Strengths, weaknesses and opportunities of artificial intelligence (AI) in radiation oncology

Valerio Nardone

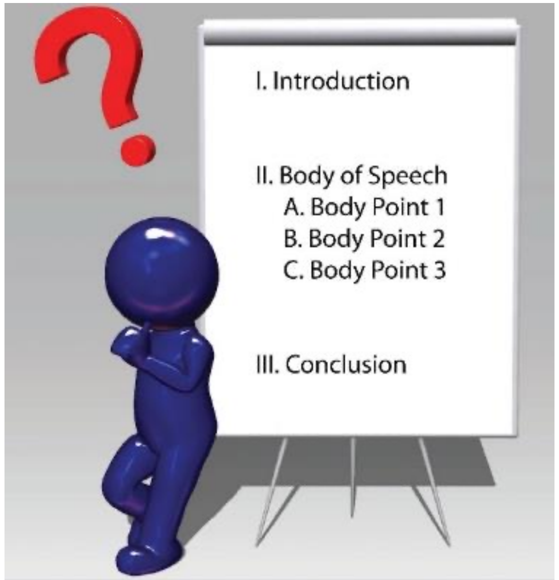
Department of Precision Medicine,
University of Campania «L. Vanvitelli», Naples

Disclosures

Per quanto concerne tale presentazione, dichiaro di non avere avuto alcuna relazione rilevante (diretta od indiretta) di tipo finanziario con alcuna compagnia farmaceutica negli ultimi 24 mesi che possa essere considerato un **conflitto di interesse.**

Outline

- ***Definition;***
- ***Application in RadOnc;***
- ***Highlights from ESTRO;***
- ***Highlights from ASTRO;***
- ***Other application;***
- ***Summary and conclusions;***



In computer science, *artificial intelligence* (AI), is intelligence demonstrated by machines, in contrast to the *natural intelligence* displayed by humans and animals. The term AI is used to describe machines that mimic *cognitive* functions associated with human minds, such as *learning* and *problem solving.*

Other terms

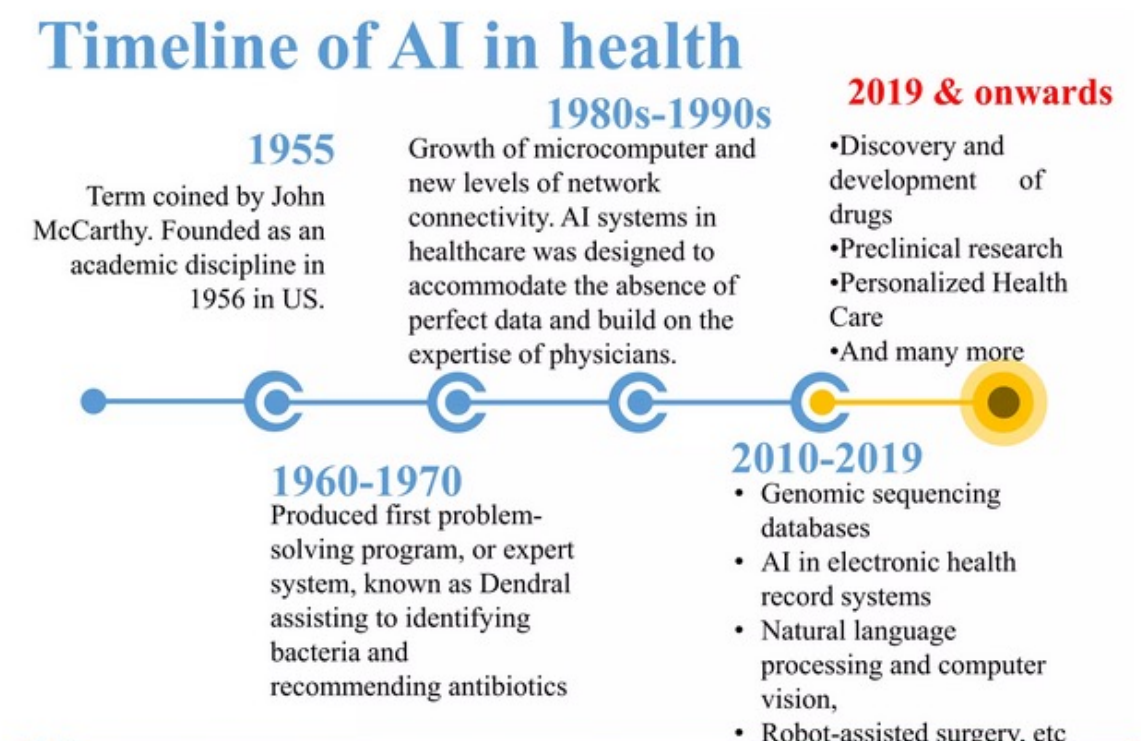
- *Machine learning:* it is an application of AI that provides systems the ability to aumatically learn and improve from experience without explicit programmation;
- *Neural Networks: are computing systems inspired bu the biological neural networks and nodes called artificial neurons.*
- *Data mining:* is the practice of esaming large databases to generate new informations;

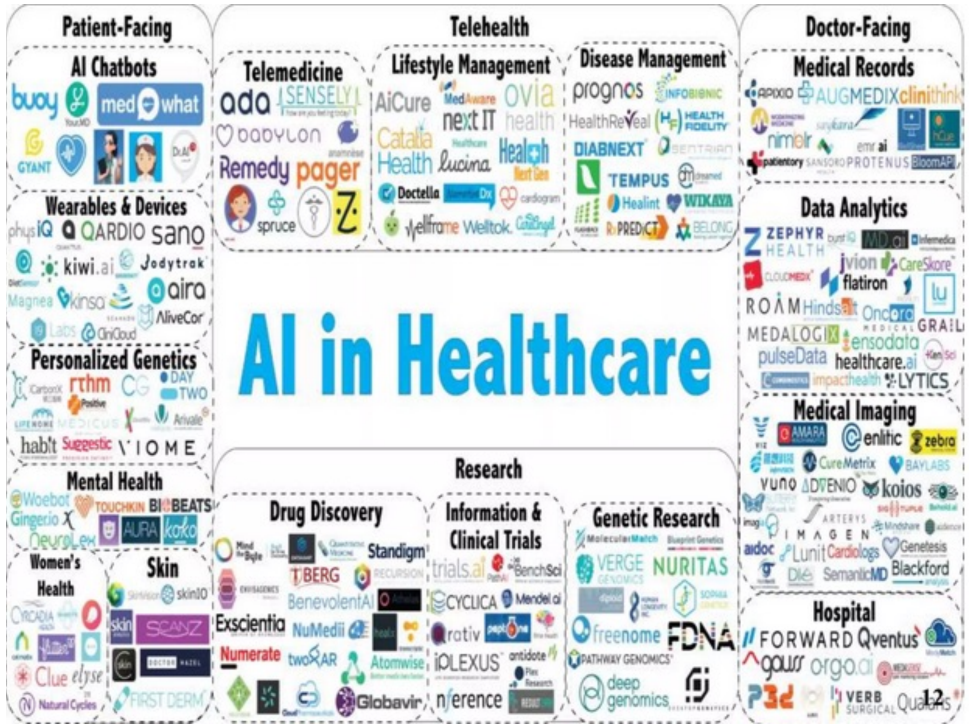
Automatic Recognition of Ripening Tomatoes by artificial intelligence

Artificial Intelligence in Factories

Japan ranked fourth in the world: In 2016, 303 robots were installed per 10,000 employees in the manufacturing industry.

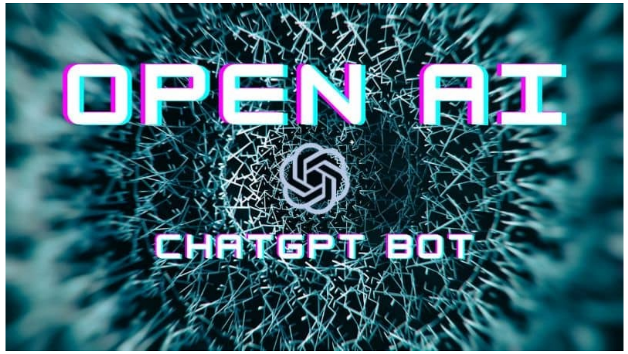
AI in Health


Timeline of AI in health
1955
Term coined by John McCarthy. Founded as an academic discipline in 1956 in US.
1960-1970
Produced first problem-solving program, or expert system, known as Dendral assisting to identifying bacteria and recommending antibiotics
1980s-1990s
Growth of microcomputer and new levels of network connectivity. AI systems in healthcare was designed to accommodate the absence of perfect data and build on the expertise of physicians.
2010-2019
• Genomic sequencing databases
• AI in electronic health record systems
• Natural language processing and computer vision,
• Robot-assisted surgery, etc
2019 & onwards
•Discovery and development of drugs
•Preclinical research
•Personalized Health Care
•And many more


AI in Healthcare
Patient-Facing
AI Chatbots
Wearables & Devices
Personalized Genetics
Mental Health
Women's Health
Skin
Telehealth
Telemedicine
Lifestyle Management
Disease Management
Research
Drug Discovery
Information & Clinical Trials
Genetic Research
Doctor-Facing
Medical Records
Data Analytics
Medical Imaging
Hospital

Digital Life Con la sua intelligenza artificiale ChatGPT scrive articoli scientifici a prova di... revisione umana

Oltre a produrre conversazioni complesse, ChatGPT può scrivere abstract di articoli scientifici e pezzi divulgativi che sembrano scritti da umani.



Special Reports > Exclusives

AI Passes U.S. Medical Licensing Exam

— Two papers show that large language models, including ChatGPT, can pass the USMLE

by Michael DePeau-Wilson, Enterprise & Investigative Writer, MedPage Today January 19, 2023

Sam Altman

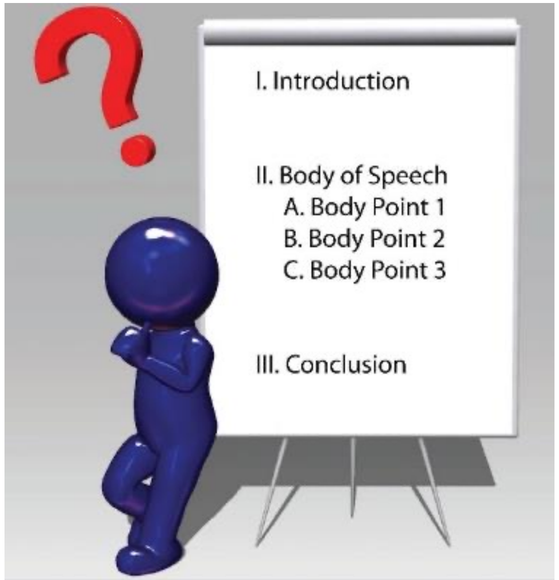
Generative storytelling has arrived.

https://beta.tome.app/

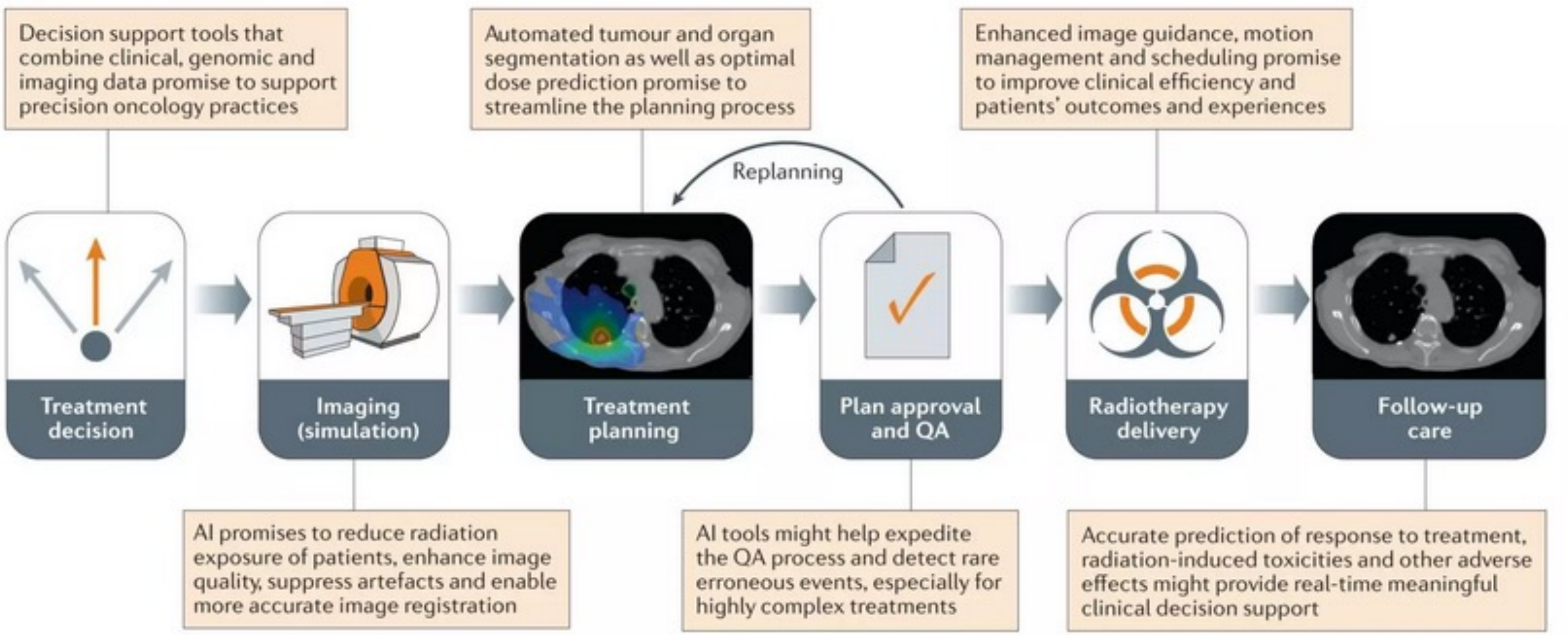
Unlock your best work with Tome's AI-powered storytelling format.

Outline

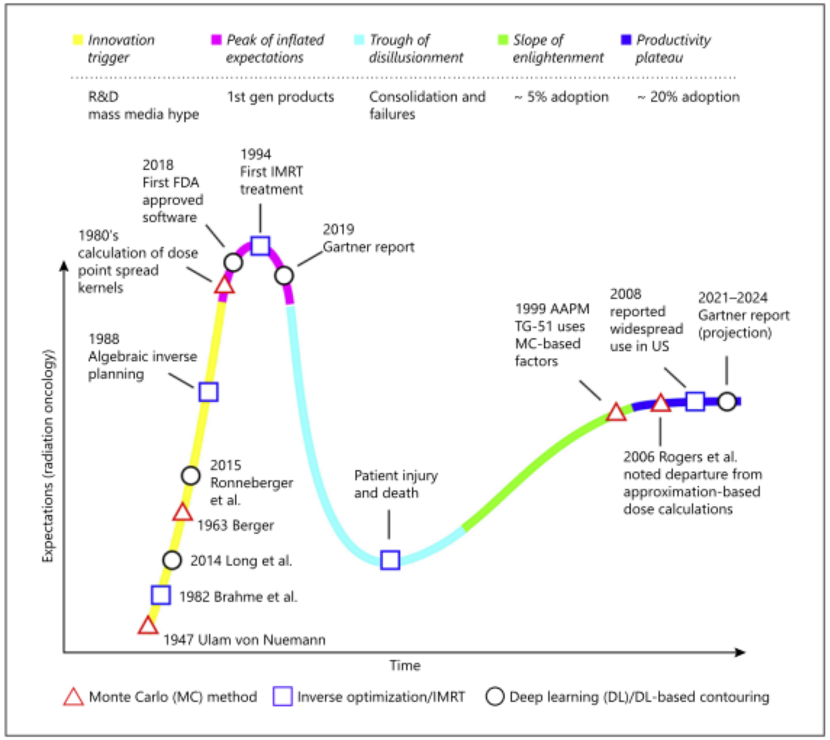
- ***Definition;***
- ***Application in RadOnc;***
- ***Highlights from ESTRO;***
- ***Highlights from ASTRO;***
- ***Other application;***
- ***Summary and conclusions;***

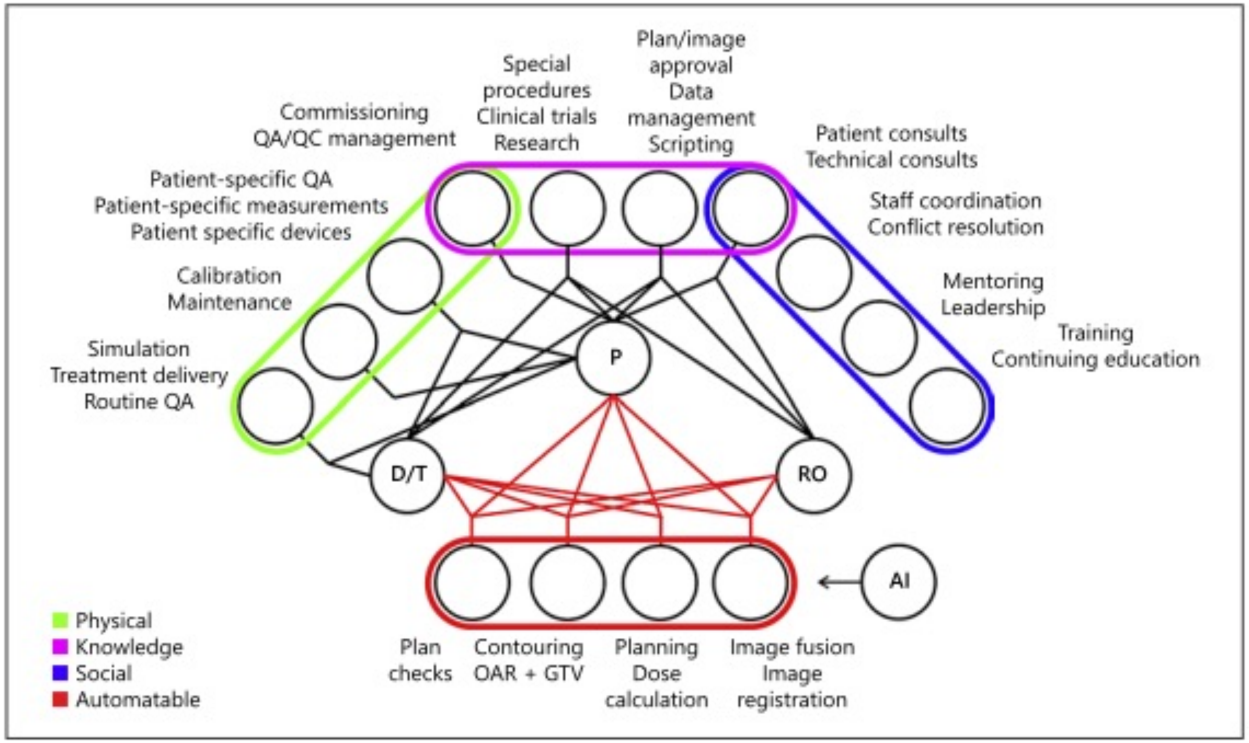


AI in Radiation Oncology



Huynh et al. Nat Rev Clin Oncol 2020

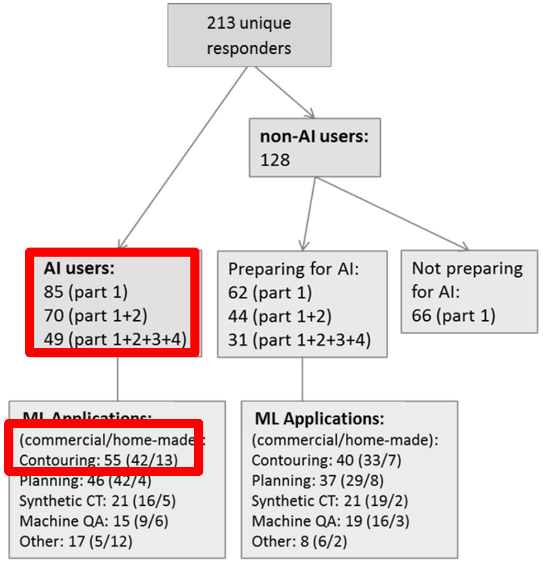


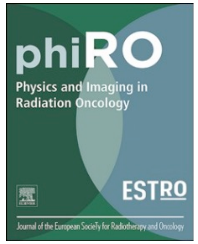


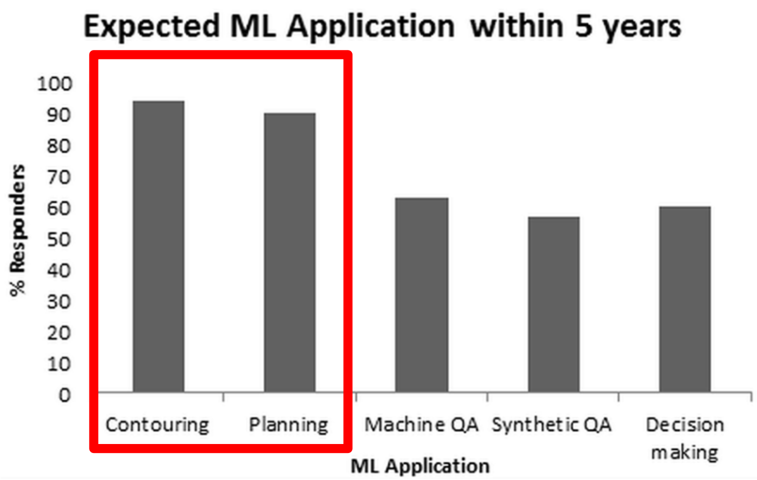
Hype cycle. This figure features a hype cycle curve for three major innovations in radiation oncology (triangle: Monte Carlo; square: Inverse optimization/IMRT; circle: deep learning-based contouring). The curve depicts expectations by the target audience (those in radiation oncology and medical physics) as a function of time. Yellow, magenta, cyan, green, and blue portions of the curve denote "innovation trigger," "peak of inflated expectations," "trough of disillusionment," "slope of enlightenment," and "productivity plateau" regions, respectively.

The Emergence of Artificial Intelligence within Radiation Oncology Treatment Planning, Tetherton et al. Oncology 2021

Use of AI in 2020







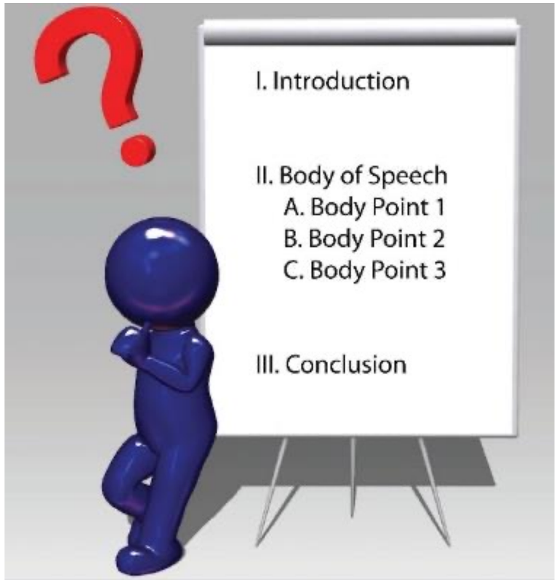
Supplemental Table 1. Number of Radiation Oncology Departments using or preparing to use machine learning applications in clinical practice per country

Radiation Oncology Departments and Machine Learning Applications	Clinical	Preparing
France	8	
Italy	7	5
Netherlands	8	3
Spain	7	2
Australia	5	4
Belgium	5	3
United Kingdom	4	3
Denmark	3	2
Switzerland	3	3
United States of Amerika	3	1
Germany	2	2
Norway	2	3

C.L. Brouwer et al. Physics and Imaging in Radiation Oncology 2020

Outline

- ***Definition;***
- ***Application in RadOnc;***
- ➢ ***Highlights from ESTRO;***
- ***Highlights from ASTRO;***
- ***Other application;***
- ***Summary and conclusions;***



AI: friend or foe

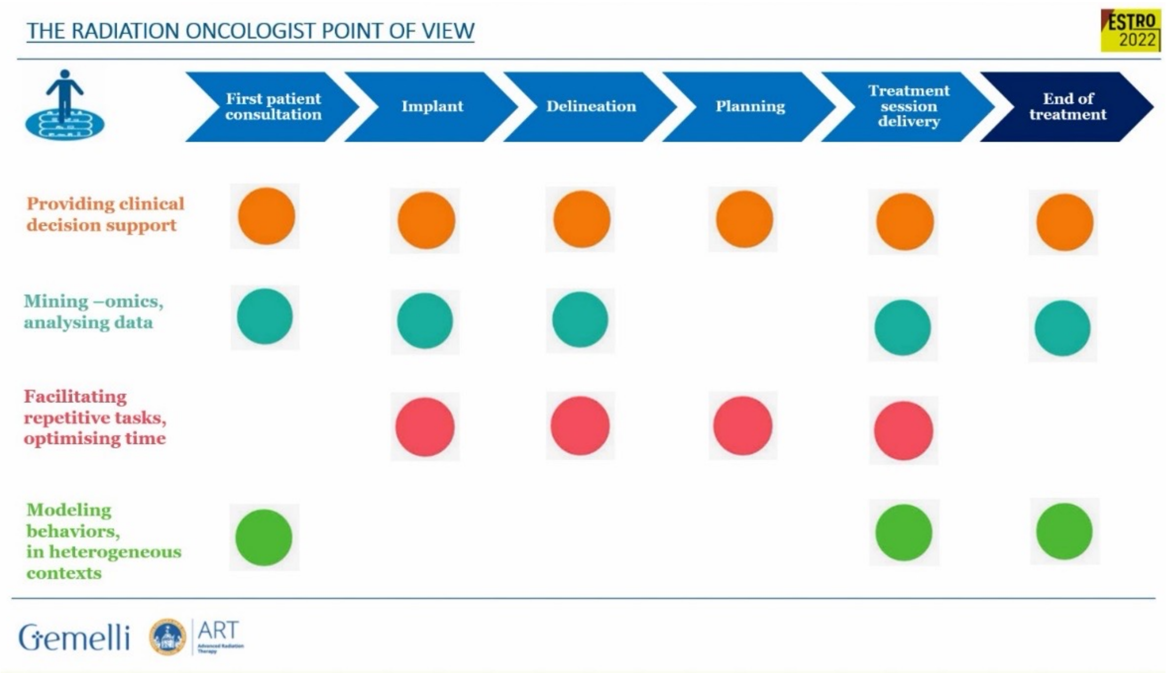
AI is a friend

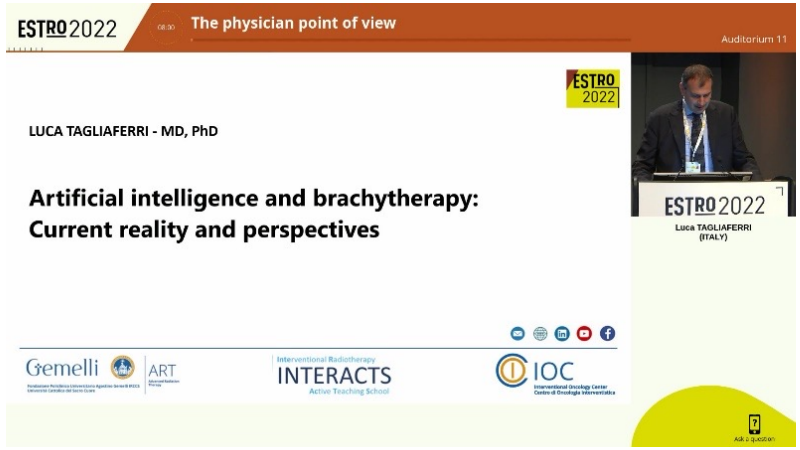
- Time reduction for the radiotherapist (contours, planning),
- Improve accuracy and precision in RT treatments,
- Predict toxicity,
- Cost reduction.

AI is a foe

- 〝I may take your job〞,
- Incorrect treatment decisions with incomplete or biased data,
- Manipulation of AI algorithms or steal patient data by hackers.

AI in Brachytherapy



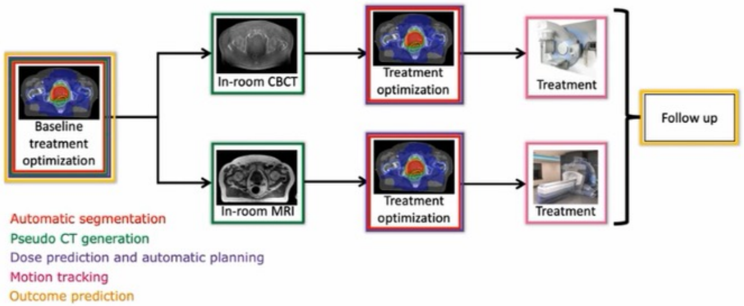


AI in the RT workflow

LMU KLINIKUM

Summary
Many roles for AI in the RT workflow

- AI algorithms are applicable to almost all aspects of the RT workflow
- Commercial solutions are now available
- Segmentation is one of the most visible applications
- Pseudo CT software is also making its way into the clinic
- Some aspects will naturally remain research topics

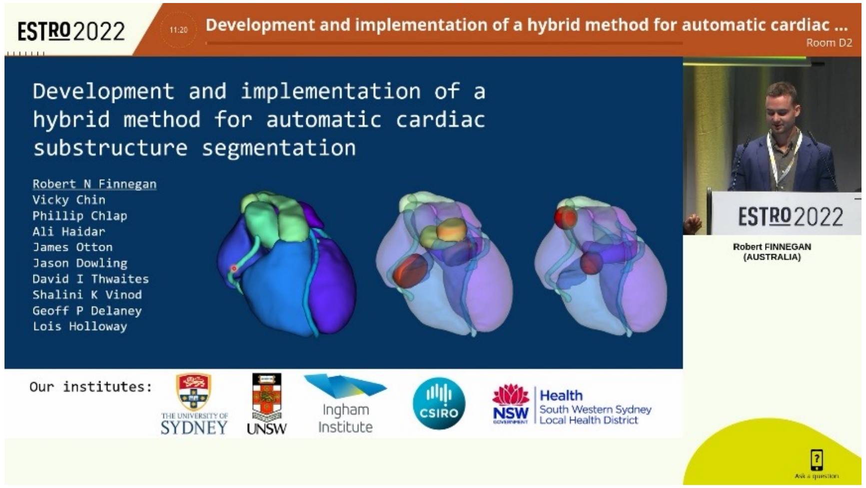


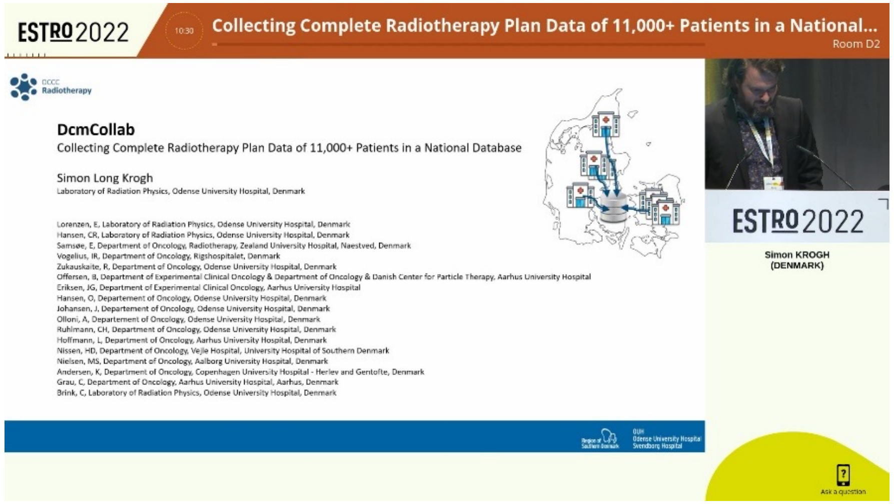
Guillaume LANDRY
(GERMANY)

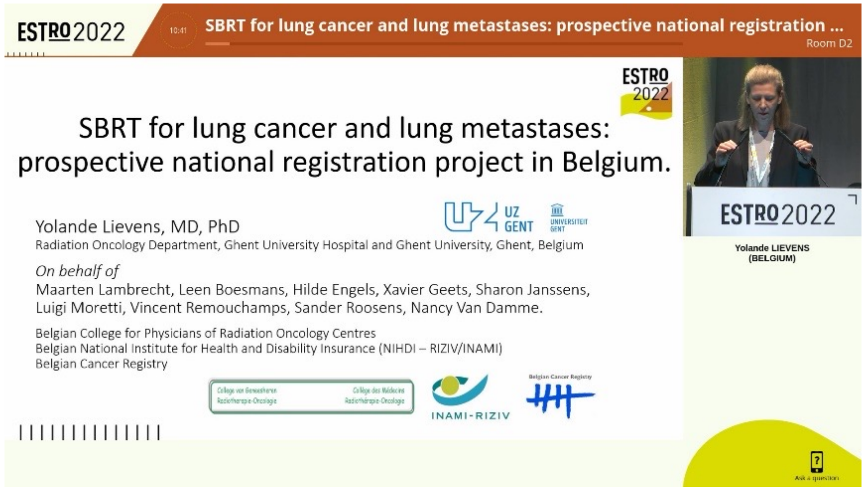
ARTIFICIAL INTELLIGENCE → DEEP LEARNING → MACHINE LEARNING

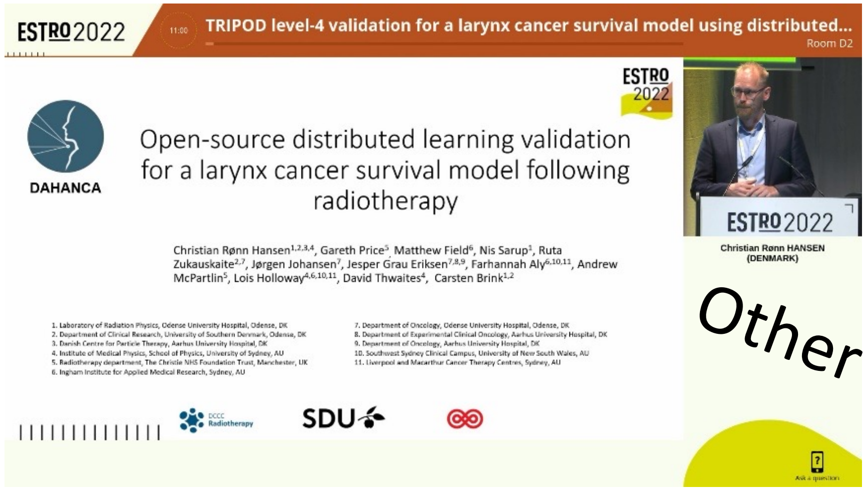
HIGHLIGHTS in RADIOTERAPIA

Update degli Studi Practice Changing 2022





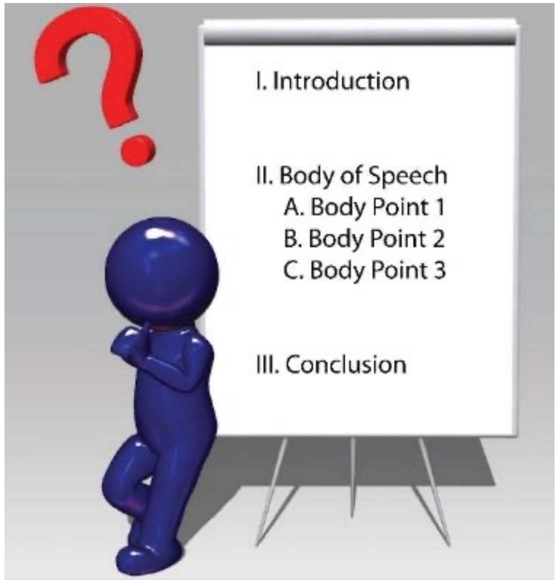




Other Hints

Outline

- ***Definition;***
- ***Application in RadOnc;***
- ***Highlights from ESTRO;***
- ➢ ***Highlights from ASTRO;***
- ***Other application;***
- ***Summary and conclusions;***



Emotional intelligence is defined as **the ability to understand and manage your own emotions, as well as recognize and influence the emotions of those around you**. The term was first coined in 1990 by researchers John Mayer and Peter Salovey, but was later popularized by psychologist Daniel Goleman.

Impact of AI on Quality of Care, Clinical Practice and Training

- Variation in quality exists, but regionalization is NOT the solution;
- AI can reduce unrewarding tasks that consume time/cognitive burden;
- AI can also inform or facilitate strategies to enhance quality (simulation training for complex cases, patient selection for escalation of clinical care);

➢ **There will be pluses and minuses, but change is certain;**

➢ **Success will come through networking within us and across disciplines;**

Erin Gillespie

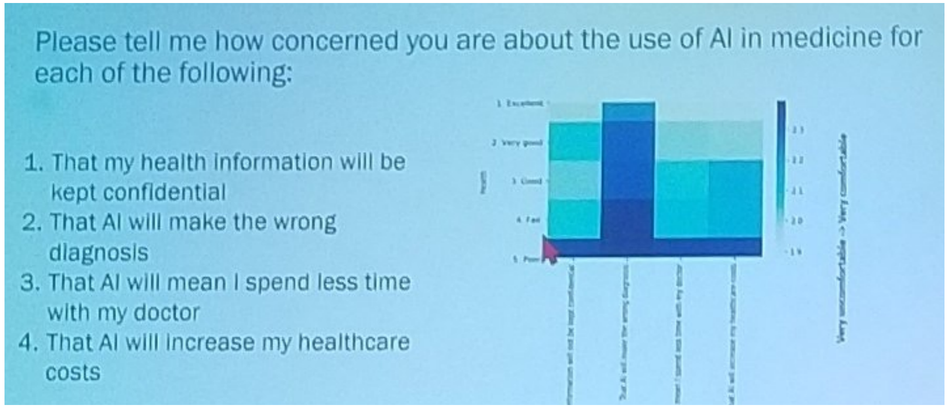
Deep learning in digital histopathology for prostate cancer

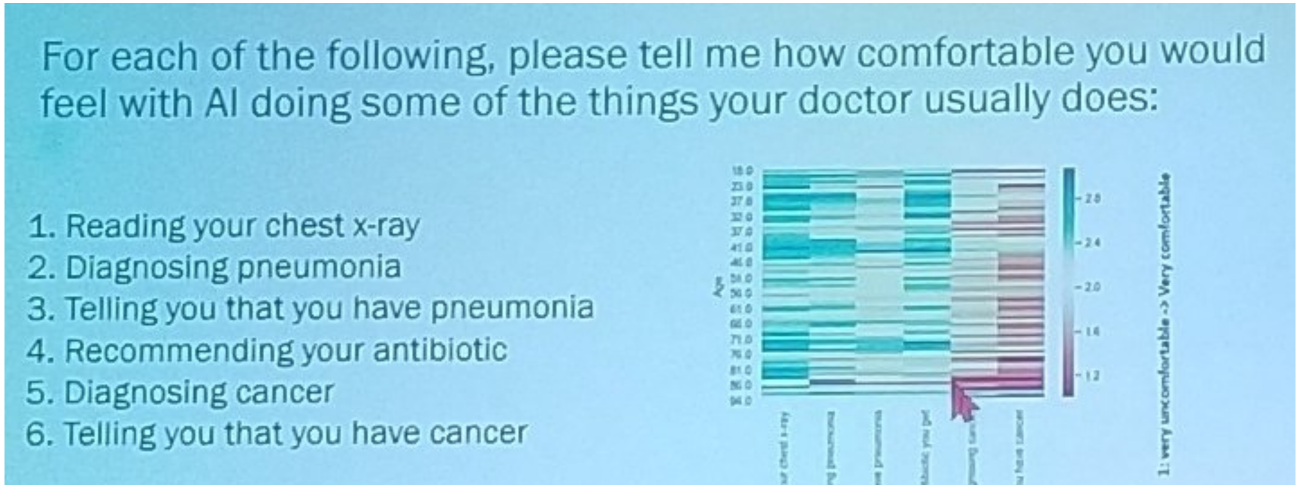
- AI derived prognostic biomarkers provide personalized risk estimates, that when grouped allows more streamlined communication;
- ArteraAI MMAI prognostic tool identifies 6-fold more low-risk patients than NCCN (safe omitting of ADT with RT, with a NNT>25);
- **Prognostic biomarkers help with shared-decision making to avoid futile treatment intensification;**
- **Use of AI tools leveraging digital pathology improves prognostication, enabling us to determine the optimal treatment plan for the single patient (precision medicine);**

Jonathan Tward

AI & EI: CARING FOR THE PATIENT IN A WIRELESS WORLD
ASTRO ANNUAL 2022 MEETING

Current Progress of Machine Learning in Radiation Oncology





Sanjay Aneja

AI & EI: CARING FOR THE PATIENT IN A WIRELESS WORLD
ASTRO ANNUAL 2022 MEETING

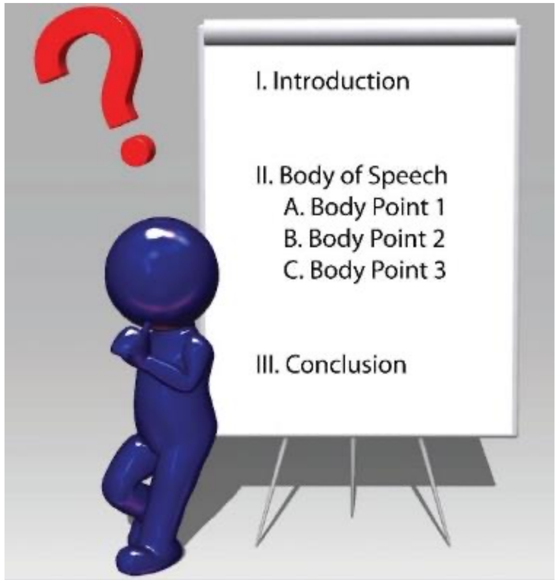
Exploring ethical challenges in RadOnc AI

- While waivers can be ethical and pragmantic solutions, patients have no idea that AI is being used in research or care involving them;
- **If for minimal risk for quality systems we can rely on good ML practice, for higher risk we necessitate prospective informed consent!**
- Umbrella consent needed to inform patients;
- **Additional disclosure duties: patient access to information about specific AI algorithms used in their care;**

Subha Perni

Outline

- ***Definition;***
- ***Application in RadOnc;***
- ***Highlights from ESTRO;***
- ***Highlights from ASTRO;***
- ➢ ***Other application;***
- ***Summary and conclusions;***



Cost-effectiveness analysis in oncology with AI

JAMA Oncology | Brief Report

Long-term Effect of Machine Learning–Triggered Behavioral Nudges on Serious Illness Conversations and End-of-Life Outcomes Among Patients With Cancer
A Randomized Clinical Trial

JAMA 2023

Christopher R. Manz, MD; Yichen Zhang, PhD; Kan Chen, MA; Qi Long, PhD; Dylan S. Small, PhD; Chalanda N. Evans, BS; Corey Chivers, PhD; Susan H. Regli, PhD; C. William Hanson, MD; Justin E. Bekelman, MD; Jennifer Braun, MHA, RN, BSN; Charles A. L. Rareshide, MS; Nina O'Connor, MD; Pallavi Kumar, MD, MPH; Lynn M. Schuchter, MD; Lawrence N. Shulman, MD; Mitesh S. Patel, MD, MBA; Ravi B. Parikh, MD, MPP

healthcare MDPI

Article

Economics of Artificial Intelligence in Healthcare: Diagnosis vs. Treatment

Narendra N. Khanna [1], Mahesh A. Maindarkar [2,3], Vijay Viswanathan [4], Jose Fernandes E Fernandes [5],

Healthcare 2023

CONCLUSIONS AND RELEVANCE In this randomized clinical trial, a machine learning–based behavioral intervention and behavioral nudges to clinicans led to an increase in SICs and reduction in end-of-life systemic therapy but no changes in other end-of-life outcomes among outpatients with cancer. These results suggest that machine learning and behavioral nudges can lead to long-lasting improvements in cancer care delivery.

Genomic analysis in oncology with AI

Validation of a 40-gene expression profile test to predict metastatic risk in localized high-risk cutaneous squamous cell carcinoma

JAAD 2021

Ashley Wysong, MD, MS,[a] Jason G. Newman, MD,[b] Kyle R. Covington, PhD,[c] Sarah J. Kurley, PhD,[c] Sherrif F. Ibrahim, MD, PhD,[d] Aaron S. Farberg, MD,[e,f] Anna Bar, MD,[g] Nathan J. Cleaver, DO,[h] Ally-Khan Somani, MD, PhD,[i] David Panther, MD,[j] David G. Brodland, MD,[j] John Zitelli, MD,[j] Jennifer Toyohara, MD,[k] Ian A. Maher, MD,[l] Yang Xia, MD,[m] Kristin Bibee, MD,[n] Robert Griego, MD,[o] Darrell S. Rigel, MD,[p] Kristen Meldi Plasseraud, PhD,[c] Sarah Estrada, MD,[q,r] Lauren Meldi Sholl, MS,[q] Clare Johnson, RN,[q] Robert W. Cook, PhD,[c] Chrysalyne D. Schmults, MD, MSCE,[s] and Sarah T. Arron, MD, PhD[t]

– JAAD 2021

Development and validation of a nomogram incorporating gene expression profiling and clinical factors for accurate prediction of metastasis in patients with cutaneous melanoma following Mohs micrographic surgery

Ryan B. Thorpe, MD,[a] Kyle R. Covington, PhD,[b] Hillary G. Caruso, PhD,[b] Ann P. Quick, PhD,[b]

Seminars in Cancer Biology 88 (2023) 187–200

Contents lists available at ScienceDirect

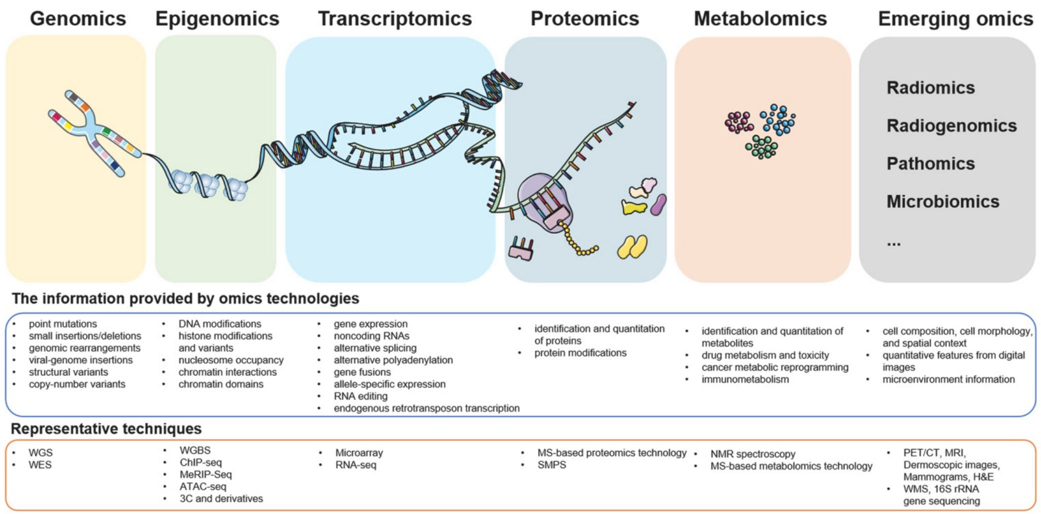
Seminars in Cancer Biology

journal homepage: www.elsevier.com/locate/semcancer

Artificial intelligence-based multi-omics analysis fuels cancer precision medicine

Xiujing He[1], Xiaowei Liu[1], Fengli Zuo, Hubing Shi, Jing Jing*

2023



Genomic analysis in oncology with AI: the risk for RADONC

original reports

Development and Validation of a Genomic Profile for the Omission of Local Adjuvant Radiation in Breast Cancer

JCO 2023

Martin Sjöström, MD, PhD[1,2]; Anthony Fyles, MD[3]; Fei-Fei Liu, MD[3]; David McCready, MD[3]; Wei Shi, MSc[3]; Katrina Rey-McIntyre, MBA, BSc[3]; S. Laura Chang, PhD[4]; Felix Y. Feng, MD[2]; Corey W. Speers, MD, PhD[5]; Lori J. Pierce, MD[5]; Erik Holmberg, PhD[6]; Mårten Fernö, PhD[1]; Per Malmström, MD, PhD[1,7]; and Per Karlsson, MD, PhD[6]

21-Gene recurrence score predictive for prognostic benefit of radiotherapy in patients age ≥ 70 with T1N0 ER/PR + HER2- breast cancer treated with breast conserving surgery and endocrine therapy

Neil Chevli • Waqar Haque • Kevin T. Tran • ... Sandra S. Hatch • E. Brian Butler • Bin S. Teh

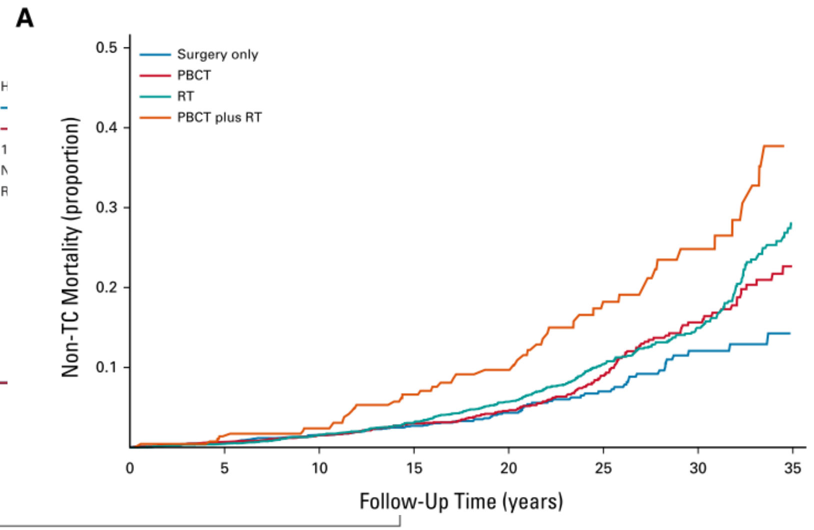
Show all authors

Published: June 27, 2022 • DOI: https://doi.org/10.1016/j.radonc.2022.06.013 • Check for updates

BUT CONSIDER THIS

Testicular Cancer in the Cisplatin Era: Causes of Death and Mortality Rates in a Population-Based Cohort

Ragnhild Hellesnes, MD[1,2]; Tor Åge Myklebust, PhD[3,4]; Sophie D. Fosså, MD, PhD[4,5,6]; Roy M. Bremnes, MD, PhD[1,2]; Ásà Karlsdottir, MD, PhD[7]; Øivind Kvammen, MD, PhD[8]; Torgrim Tandstad, MD, PhD[9,10]; Tom Wilsgaard, PhD[11]; Helene F. S. Negaard, MD, PhD[5]; and Hege S. Haugnes, MD, PhD[1,2]

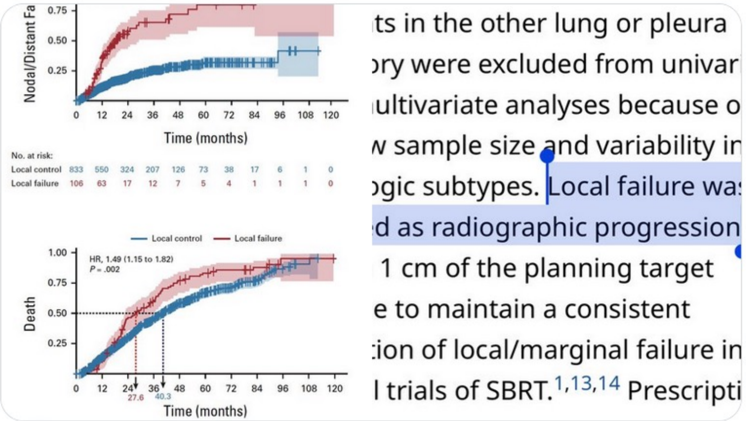


Genomic analysis in oncology with AI: the opportunity for RADONC

original reports

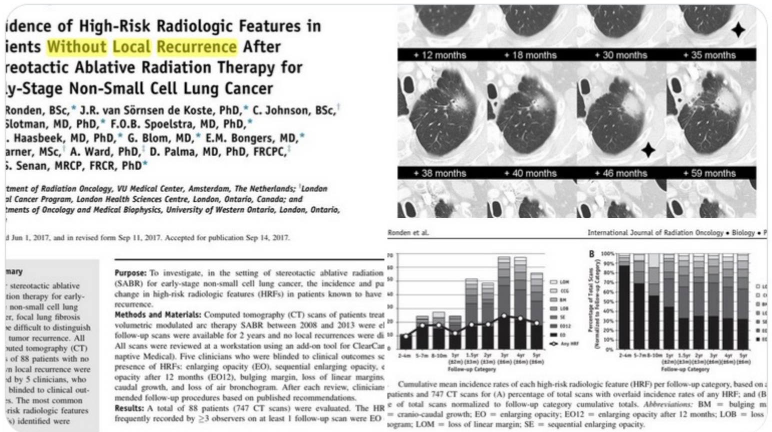
Drew Moghanaki @DrewMoghanaki · 16h
In risposta a @theabzlab
Congratulations on pushing us into the future.

I noticed a very high event rate in your cohort, suggesting these data will need to be validated in a healthier cohort to be applicable to operable pts.



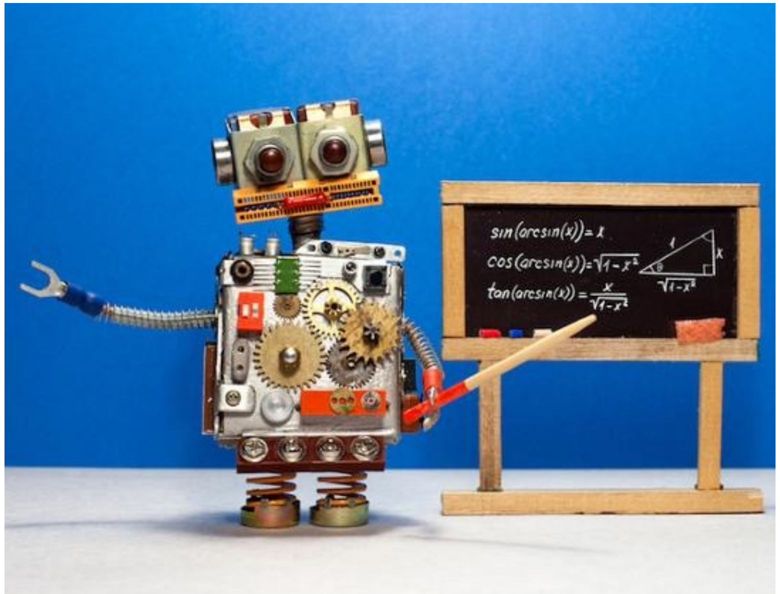
1 · 1 · 153

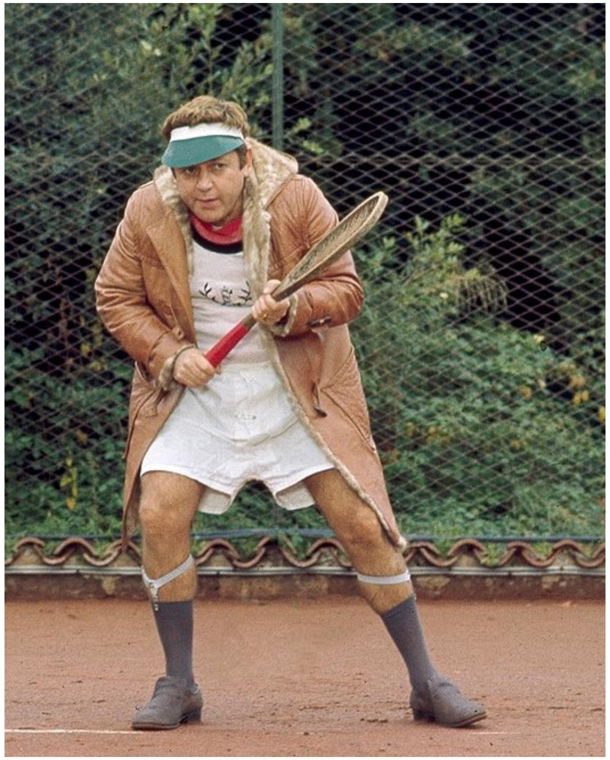
Drew Moghanaki @DrewMoghanaki · 16h
In risposta a @DrewMoghanaki e @theabzlab
This is a MUST READ paper for anyone coding local failures after SBRT. It shows how easy, but not how often, it is for coders to be fooled and overcall LF. doi.org/10.1016/j.ijro...



1 · 1 · 107

Things to remember: AI performance depends on the TRAINING





Genomic analysis in oncology with AI: the opportunity for RADONC

Journal Pre-proof

Red Journal 2022

Genomic classifiers in personalized prostate cancer radiotherapy approaches – a systematic review and future perspectives based on international consensus

Simon K.B. Spohn MD , Cédric Draulans MD ,
Amar U. Kishan MD , Daniel Spratt MD , Ashley Ross MD, PhD ,
Tobias Maurer Prof. MD , Derya Tilki Prof., MD ,
Alejandro Berlin MD , Pierre Blanchard MD, PhD ,
Sean Collins MD , Peter Bronsert MD , Ronald Chen MD, PhD ,
Alan Dal Pra MD , Gert de Meerleer MD, Prof. ,
Thomas Eade MD, Prof. , Karin Haustermans MD, Prof.

Published in final edited form as:
J Thorac Oncol. 2021 March ; 16(3): 428–438. doi:10.1016/j.jtho.2020.11.008.

Personalizing Radiotherapy Prescription Dose Using Genomic Markers of Radiosensitivity and Normal Tissue Toxicity in Non-Small Cell Lung Cancer

Jacob G. Scott[1,2,†,*], Geoff Sedor[2,†], Jessica A. Scarborough[1,2], Michael W. Kattan[3], Jeffrey Peacock[4], G. Daniel Grass[4], Eric A. Mellon[5], Ram Thapa[6], Michael Schell[6], Anthony Waller[7], Sean Poppen[8], George Andl[7], Jamie Teer[6], Steven A. Eschrich[6], Thomas J. Dilling[4], William S. Dalton[9], Louis B. Harrison[4], Tim Fox[7], Javier F. Torres-Roca[3,*]

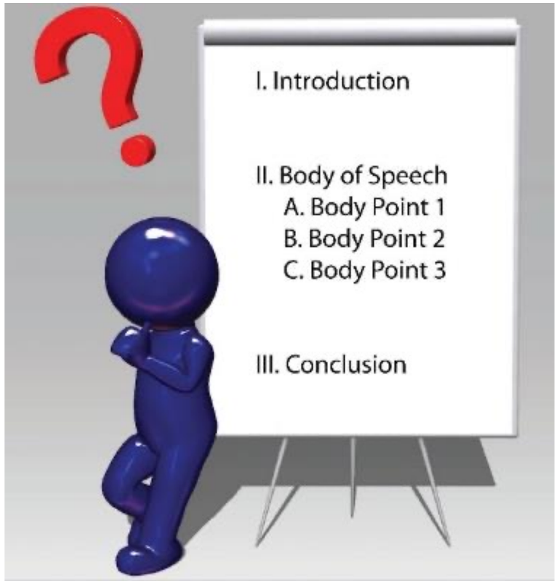
Pan-cancer prediction of radiotherapy benefit using genomic-adjusted radiation dose (GARD): a cohort-based pooled analysis

Jacob G Scott, DPhil † • Geoffrey Sedor, MD † • Patrick Ellsworth, BA • Jessica A Scarborough, MS • Kamran A Ahmed, MD • Daniel E Oliver, MD • et al. Show all authors • Show footnotes

Published: August 04, 2021 • DOI: https://doi.org/10.1016/S1470-2045(21)00347-8 • Check for updates

Outline

- ***Definition;***
- ***Application in RadOnc;***
- ***Highlights from ESTRO;***
- ***Highlights from ASTRO;***
- ***Other application;***
- ➢ ***Summary and conclusions;***



SUMMARY

- In the next years we will see many different application of AI in RadOnc workflow;
- Current applications focus on contouring, planning, adaptive;
- Future development in other areas (genomic profiling, radiomics) could have an high impact on RadOnc;
- Ethical challenges need to be solved;
- A big effort of RadOnc community is needed to train and validate AI approaches (networking is the key);

CONCLUSIONS

Don't be afraid of the future → Where were we until 20 years ago?

3DRT

IMRT

VMAT

MRI-LINAC

Advanced SRT

?

There is no SOUL in
the MACHINE.
Only in front of it.

Without you, it's just DATA.

Università degli Studi della Campania *Luigi Vanvitelli*