Modern Radiation Oncology
Innovation in personalized oncology: back to the future

Modern Imaging and AI applications in external beam radiotherapy

Dr. Luca Boldrini, MD, PhD

Head of MR Linac Unit
Head Radiomics G-STEP core research facility
Fondazione Policlinico Universitario «A. Gemelli» IRCCS, Roma
Dipartimento di Diagnostica per Immagini, Radioterapia Oncologica ed Ematologia

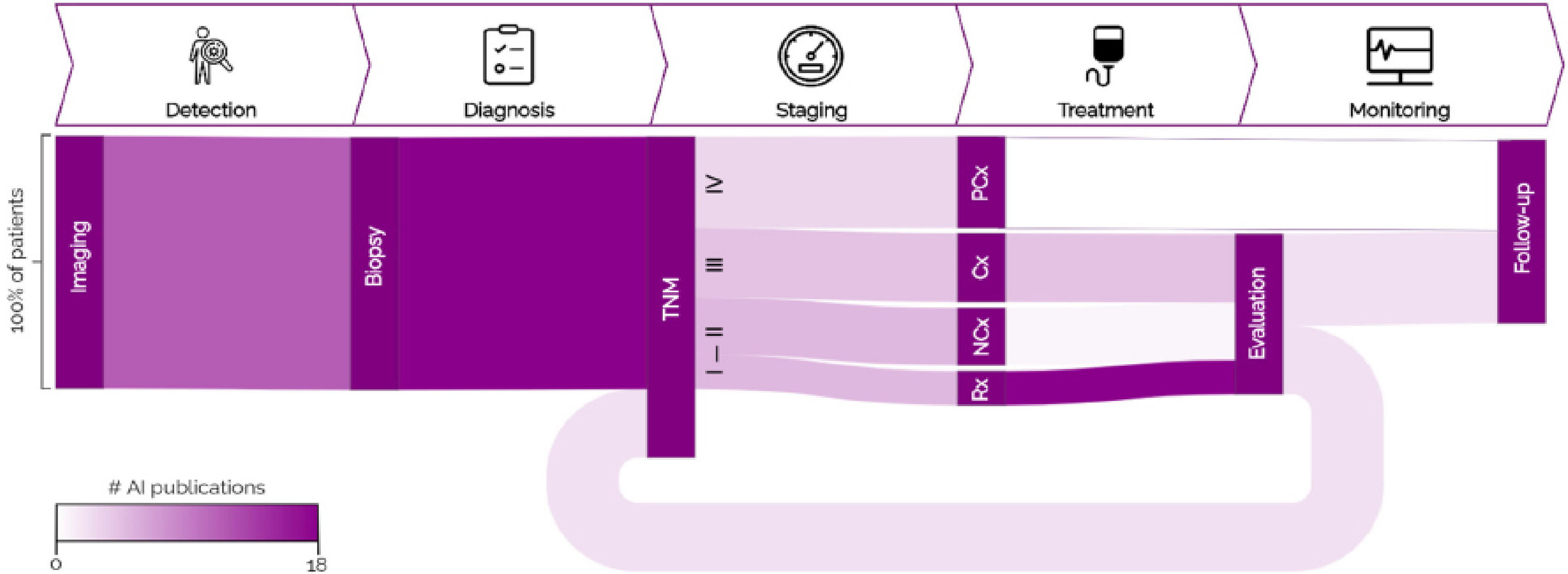
Conflicts of interest

- Speaker honorarium and travel reimbursements from View Ray Inc.
- Member of the IBA Victoria Advisory Committee
- Scientific consultant for Varian Medical Systems
- Scientific consultant for KBMS.com & KBO Labs
- Scientific consultant for Medipass srl
- Scientific consultant for Roche
- Scientific consultant for Radius srl
- Sponsored researcher for Nanovi
- Sponsored researcher for Sophia genetics
- Sponsored researcher for View Ray Inc.
- Inventor patent #202020000005950

Rationale for using AI in healthcare

- To do quicker (and better) what humans can already do
- To do what humans can not do

AI in radiation oncology

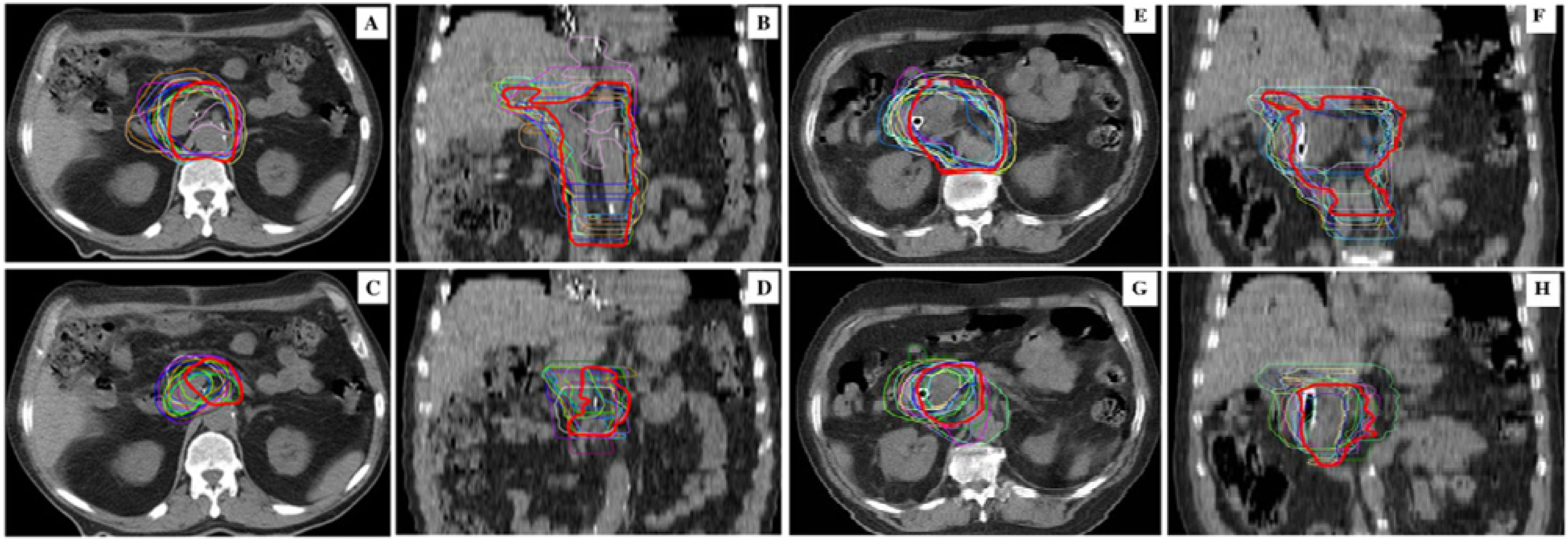


Schuurmans M et al. Cancers 2022, 14, 3498.

AI based treatment optimization

Radiotherapy : New technologies

The need of autosegmentation

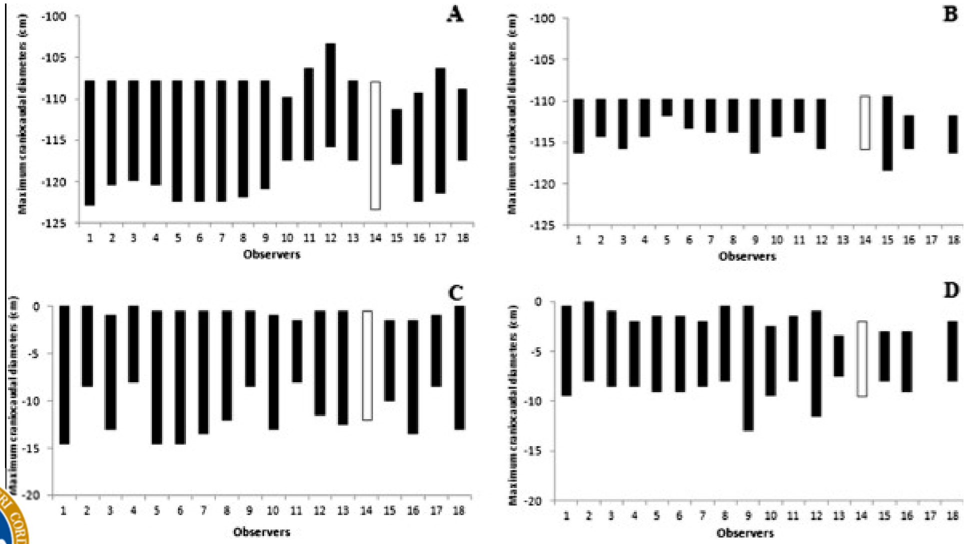


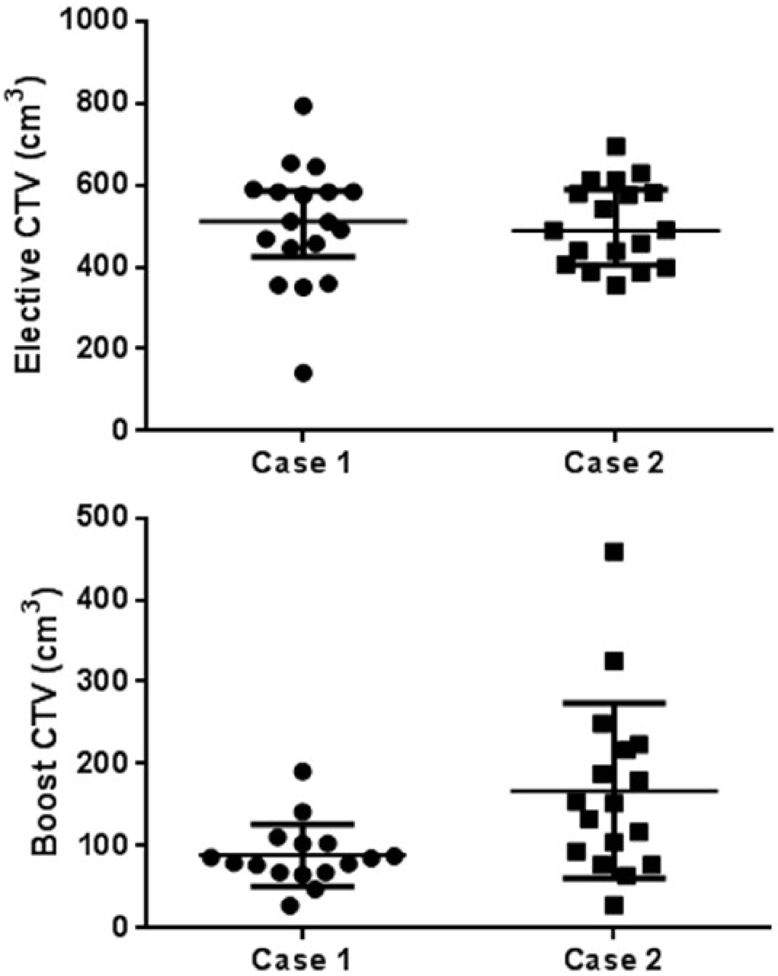
Aim evaluate the inter-observer variability in clinical target volume (CTV) delineation

18 Radiation oncologists

DSC 0.68 in elective CTV

DSC 0.44-0.52 Boost volume



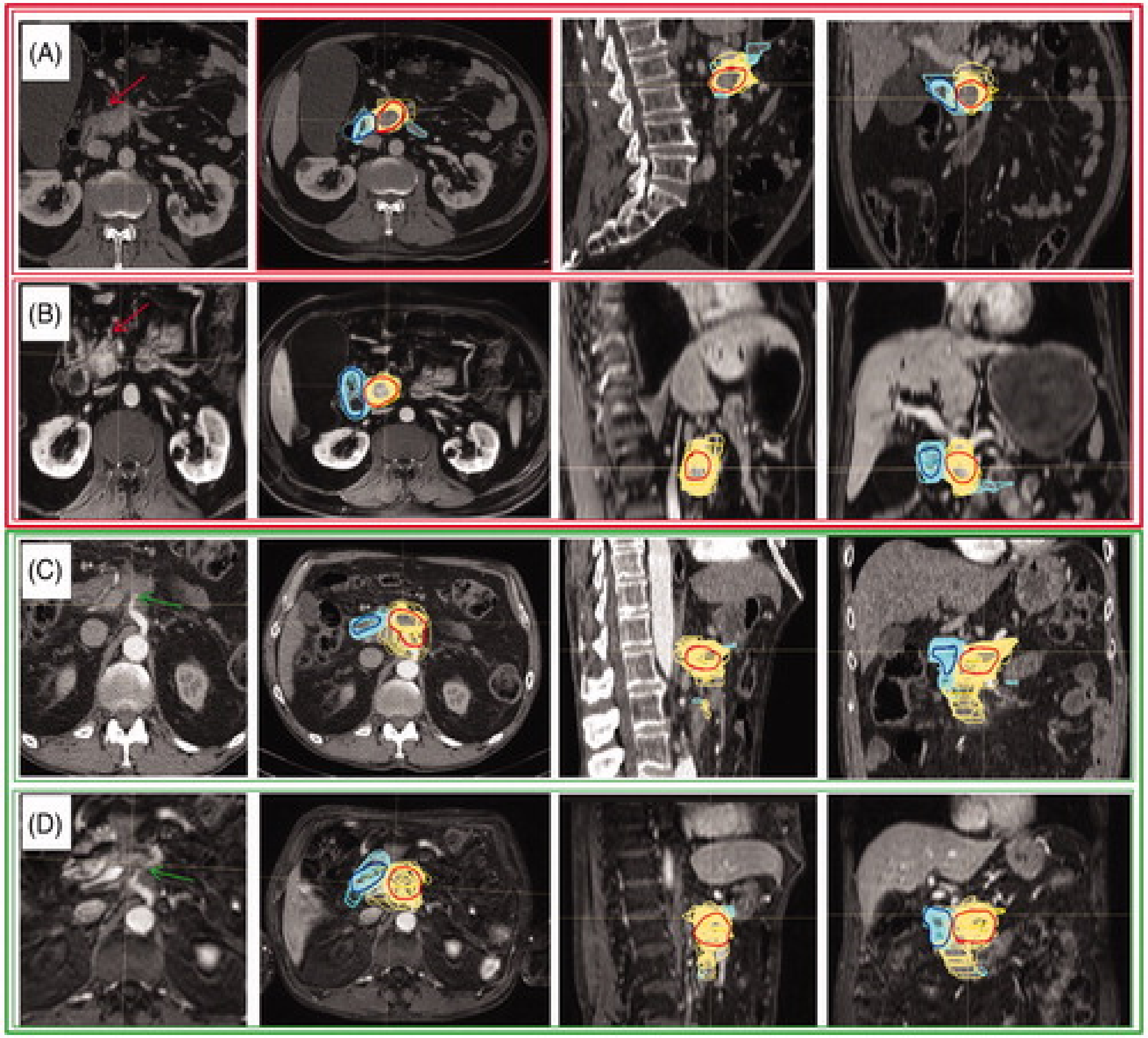


Aim inter-observer agreement GTV and duodenum delineation in :
borderline resectable (Case 1)
unresectable pancreatic cancer (Case 2)
CE CT versus MRI

31 Radiation oncologists

MRI resulted in smaller GTV in **borderline** resectable case with a substantial agreement between observers, and was comparable to CT scan in interobserver variability

Greater variability in the **unresectable** case
DSC (0.56)

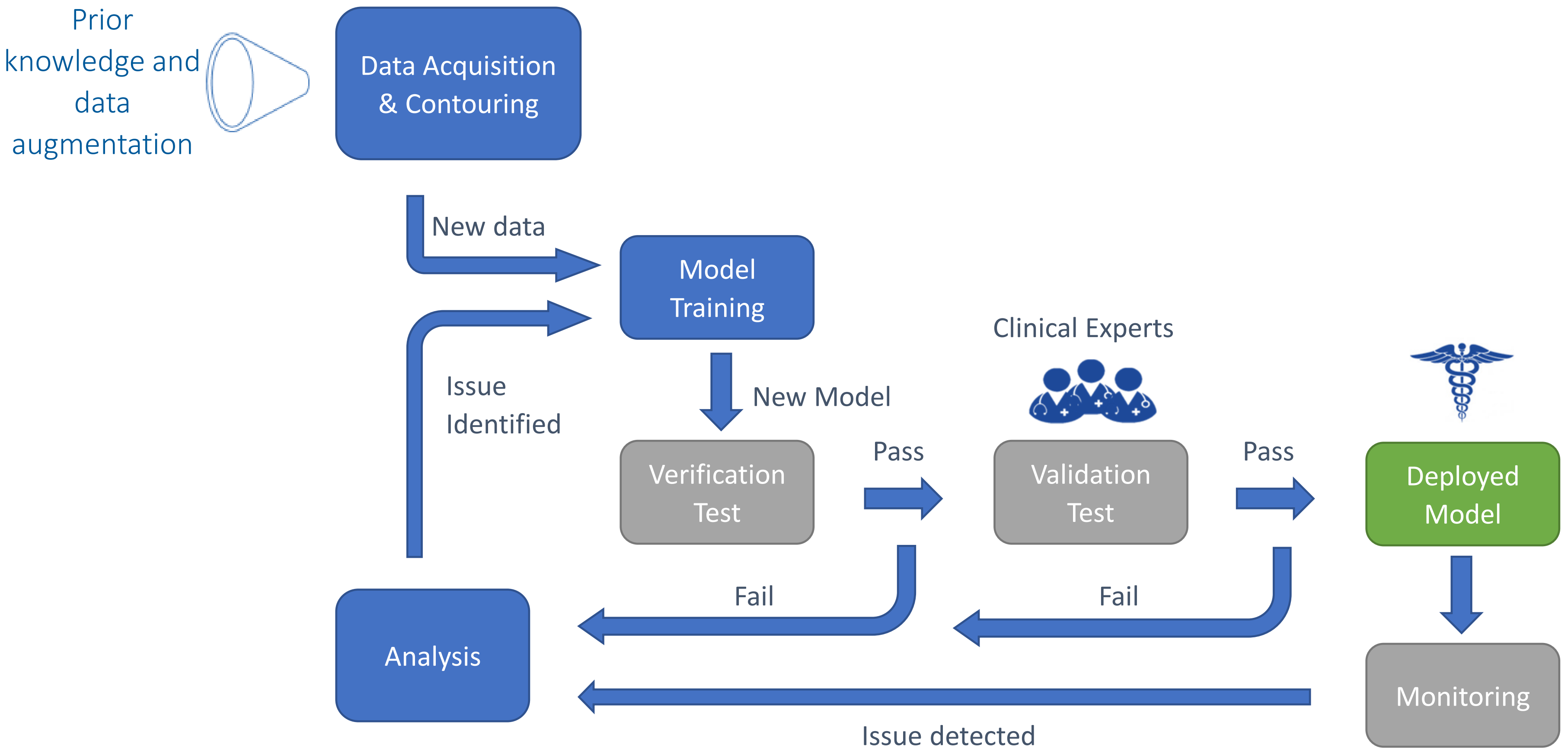


AI based treatment optimization

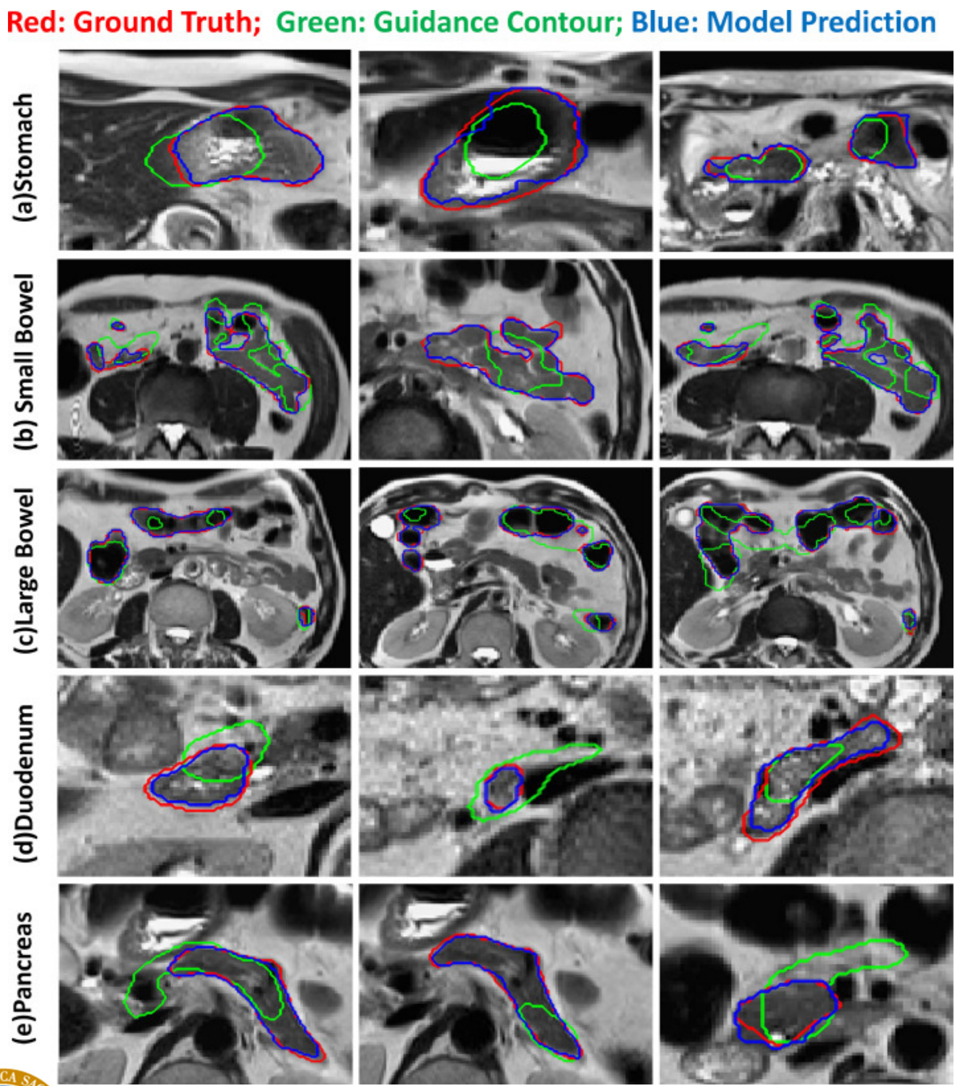
Autosegmentation

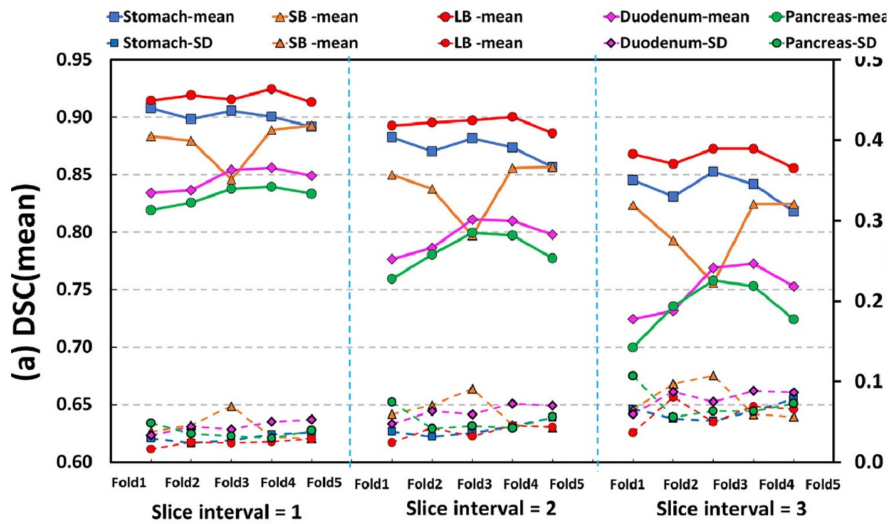
1. High quality training with segmentation sets
2. Multiple models of classical image processing
3. Post processing of network output
4. Extensive results verification
5. Independent clinical validation

Verification and validation workflow



Modified image, courtesy of varian





75 patients (65 for training and 10 for testing)
Prior knowledge-guided DL semiautomatic segmentation

Acceptable slices values were in the range of 48% to 66%

Large bowel	0.93 ± 0.02
Stomach	0.92 ± 0.02
Small bowel	0.91 ± 0.02
Duodenum	0.88 ± 0.03
Pancreas	0.87 ± 0.02

Zhang Y et al. Int J Radiat Oncol Biol Phys. 2022;114(2):349-359

La radiologia medica
https://doi.org/10.1007/s11547-023-01708-4

RADIOTHERAPY

Check for updates

Artificial intelligence applied to image-guided radiation therapy (IGRT): a systematic review by the Young Group of the Italian Association of Radiotherapy and Clinical Oncology (yAIRO)

Luca Boldrini[1,2] · Andrea D'Aviero[3] · Francesca De Felice[4,5] · Isacco Desideri[6] · Roberta Grassi[7] · Carlo Greco[8] · Giuseppe Carlo Iorio[9] · Valerio Nardone[7] · Antonio Piras[10] · Viola Salvestrini[6,11]

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Abstract

Introduction The advent of image-guided radiation therapy (IGRT) has recently changed the workflow of radiation treatments by ensuring highly collimated treatments. Artificial intelligence (AI) and radiomics are tools that have shown promising results for diagnosis, treatment optimization and outcome prediction. This review aims to assess the impact of AI and radiomics on modern IGRT modalities in RT.

Methods A PubMed/MEDLINE and Embase systematic review was conducted to investigate the impact of radiomics and AI to modern IGRT modalities. The search strategy was "Radiomics" AND "Cone Beam Computed Tomography"; "Radiomics" AND "Magnetic Resonance guided Radiotherapy"; "Radiomics" AND "on board Magnetic Resonance Radiotherapy"; "Artificial Intelligence" AND "Cone Beam Computed Tomography"; "Artificial Intelligence" AND "Magnetic Resonance guided Radiotherapy"; "Artificial Intelligence" AND "on board Magnetic Resonance Radiotherapy" and only original articles up to 01.11.2022 were considered.

Results A total of 402 studies were obtained using the previously mentioned search strategy on PubMed and Embase. The analysis was performed on a total of 84 papers obtained following the complete selection process. Radiomics application to IGRT was analyzed in 23 papers, while a total 61 papers were focused on the impact of AI on IGRT techniques.

Discussion AI and radiomics seem to significantly impact IGRT in all the phases of RT workflow, even if the evidence in the literature is based on retrospective data. Further studies are needed to confirm these tools' potential and provide a stronger correlation with clinical outcomes and gold-standard treatment strategies.

84 analysed papers

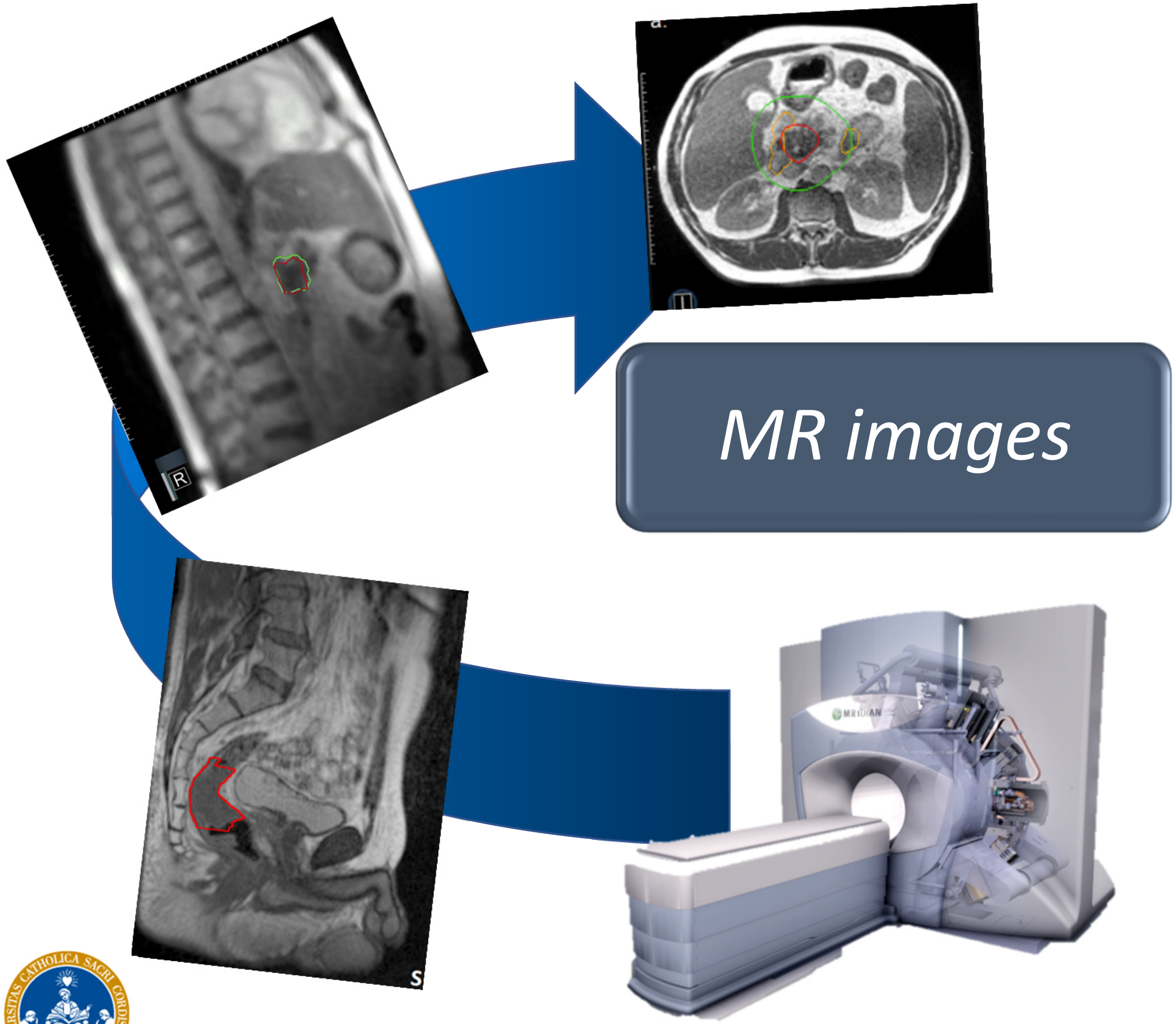
Radiomics 23 (69% CBCT-31% MRI)

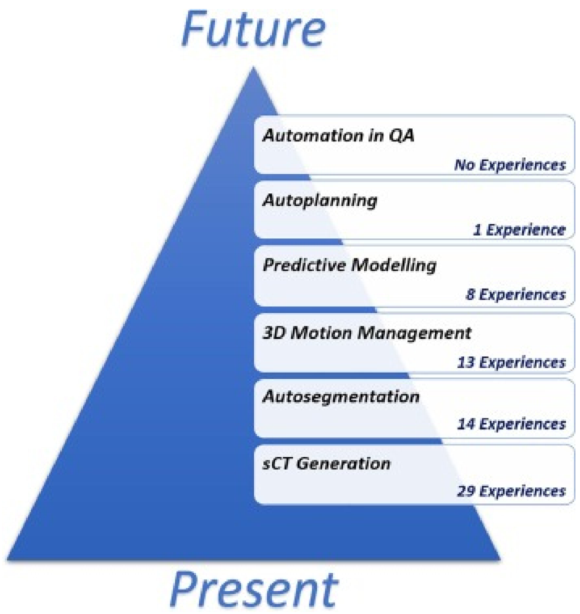
AI applications 61 (56% CBCT-44% MRI)

synthetic imaging
autoseg & autoplan
planning QA and dose
delivery optimization
response prediction

AI treatment optimization

delivery technologies

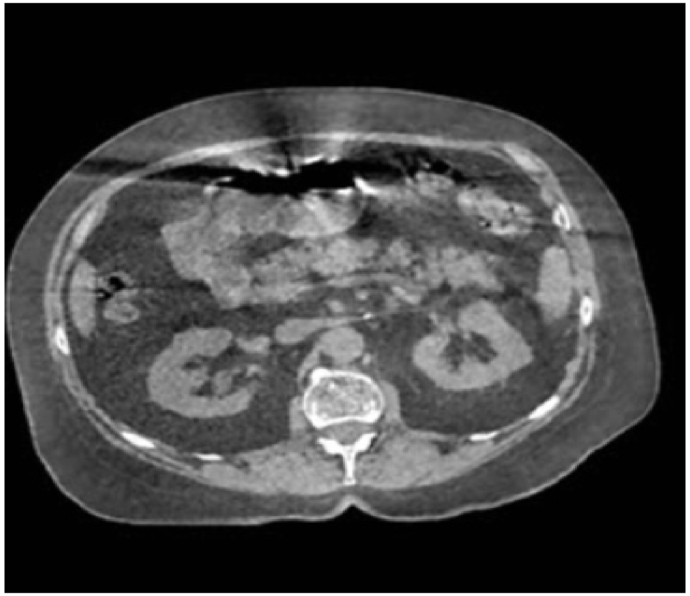




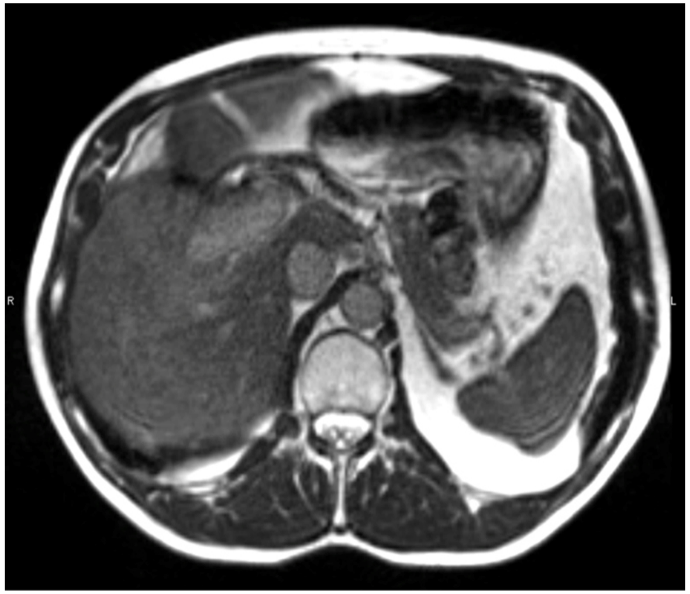
Cusumano D et al. Phys Med. 2021; 85:175-191

To see better

CBCT

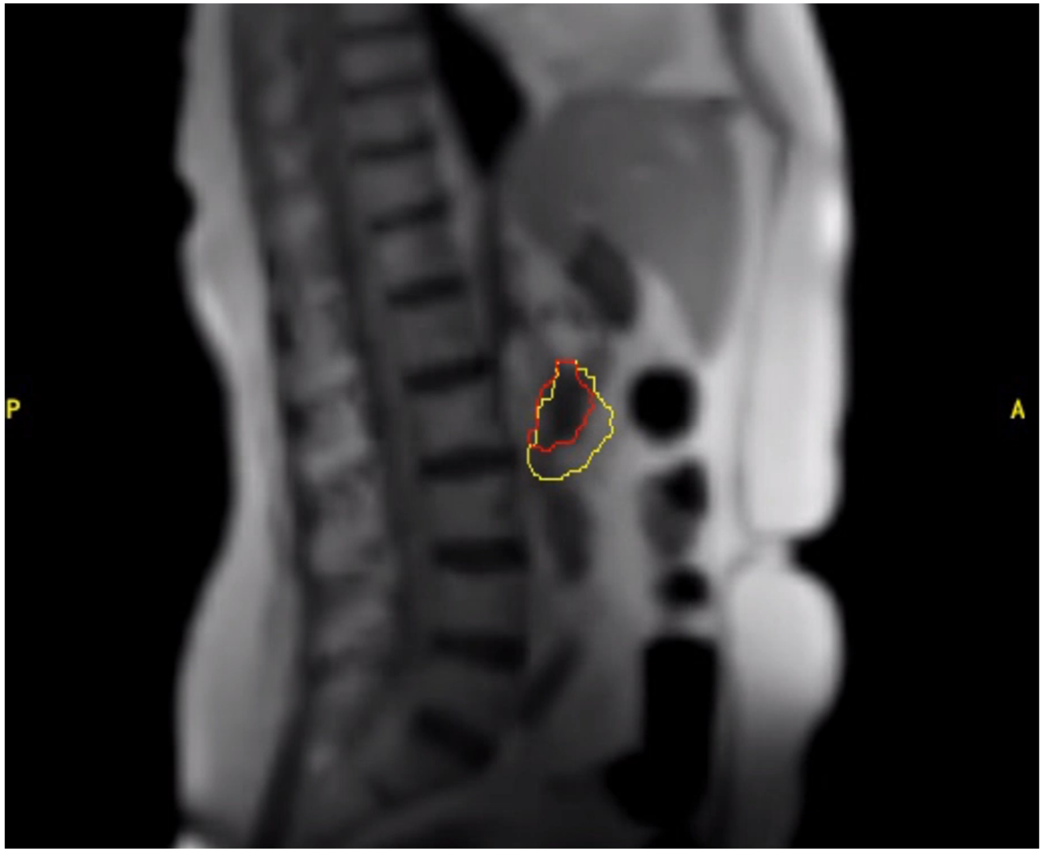


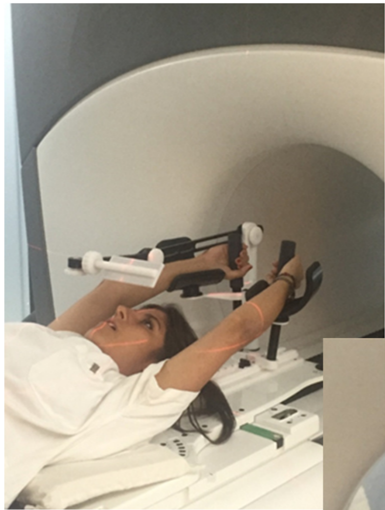
0.35 T MRI

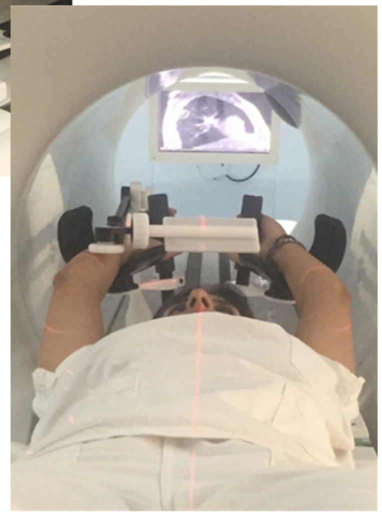


	CBCT	0.35 T MRI
GTV (CTV)	✗	✓
OaRs	✗	✓

To gate better







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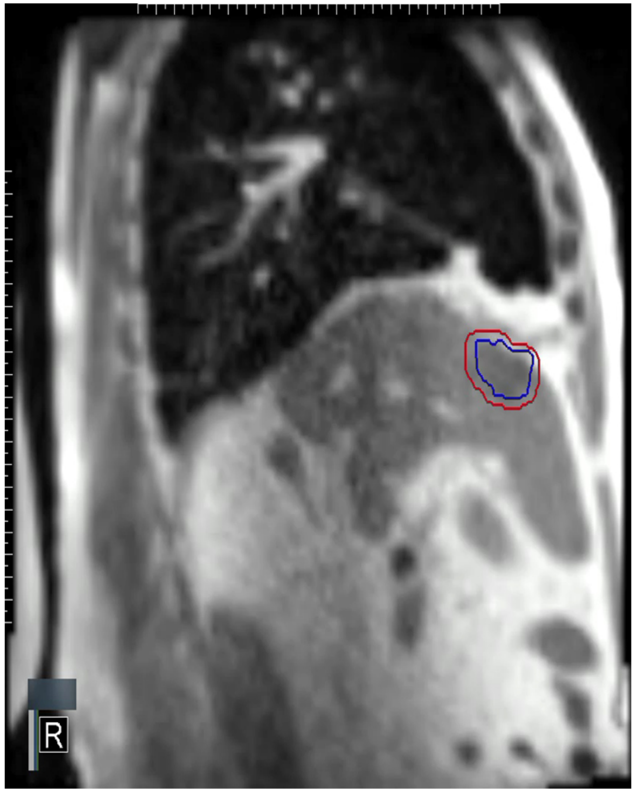
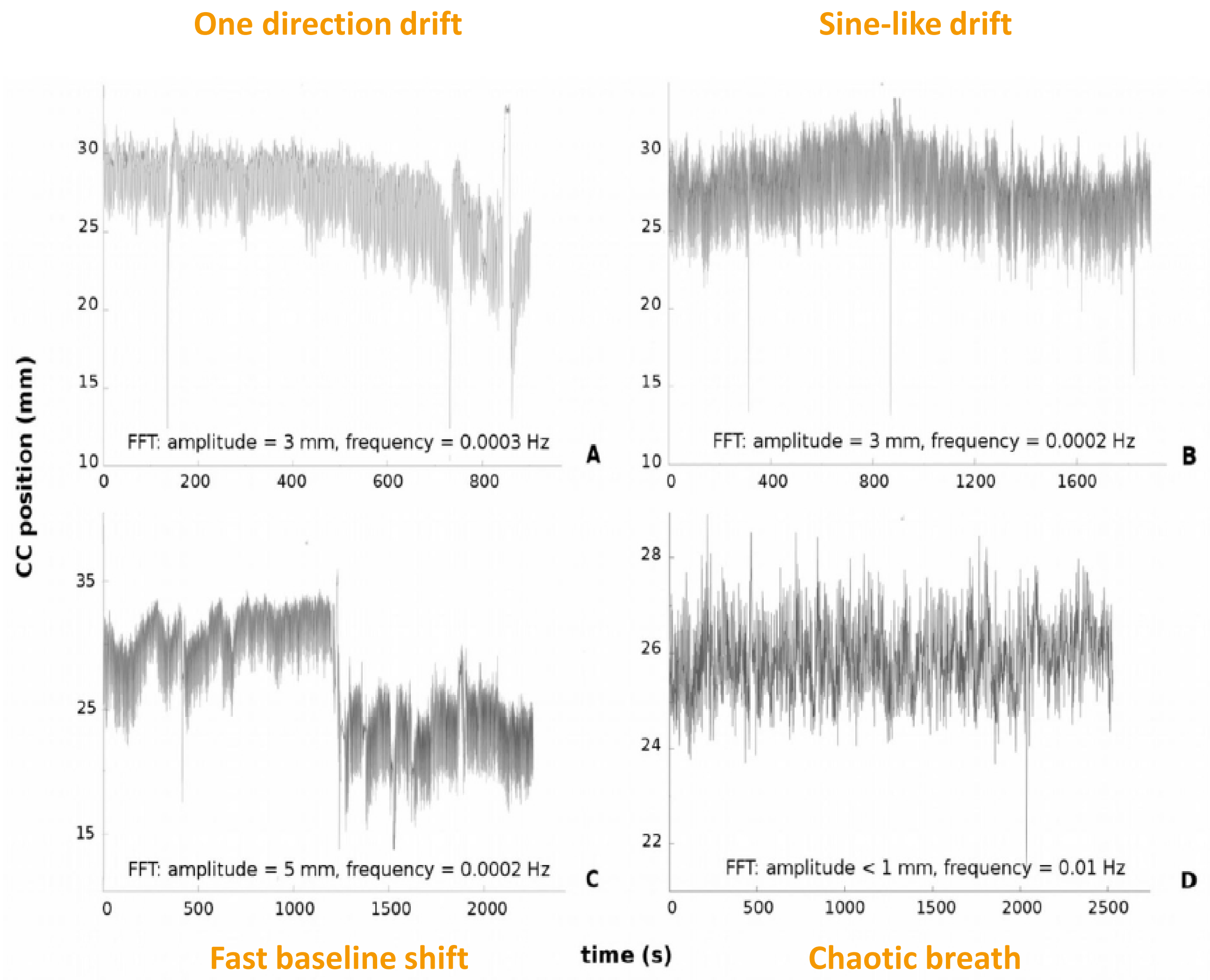
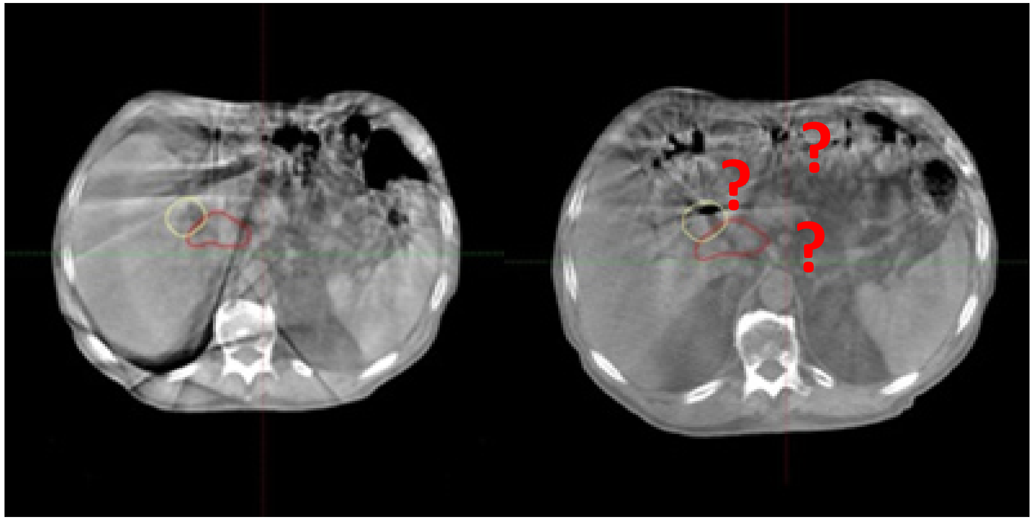




Cusumano D et al. Radiother Oncol. 2018;129(3):456-462

To adapt better

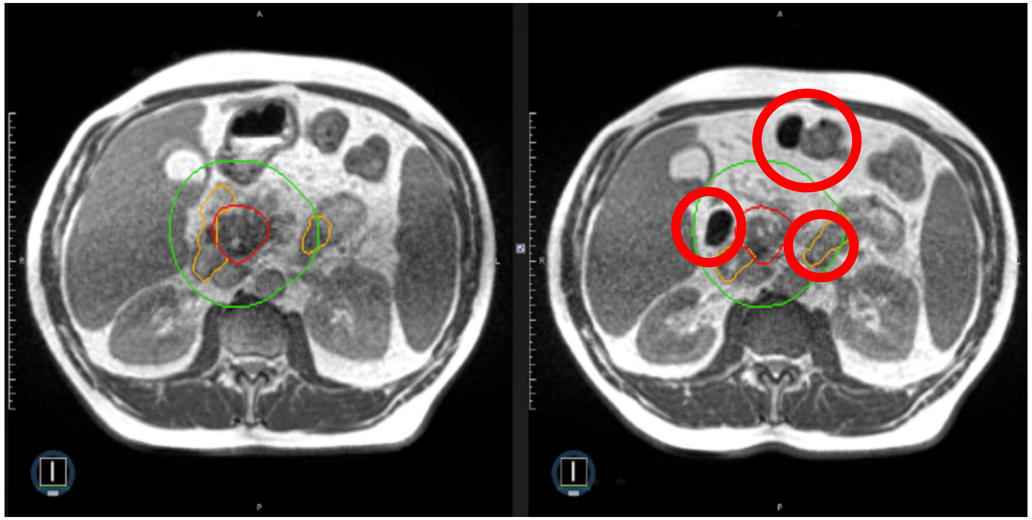
CBCT



GTV (CTV)

OaRs

0.35 T MRI

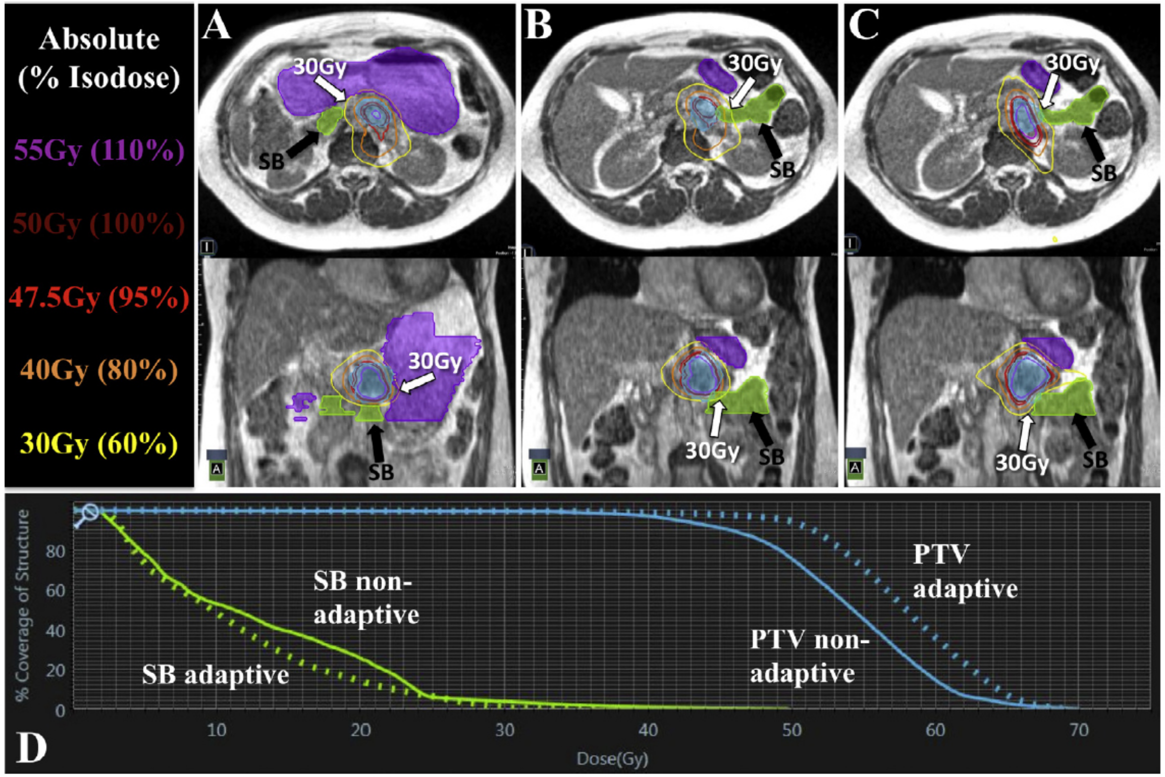


GTV (CTV)

OaRs

Boldrini L. et al Radiat Oncol 2019; 29;14(1):71

Pancreatic cancer: a promising scenario



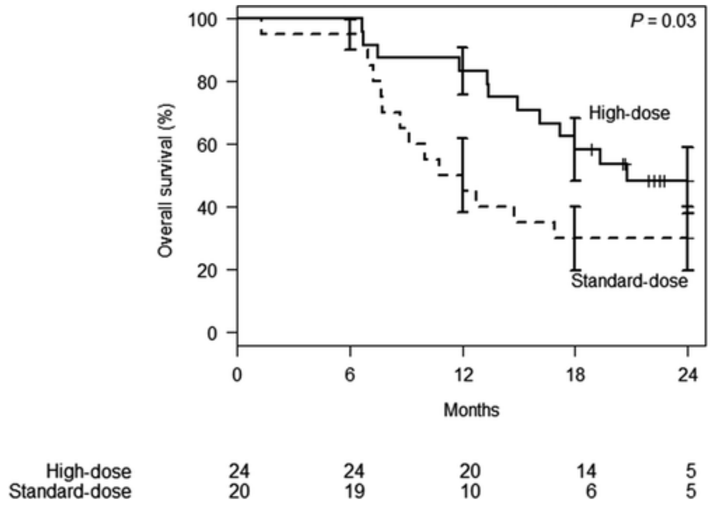
The stereotactic MR-guided online adaptive radiation therapy (SMART) approach

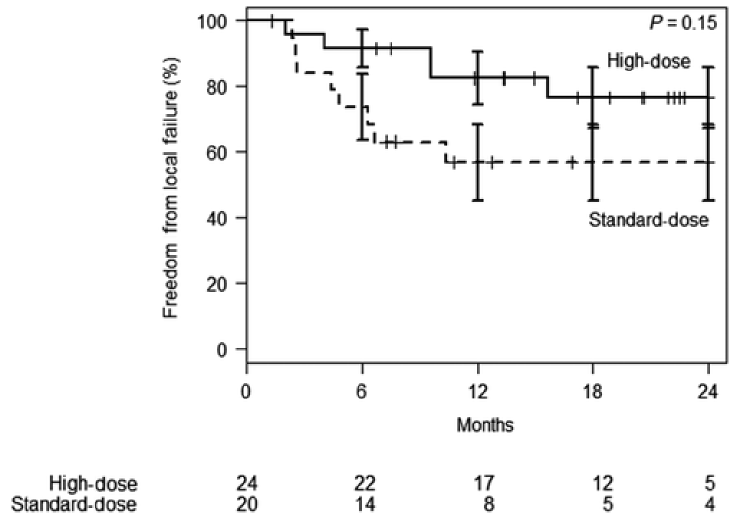
20 patients affected by liver and non liver abdominal malignancies

SMART increased PTV coverage in 64/97 fractions.

No Grade 3 acutetoxicity

Pancreatic cancer: a promising scenario





- 44 patients divided in high-dose (BED10 >70 Gy) and standard-dose groups
- 2yOS (49% vs 30%, p= 0.03)
- 2yFFLF (77% vs 57%, p= 0.15)
- 18mFFDF(24% vs 48%, p=0.92)
- No G3 toxicity in high-dose group

Rudra S. et al. Cancer Med 2019 May;8(5):2123-

SMART Trial - prospective, multi-center, phase II study

Stereostatic MR-guided On table adaptive RT for patients with borderline or inoperable locally advanced pancreatic cancer

Primary objective To determine **≥ G3 gastrointestinal** toxicity at **90 days** for pts with **boderline resectable or inoperable LAPC** treated with **MR-guided on-table adaptive RT** and soft tissue tracking with radiation beam gating to **50 Gy in 5 fractions (BED 100 Gy)**

Secondary objectives OS at 12 months; dPFS at 6 months; QoL 3 and 12 months post-RT

Results

136 enrolled patients, no ≥ G3 tox

From SMART	OS 65%	dPFS 50.6%	LC 82.9%
From diagnosis	OS 93.9%	dPFS 80.1%	LC 90%

32.4% pts got surgery after RT

Parikh P et al. Int J Radiat Oncol Biol Phys.2023.19;(23)

Thank you for your attention

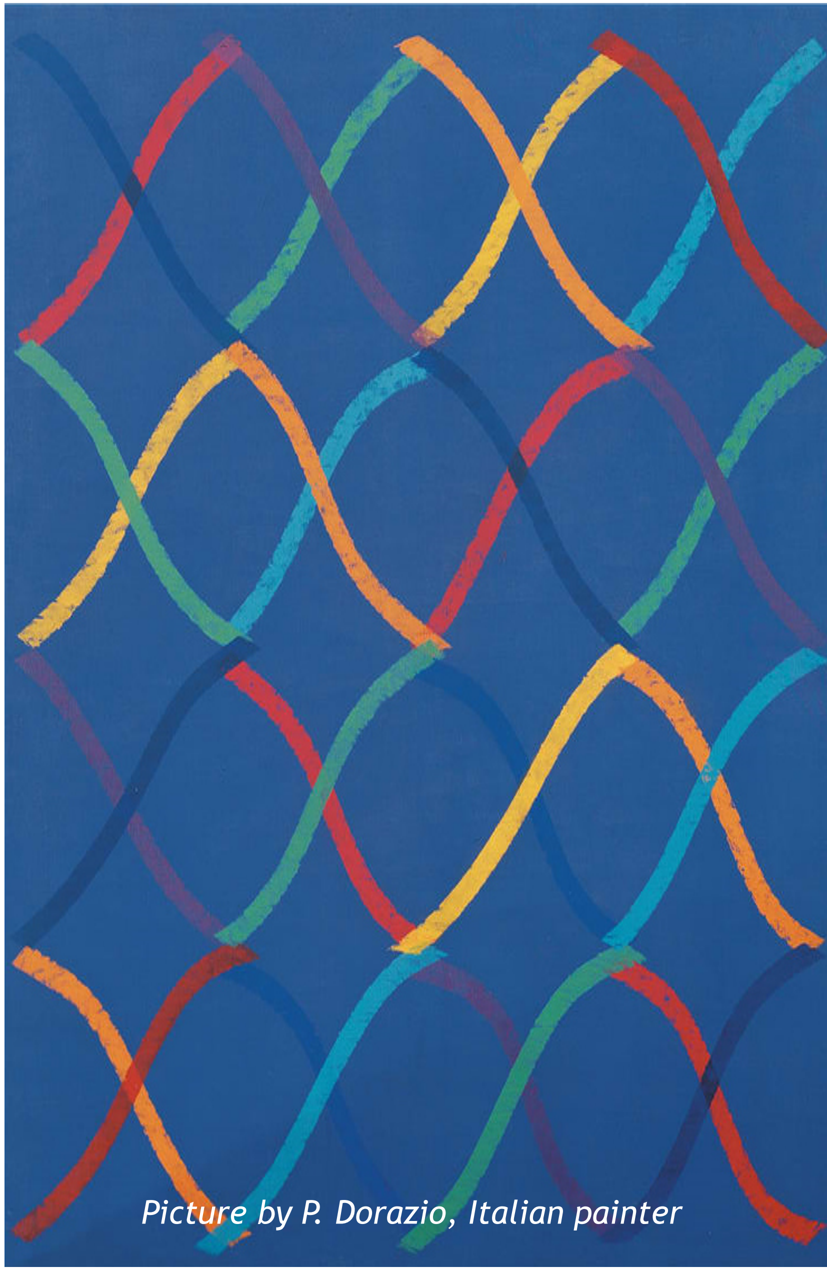
luca.boldrini@policlinicogemelli.it

Gemelli
Fondazione Policlinico Universitario Agostino Gemelli IRCCS
Università Cattolica del Sacro Cuore

ART
Advanced Radiation Therapy

GSTeP
Gemelli Science and Technology Park

ARC
Advanced Radiology Center



Picture by P. Dorazio, Italian painter