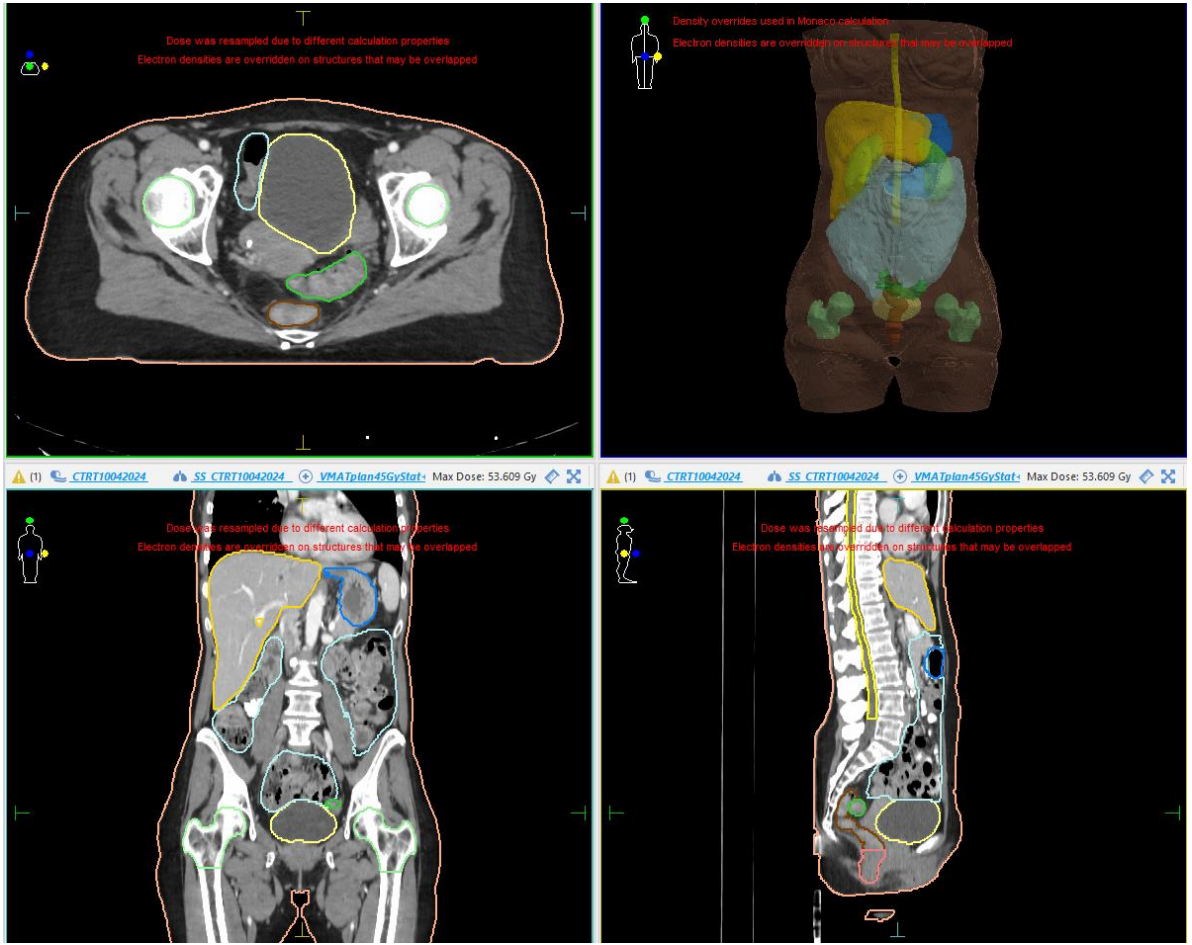


- Follow-up
- Local control
- Toxicity

Organs at Risk (OAR) Contouring

- Highly demanding.
- Time-consuming.
- Subject to inter-observer variability.

Organs at Risk (OAR) Contouring



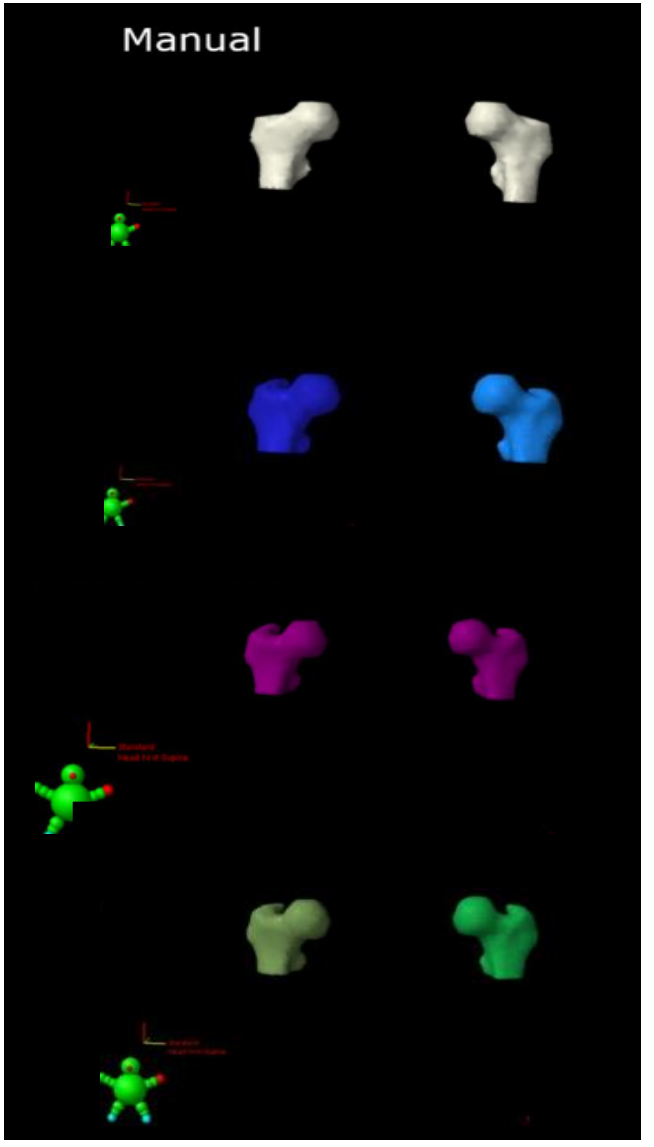
- **Organs at risk:**
- Rectum
- Sigmoid colon
- Bowel bag
- Bladder
- Femoral heads
- Spinal cord
- Kindeys
- Liver
- Stomach
- Duodenum
- Pancreas
- Bone marrow surrogate

Organs at Risk (OAR) Contouring

Investigation on performance of multiple AI-based auto-contouring systems in organs at risks (OARs) delineation

Young Woo Kim[1] · Simon Biggs[3] · Elizabeth Claridge Mackonis[1,2]

- The study successfully investigated the performance of multiple AI-based auto-contouring systems by performing quantitative comparisons.
- Each tested AI system was able to produce comparable contours to the expert's contours of organs at risk.



Organs at Risk (OAR) Contouring

Investigation on performance of multiple AI-based auto-contouring systems in organs at risks (OARs) delineation

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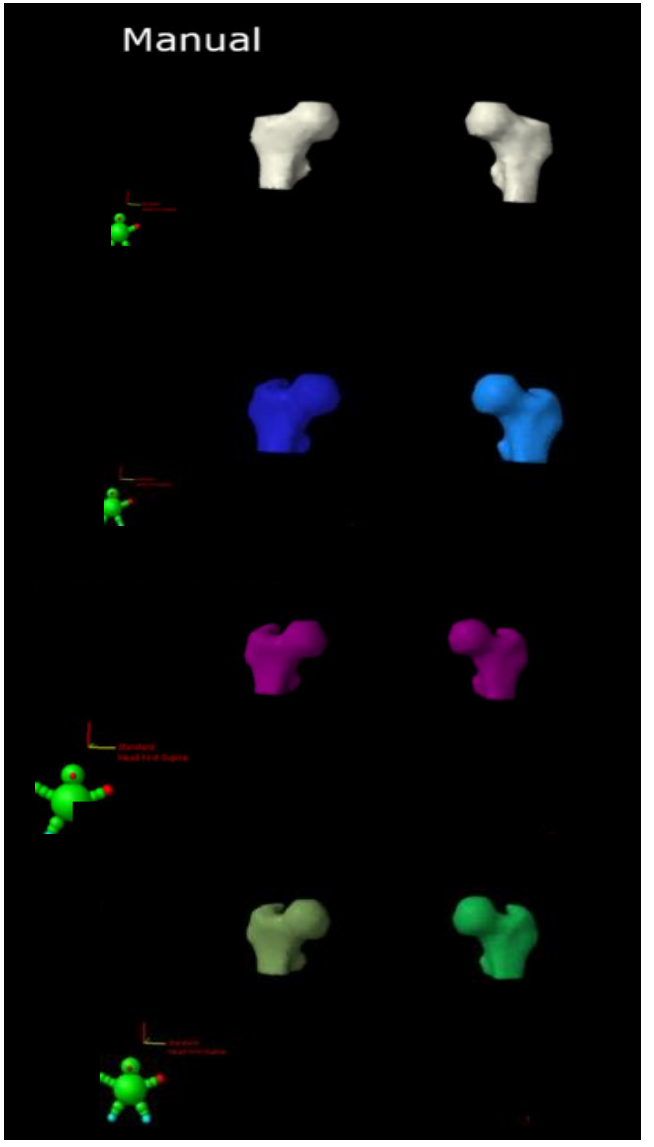
- All tested AI systems' performance were comparable to each other.
- A reduced performance of AI systems in the case of small and complex anatomical structures was found.
- It is still essential to review each contour produced by AI systems for clinical uses.



AI reduces contouring time and increases consistency between operators

Two experts contoured CTVs/OARs of 20 patients in the TPS.

- CT images were sent to the automatic contouring workstation.
- Automatic contours were generated and sent back to TPS, where observers could edit them if necessary.
- Inter- and intra-observer consistency was estimated using Dice Similarity Coefficients.
- Radiation oncologists scored the quality of automatic contours, ranging from 1 (complete re-contouring) to 5 (no editing).
- Contouring times (manual vs automatic + edit) were compared.

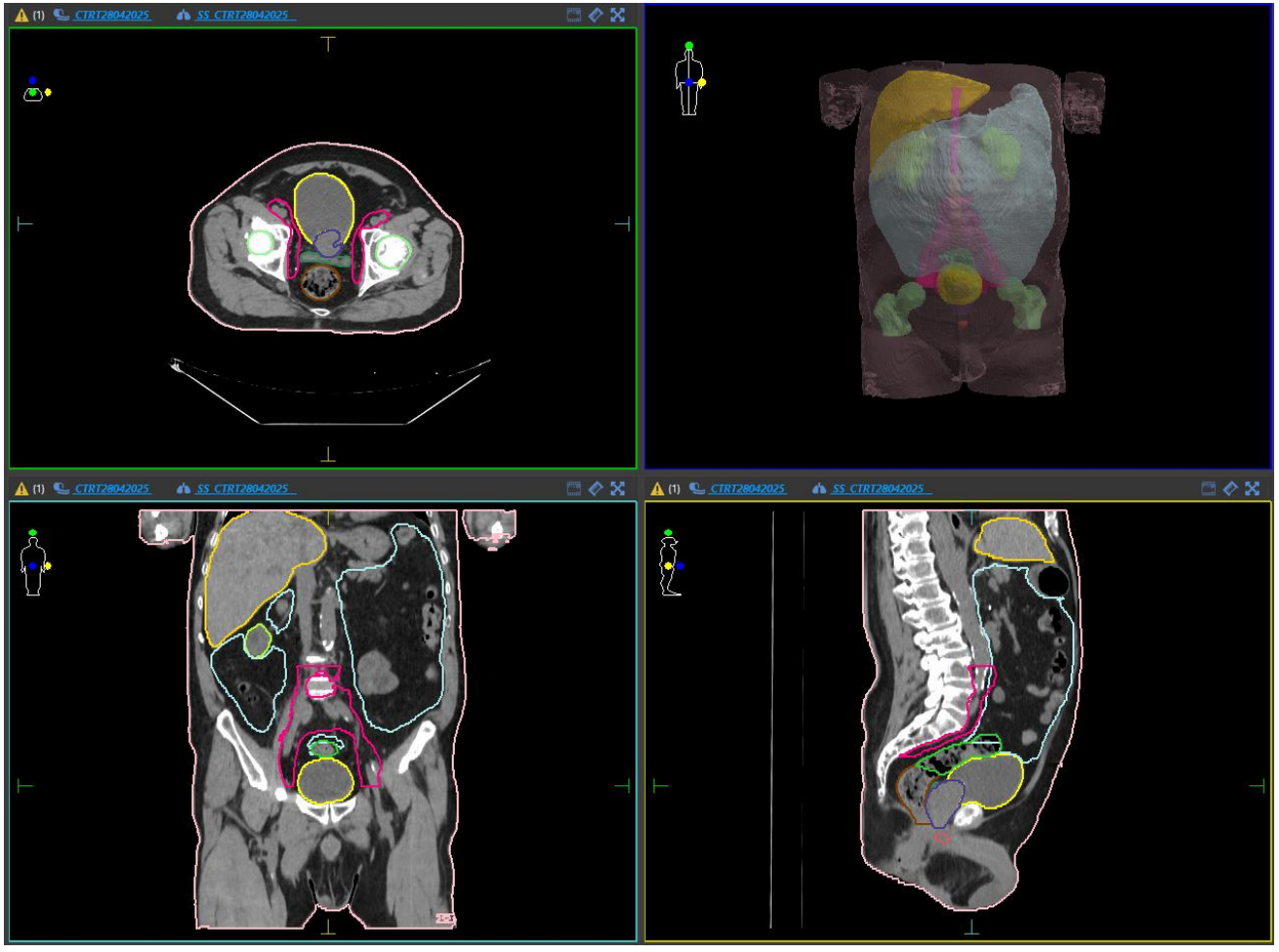
Palazzo G, Phys Imaging Radiat Oncol. 2023

AI reduces contouring time and increases consistency between operators

- Score for the quality of automated contour: clinical score was 4 (little editing).
- The median inter-observer variability of automatic + editing contours improved significantly, being lower than manual contouring.
- Oncologist contouring time reduced from 17-24 min of manual contouring time to 3–7 min of editing time for the two observers ($p < 0.01$).
- Automatic contouring with a commercial AI-based system followed by editing can replace manual contouring, resulting in significantly reduced time for segmentation and better consistency between operators.

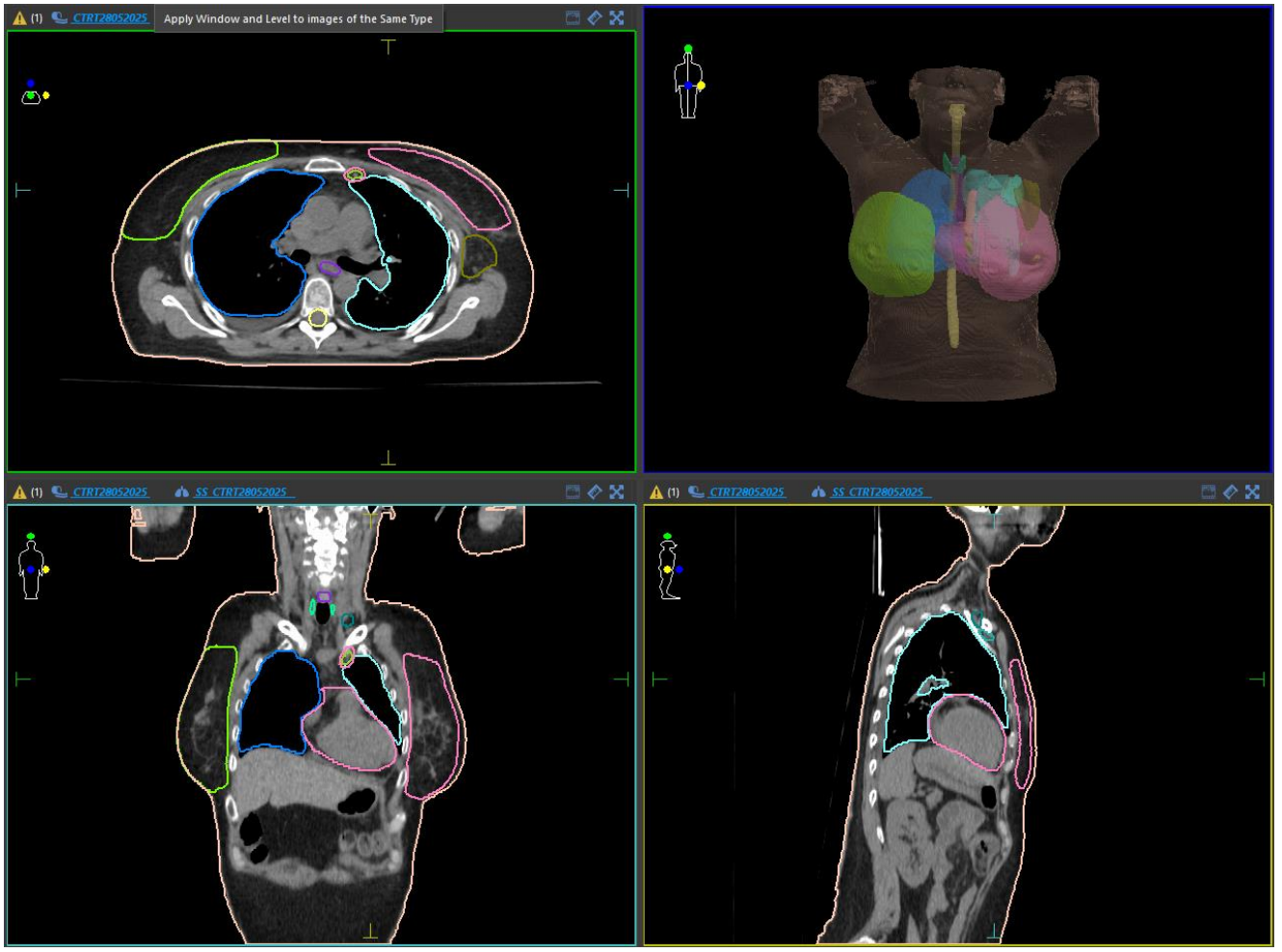
Palazzo G, Phys Imaging Radiat Oncol. 2023

AI reduces contouring time: prostate cancer



- **Organs at risk:**
- Rectum
- Sigmoid colon
- Bowel bag
- Bladder
- Femoral heads
- Spinal cord
- Penile bulb
- **CTVs**
- Prostate
- Seminal vesicles
- Pelvic lymph nodes

AI reduces contouring: breast cancer



- **Organs at risk:**
- Lungs
- Heart
- LADA
- Thyroid gland
- Contralateral breast
- Spinal cord
- **CTVs**
- Breast
- Lymph nodes
- (level I-IV, IMN)

AI reduces contouring time: breast cancer

Comparison of manual and corrected auto-contouring times across studies.

Study	Mean manual contouring time (min/patient)	Mean corrected auto-contouring time (min/patient)	Time reduction
Bakx et al.	**OAR:** 17, **CTV:** 41	**OAR:** 8, **CTV:** 16	**OAR:** 9, **CTV:** 25
Buelens et al.	35	11	24
Byun et al.	38	7	84 % reduction
Chung et al.	35–42	<10	/
Liu et al.	**OAR:** 30, **CTV:** 20	**OAR:** 5, **CTV:** 10	**OAR:** 25, **CTV:** 10
Mikalsen et al.	**Breast:** 3, **Lymph nodes:** 23, **Heart:** 2	**Breast:** 4, **Lymph nodes:** 9, **Heart:** 1	**Breast:** −1, **Lymph nodes:** 14, **Heart:** 1
Zeleznik et al.	**Heart:** 4 min (median)	**Heart:** 2 min (median)	50 % reduction

Smine Z, Radiother Oncol 2025

AI reduces contouring time: breast cancer

Comparison of manual and corrected auto-contouring ti

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			OAR: 25, **CTV:** 10
	Lymph nodes: 23, **Heart:** 2	**Breast:** 4, **Lymph nodes:** 9, **Heart:** 1	**Breast:** −1, **Lymph nodes:** 14, **Heart:** 1
Zeleznik et al.	**Heart:** 4 min (median)	**Heart:** 2 min (median)	50 % reduction

Corrected auto-contouring reduces time compared to manual segmentation by at least 50%.

Smine Z, Radiother Oncol 2025

AI performance: time efficiency, geometrical accuracy, inter-observer variability

- Corrected auto-contouring reduces time compared to manual segmentation by at least 50%.
- Improves geometrical accuracy (OARs: heart, lungs, spinal cord, thyroid, contralateral breast and liver, CTVs: ipsilateral breast).
- Improves homogeneity and accuracy of OARs contours with corrected autocontours.

Smine Z, Radiother Oncol 2025

AI performance: time efficiency, geometrical accuracy, inter-observer variability

However...

- The implementation of an auto-contouring system results in greater dependence on automated settings.
- Users often accept changes in their final contours when using auto-contours and perceive these differences as clinically minimal while appreciating the convenience.
- Thorough review and correction of discrepancies between the final contour of the target volume and the auto-contour is crutial.

Zeleznik R, npj Digital Med 2021 – Lee BM, Int J Radiat Oncol Biol Phys 2024 - Vandewinckele L, Radiother Oncol 2020

AI performance: time efficiency, geometrical accuracy, inter-observer variability

- These findings underscore the necessity of developing QA methods alongside these technologies.

- Regular testing, especially following changes in imaging protocols or equipment, is essential and the model should be recommissioned as needed to maintain accuracy and reliability.

- Most papers relied on clinical data for definition for training their AI-algorithms.
  However, contouring guidelines may change and new training data would have to be manually generated before an updated auto-segmentation algorithm can be trained.

AI performance: time efficiency, geometrical accuracy, inter-observer variability

- Automated contouring has been proven accurate for most OARs and the breast-CTV, but further dosimetric analyses and more high-level evidence is needed.

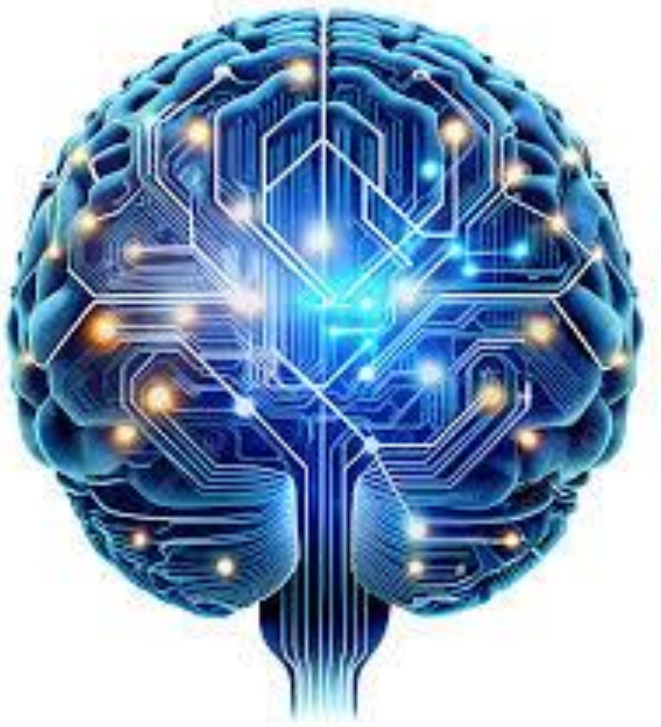
- Remaining challenges: automated contouring beyond the ‘average patient’ and a continued effort to reach consensus in clinical practice.

Is AI Panacea ?

- In Greek mythology, Panacea was one of the daughters of the Greek god of medicine Asclepius:
- Panacea (the goddess of the cure)/
- Hygieia (the goddess of cleanliness and sanitation).
- Aceso (the goddess of the healing process).
- Iaso (the goddess of recuperation from illness).
- Aegle (the goddess of good health).
- Nowadays the term is used to describe any supposed remedy that is claimed to cure all diseases or a practice/a means that can solve all our problems in a certain scenario.

Is AI Panacea ?

Is AI Panacea ?

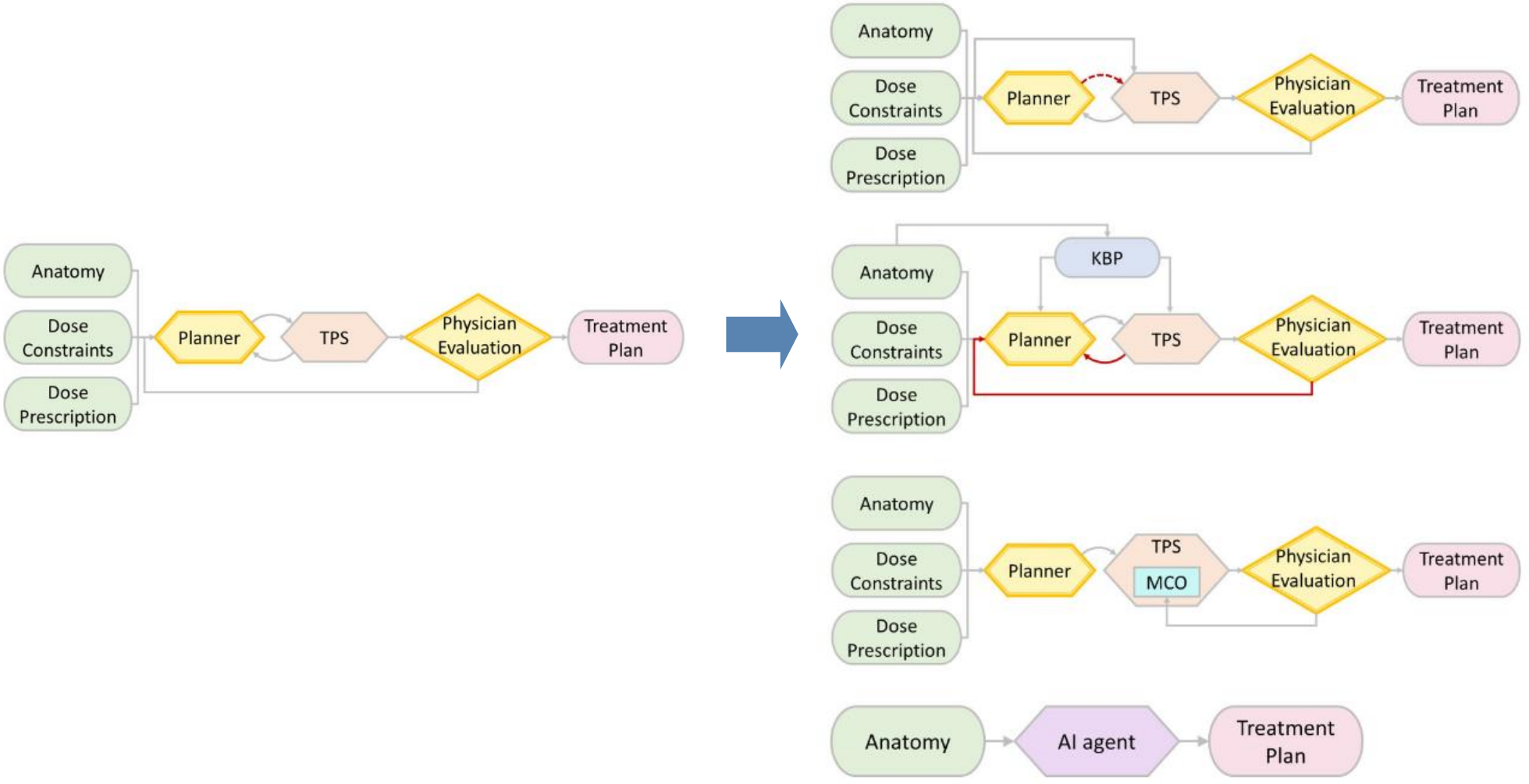


AI can spare

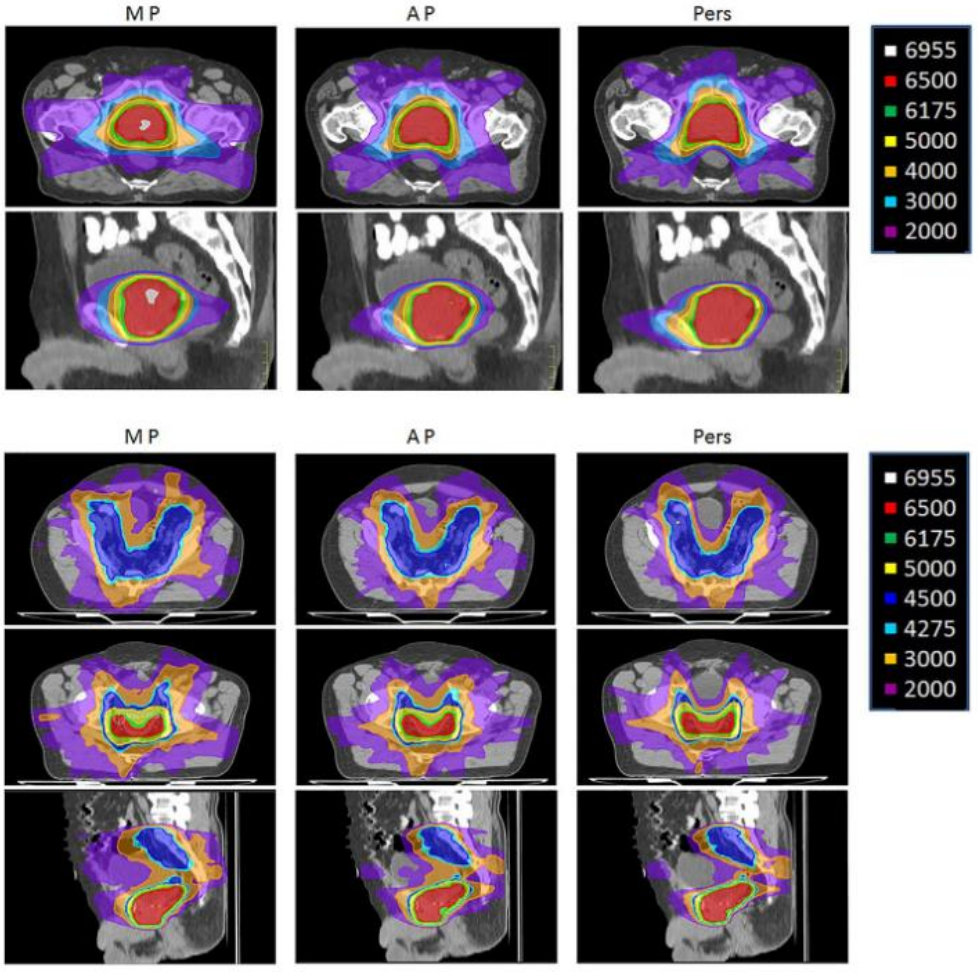
>60% of contouring time.

Spare time to interact with patients

AI in RT Treatment Planning



AI in RT Treatment Planning

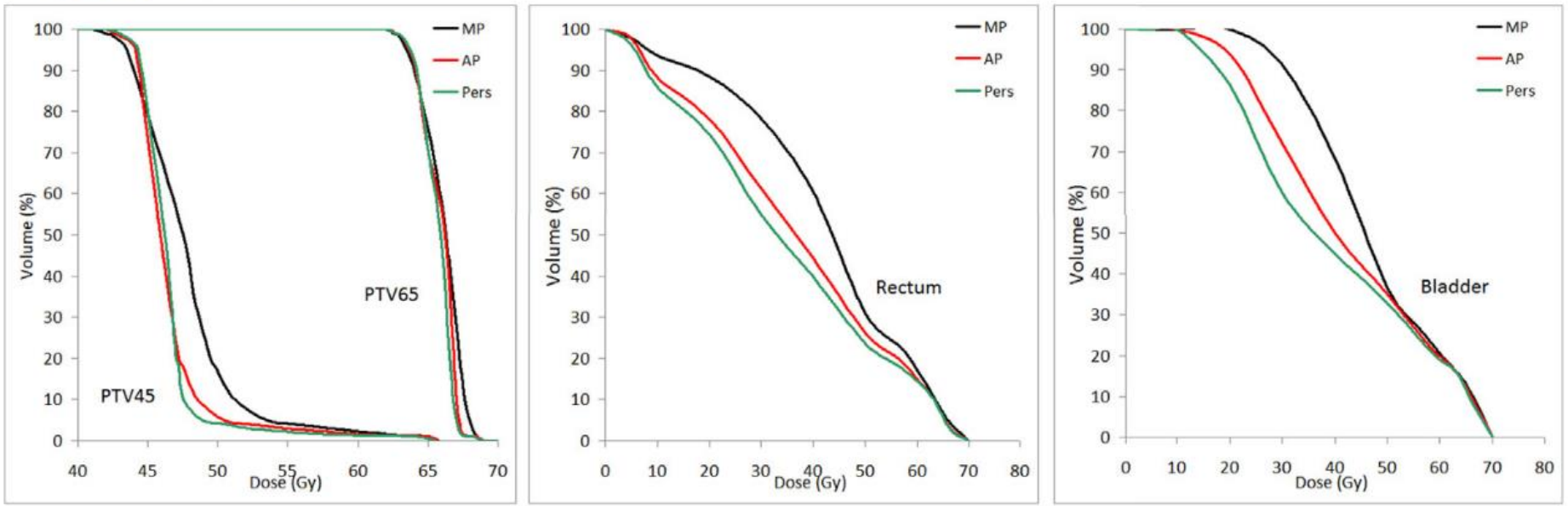


MP: manual plans, AP: Autoplanning, Pers: Personalized plans

Cilla S, Front Oncol 2021

AI in RT Treatment Planning

High-risk prostate cases



- No differences were observed for target coverage.
- Automated plans had improved quality in terms of dose conformity and sparing of OARs.

Cilla S, Front Oncol 2021

AI in RT Treatment Planning

Manual vs Automated plans: Similar targets coverage.

But...Automated plans had:

- Reduced high-doses (D2%).
- Better dose conformity.
- Lower rectal and bladder doses.
- Lower integral dose (a reduction of ID of about 11–16% for the Pers plans and 7–15% for the AP plans, with respect to MP plans).
- Decreased planning times.

Do I ... ???...

- Use AI in every day practice?
- Review auto-contours?
- Believe in AI in RT?

"The practice of medicine
is an art, not a trade; a
calling, not a bussiness;
a calling in which your heart
will be exercised equally
with your head."

Sir William Osler