Advances in AI in advanced prostate cancer

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Disclosures

Professor Alcaraz has acted as a speaker for the following companies:

- Astellas, Bayer, Casen Recordati, Ipsen, Janssen and Olympus
- The speaker has received an honorarium for this presentation

Artificial intelligence (AI)

The ability of a *machine*
to perform *cognitive tasks*
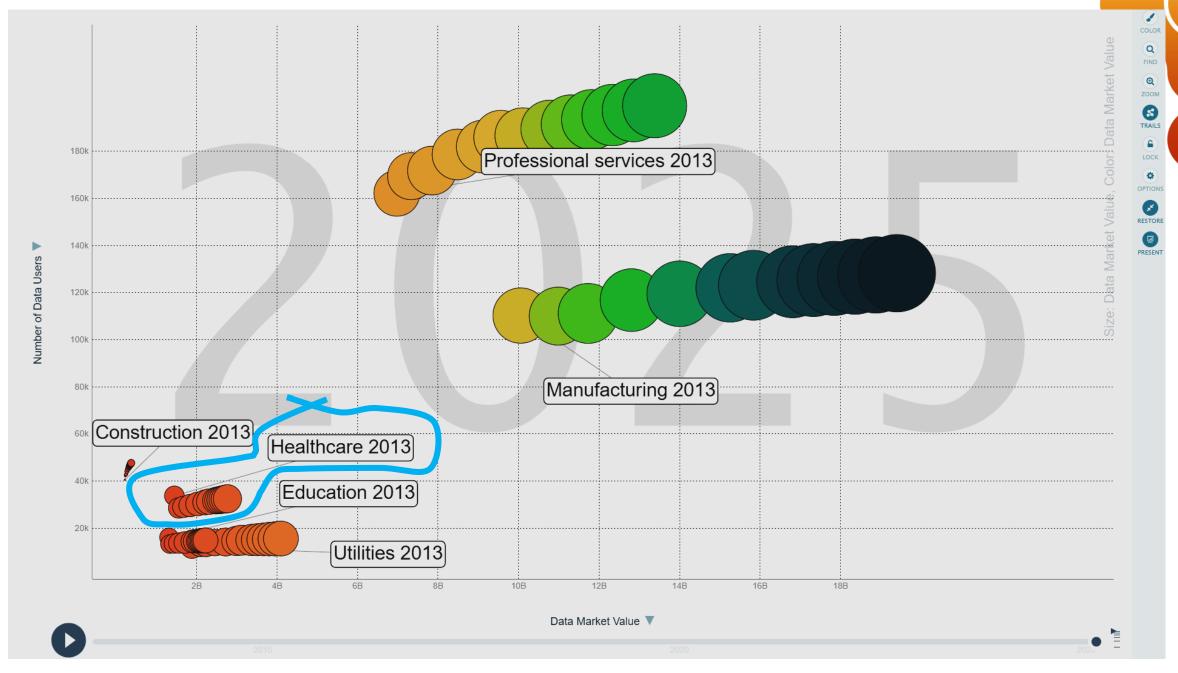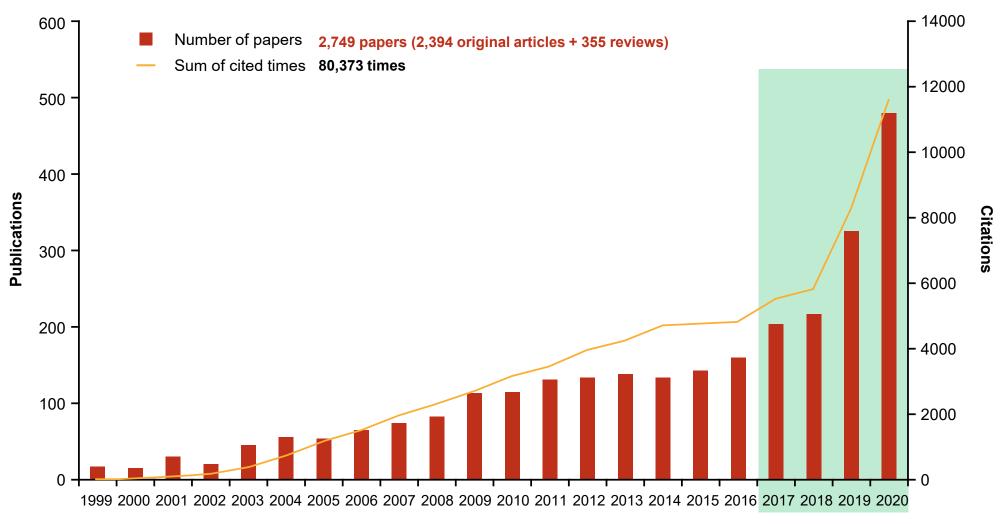*with a* *specific objective*
based on the *provided data*

Size: Data Market Value, Color: Data Market Value

Number of Data Users

Professional services 2013

Manufacturing 2013

Construction 2013

Healthcare 2013

Education 2013

Utilities 2013

Data Market Value

Global trend of publications and total citations on AI research in prostate cancer from 1999 to 2020

Legend:
- Number of papers — **2,749 papers (2,394 original articles + 355 reviews)**
- Sum of cited times — **80,373 times**

Subsets of artificial intelligence

Artificial Intelligence, AI:
The ability of a machine to perform cognitive tasks with a specific objective based on the provided data.

Machine Learning, ML:
- Supervised learning:
  - Naive Bayes Classification
  - Linear And Logistic Regression
  - Support Vector Machines
  - Random Forests
- Unsupervised learning:
  - K-means Clustering
  - Principal Component Analysis
  - Autoencoders

Deep Learning, DL:
- Artificial Neural Network
- Convolutional Neural Network

Applications of AI in prostate cancer care: A path to enhanced efficiency and outcomes

Riaz I, et al. *Am Soc Clin Oncol Educ Book*. 2024;44(3):e438516

PRACTICAL APPLICATIONS

- Integrating artificial intelligence (AI) into prostate cancer care can enhance clinical decision making, lower documentation burden, and accelerate evidence generation and synthesis and drug development.

- Significant progress in localized prostate cancer has been made, including improved and early detection, targeted biopsy, grading, disease prognostication, and outcome prediction, using imaging and pathology data. AI products are now available to facilitate prostate cancer diagnosis, determine Gleason score, and predict the benefit of androgen deprivation therapy in patients receiving radiation therapy.

- In metastatic prostate cancer, AI-facilitated quantification of metastatic burden, accurate identification of castration resistance, and prediction of treatment sensitivity and resistance are active research areas. Integrating multimodal data, including imaging, genomics, and clinical information, holds promise for refined prognostication and personalized treatment selection.

- Large language models are well-poised to facilitate information extraction from patients' electronic health records for deep clinical phenotyping of patients with cancer, thus lowering the effort for maintaining clinical-genomic registries and facilitating information gathering and reporting across the life cycle of clinical trials.

- Generative AI can be leveraged for actively monitoring and synthesizing newly published information for living clinical practice guidelines and synthetic data generation and in silico trial emulation, accelerating clinical research while reducing costs and time effort.

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Applications of ChatGPT and CoPilot in daily life

- To respond to email

- To design a study

- To write a scientific paper

- To do a meta-analysis

- To get immediate answer to a specific question

We should not lose the opportunity to use one of the greatest discoveries over the last years

Applications of ChatGPT and CoPilot in daily life

- Outpatient note on the clinical chart

- Ordering image/blood test

- Making patient report

- ……..

- Lowering documentation burden

- **Looking in the patient's eyes. Paying attention to what he says**

Applications of AI in prostate cancer care: A path to enhanced efficiency and outcomes

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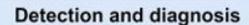
AI, artificial intelligence.
Riaz I, et al. *Am Soc Clin Oncol Educ Book*. 2024;44:e438516.
MAT-NL-XTD-2025-00036 | July 2025

AI and prostate cancer

Figure adapted from Riaz I, et al. 2024.
AI, artificial intelligence.
Riaz I, et al. *Am Soc Clin Oncol Educ Book*. 2024;44:e438516.
MAT-NL-XTD-2025-00036 | July 2025

Ongoing studies for the utility of AI in prostate cancer care

TABLE 1. On-Going Studies for the Utility of Artificial Intelligence in Prostate Cancer Care

NCT	Study	Inclusion Criteria	Exclusion Criteria	Design	Primary Outcome Measures
NCT05355727 PROSAIC-DS Study	All patients referred to prostate MDT meetings with sufficient information for treatment decisions	Patients with inadequate data for treatment decisions, nonconsenting	Randomized parallel assignment double blind trial	Evaluation of PROSAIC-DS as a triage tool and its influence on MDTM concordance with guidelines over 6-9 months
NCT05384002 AI Platform Integrating Imaging Data	Histologically confirmed PCa or suspicion of PCa; MRI examination; age ≥18 years; signed informed consent	None specified	Nonrandomized cohort	Development of AI models for prostate cancer diagnosis and management
NCT05443412 AI-Assisted Risk-based Prostate Cancer Detection	Men ≥18 years; clinical suspicion of prostate cancer; PSA 4-20 ng/mL; digital rectal examination ≤cT2; able to provide consent	Prior prostate biopsy; past/current history of prostate cancer; contraindications to MRI or biopsy	Nonrandomized cohort	Diagnosis of csPCa; assessed by machine learning algorithms over an average of 1 year
NCT06363435 AI-based Measurements of Tumor Burden in PSMA PET-CT	Patients referred for clinically indicated 18F-PSMA-1007 PET-CT scan at Skåne University Hospital	Patients younger than 20 years	Nonrandomized cohort	Evaluation of tumor burden in relation to overall survival over a 5-year follow-up
NCT04605276 3DmpUS for Pca	Men ≥18 years with clinical or confirmed prostate cancer; scheduled for biopsy or prostatectomy; signed consent	No mpMRI performed prior; chemotherapy for PCa; recent prostate biopsy; hormonal therapy for prostate cancer within the past 6 months; severe pulmonary hypertension or other specified conditions	Nonrandomized cohort	Collection and analysis of 3D multiparametric ultrasound and histology data to train and improve the classifier algorithm
NCT06362291 MRI AI-cTB v Routine cTB	Age 45-85 years; complete mpMRI data; suspicious prostate lesions or indications of prostate biopsy; qualifying PSA levels or ratios	Received prior radiotherapy, chemotherapy, or surgery; unqualified or incomplete mpMRI data; patients not fitting the biopsy indication criteria; incomplete clinical information	Randomized parallel assignment single-blind trial	Comparison of the clinically significant prostate cancer (csPCa) detection rate between targeted biopsy and systematic biopsy combined approaches, evaluated 1 month after the biopsy procedure
NCT03452774 SYNERGY-AI	Patients with solid and hematological malignancies; cancer-related biomarkers detected; decision for clinical trial prescreening enrollment by provider and/or patient	ECOG PS >2; abnormal organ function; hospice enrollment	Nonrandomized cohort	Proportion of patients eligible for clinical trial prescreening enrollment versus actual enrollment, assessed through study completion, an average of 1 year

Need for validation

Real-World Evidence in Localized and Locally Advanced Prostate Cancer.

Applying Artificial Intelligence to Electronic Health Records: The

OVERVIEW Study

AUTORES: Maroto P.[1], Puente J.[2], Conde Moreno A.J.[3], Juárez A.[4], Garcillán B.[5], Calderón J.M.[5], Muñoz del Toro J.[5], Valdivieso J[6], López M[6], Sarró E [6], Alcaraz A.[7]

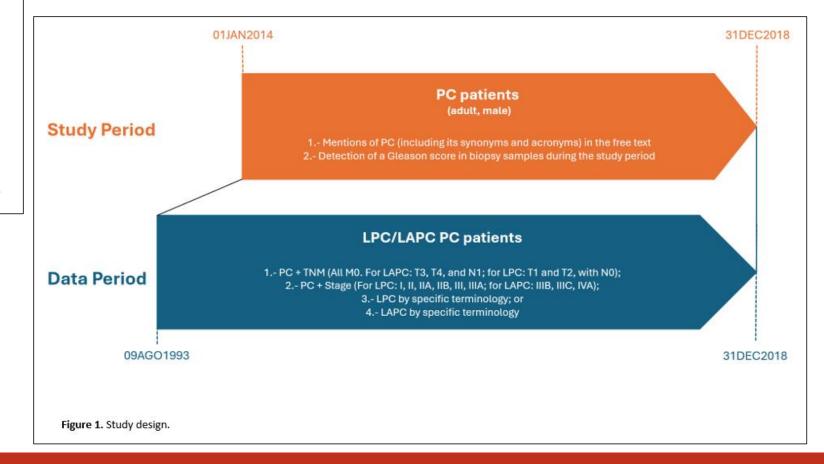[1]Hospital de la Santa Creu i Sant Pau, Dept. of Medical Oncology, Barcelona, Spain
[2]Hospital Clínico San Carlos, Dept. of Medical Oncology, Madrid, Spain
[3]Hospital Universitario La Fe, Dept. Of Radiation Oncology, Valencia, Spain
[4]Hospital Universitario de Jerez, Dept. of Urology, Jerez, Spain
[5]Johnson & Johnson Innovative Medicine, Medical Affairs Dept., Madrid, Spain
[6]Savana Research S.L., Madrid, Spain
[7]Hospital Clinic, Dept. of Urology, Barcelona, Spain

Figure 1. Study design.

Study groups and subgroups
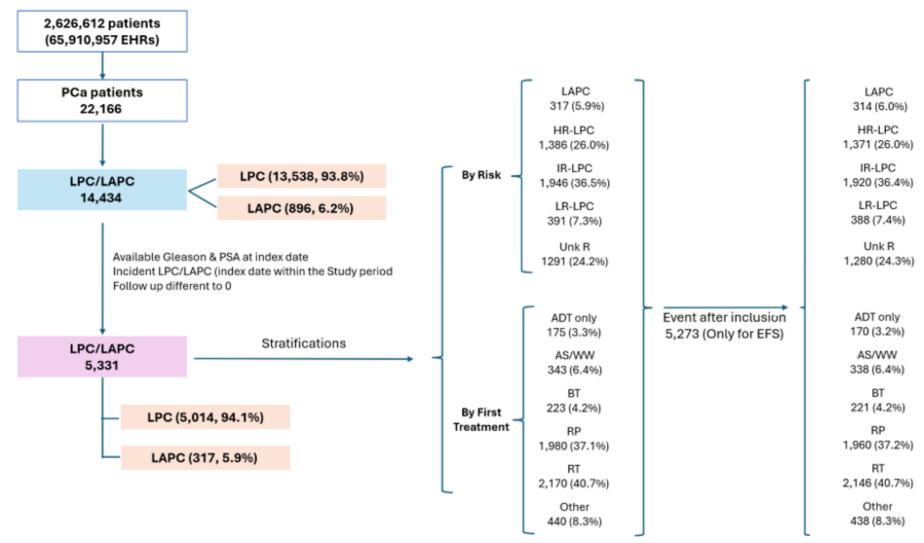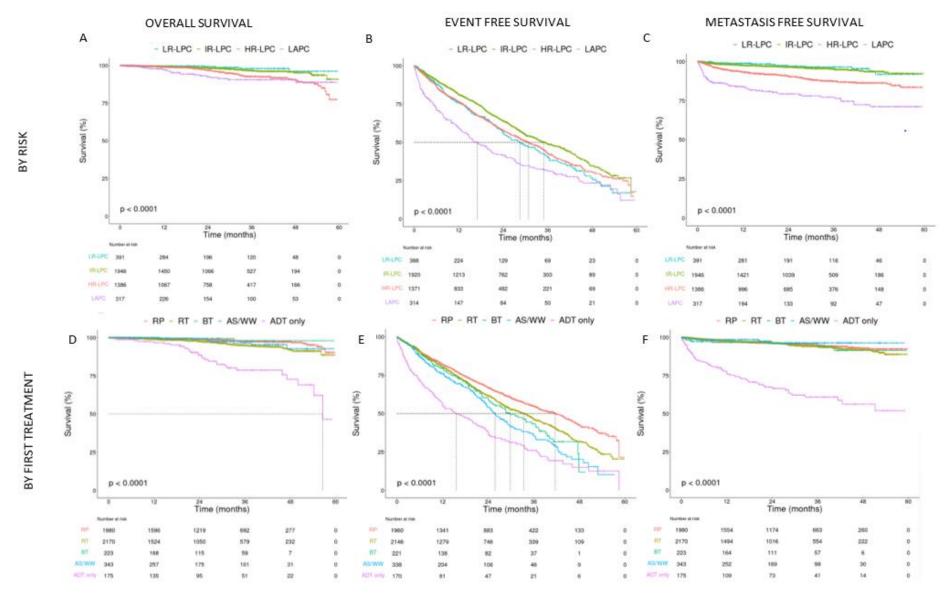
Figure used with speaker/author permission.
ADT, androgen therapy; AS, active surveillance; BT, brachytherapy; EFS, event-free survival; EHR, electronic health record; HR, high-risk; IR, intermediate risk; LPC, localised prostate cancer; LAPC, locally advanced prostate cancer; PCa, prostate cancer antigen; PSA, prostate-specific antigen; RT, radiotherapy; Unk R, unknown risk; WW< watchful waiting.
Puente MP, et al. Unpublished data.
MAT-NL-XTD-2025-00036 | July 2025

OVERALL SURVIVAL — EVENT FREE SURVIVAL — METASTASIS FREE SURVIVAL

BY RISK (A, B, C): LR-LPC, IR-LPC, HR-LPC, LAPC

BY FIRST TREATMENT (D, E, F): RP, RT, BT, AS/WW, ADT only
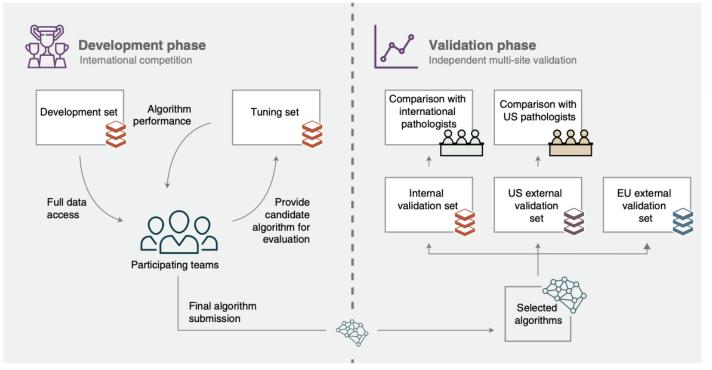
Diagnosis
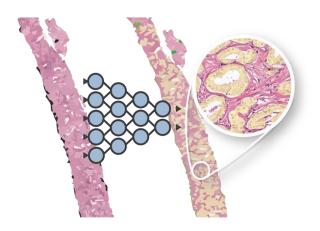
Pathology
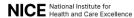
Artificial intelligence for diagnosis and Gleason grading of prostate cancer: the PANDA challenge

The algorithms achieved agreements of 0.862 (quadratically weighted κ, 95% confidence interval (CI), 0.840–0.884) and 0.868 (95% CI: 0.835–0.900) with expert uropathologists.

Summary

- The **technology** described in this briefing is Paige Prostate. It is an artificial intelligence-based imaging system designed to help identify and diagnose cancer in prostate biopsies.

- The **innovative aspects** are the multiple instance learning algorithm which reports to improve accurate and timely prostate cancer detection.

- The intended **place in therapy** would be in addition to standard care, supporting the detection of prostate cancer from biopsies. It can be used in laboratories that have partial or fully digital operations.

- The **main points from the evidence** summarised in this briefing are from 5 published observational studies including a total of 3,444 biopsy slides reviewed in a pathology lab. They show that Paige Prostate may be an effective addition to standard care to increase sensitivity in detecting prostate cancer and may also help provide more efficient analysis to increase throughput and support high caseload demand in the field.

- **Key uncertainties** around the evidence are that the available studies are mainly retrospective and only 2 reported on statistical significance of using Paige Prostate compared with standard care alone. None of the studies are UK based.

- **Experts** were positive about the potential to improve both detection and efficiencies in the pathway but highlighted the current lack of prospective data showing the system benefit and cost savings in the UK. Experts highlighted the importance of training for pathologists, particularly in understanding the limitations of the technology.

- The **cost** of Paige Prostate is based on a software as a service product on a subscription basis which would depend on the laboratory's volume of biopsies but would typically start at £1 per slide. An initial one-off fee is needed for integrating into the laboratory information management system. This varies depending on the level and type of integration and typically starts at £15,000.

- The **resource impact** may be greater than standard care, needing additional investment initially however further evidence is needed to quantify the real-world cost savings and system impact of Paige Prostate.

Technology costs

The company state that the final cost per case pricing model for Paige Prostate is in development and will include the acquisition or purchase of the software as a service (SaaS) product on a subscription basis. Prices typically start at £1 per slide but can increase depending on the laboratory's volume of prostate biopsies; the number of biopsies per slide; the number of slides per case; and usage of cloud storage and archiving services. This fee includes both detection and grading and quantification modalities with all outputs displayed within the CE-IVD Paige FullFocus clinical viewer. No hardware purchase or installation is needed for a cloud-based system. There are one-time fees associated with integrating Paige Prostate into the laboratory information management system which allows for an optimised, integrated workflow and automatic analysis of prostate cases. This cost depends on the level and type of integration and the laboratory information management system provider with the fee typically starting at £15,000.

Imaging and radiomics

AI-assisted vs. unassisted identification of prostate cancer in magnetic resonance images
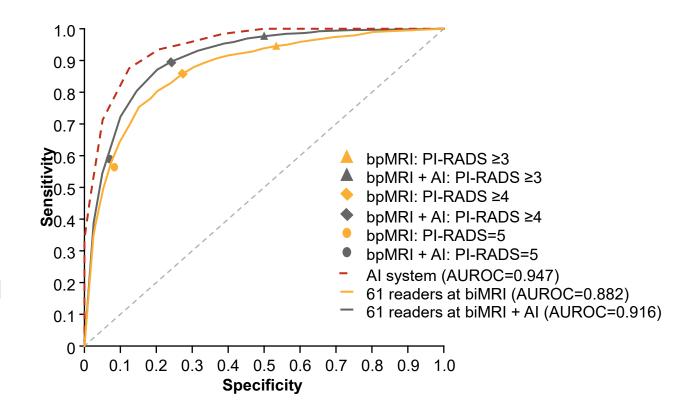
- **Study design:**
  - 61 readers (34 experts and 27 nonexperts)
  - Biparametric prostate MRI examinations were included for 780 men

- **Conclusions:** AI assistance was associated with improved radiologic diagnosis of clinically significant disease; however further research is required to investigate generalisation of outcomes and effects on workflow improvement

The area under the receiver operating characteristics curve (AUROC) diagnostic performance at bpMRI and bpMRI + AI: ROC performance

Legend:
- bpMRI: PI-RADS ≥3
- bpMRI + AI: PI-RADS ≥3
- bpMRI: PI-RADS ≥4
- bpMRI + AI: PI-RADS ≥4
- bpMRI: PI-RADS=5
- bpMRI + AI: PI-RADS=5
- AI system (AUROC=0.947)
- 61 readers at biMRI (AUROC=0.882)
- 61 readers at biMRI + AI (AUROC=0.916)

Dr. Antonio Alcaraz

Key facts

A multimodal AI-based toolbox and an interoperable health imaging repository for the empowerment of imaging analysis related to the diagnosis, prediction and follow-up of cancer

Subscribe to our newsletter
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🐦 @incisiveEu   in @incisiveEu
INCISIVE (join our private group)

📅 Duration: 42 months
From October 2020 to March 2024

⭐ **Call**: H2020-SC1-FA-DTS-2019
Topic: DT-TDS-05-2020 AI for Health Imaging

💰 **Funding**: 9.995.727,50 €

Areas of expertise

Main objectives

1 — **AI-based toolbox** that supports the decision-making of HCPs in relation to patient prioritisation, cancer diagnosis and risk for metastasis

2 — Interoperable pan-European **federated health data repository** (medical images & clinical data) that enables secure data sharing in compliance with ethical, legal and privacy requirements

Targeted impact on:

Healthcare professionals involved in cancer care

AI developers and AI experts

Researchers

Data types

- Imaging and accompanying clinical and biological data for 4 types of cancer

- 9 data providers (12 hospitals) from 5 countries

- Imaging data (at diagnosis and subsequent timepoints)

  - MRI - CT
  - Ultrasound - PET-CT
  - Mammography - X-ray
  - Histopathological images
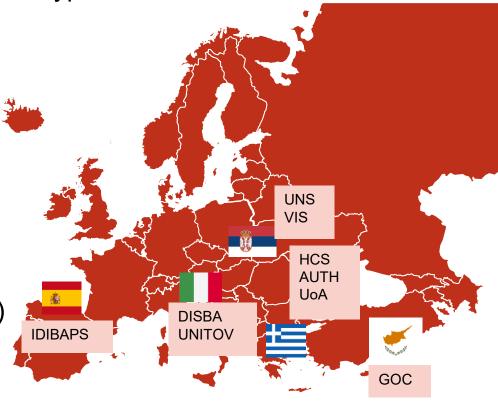
  - CT
  - PET-CT
  - X-ray

- Accompanying clinical data (at diagnosis and timepoints)

- Demographics, treatment, mutations, lab results

- Excel template used for collection

UNS
VIS

HCS
AUTH
UoA

DISBA
UNITOV

IDIBAPS

GOC

Data collection process

Steps followed

ETHICAL APPROVAL ACTIONS
- From M3-M12
- Updates, where required

PATIENT SELECTION
- Medical image type and quality specifications
- Within hospital data collection
- Complete cases – Incomplete cases (less time points available)
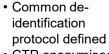
IMAGE DE-IDENTIFICATION
- Common de-identification protocol defined
- CTP anonymised →
- INCISIVE-specific de-identification tool

CLINICAL DATA EXTRACTION
- Extraction of clinical data from EHR into predefined data templates

DATA QUALITY CHECK
- Checks various data quality and structuring parameters

IMAGE ANNOTATION
- Annotation guidelines
- ITK SNAP tool →
- INCISIVE-specific annotation tool

DATA HOMOGENISATION
- Mapping to medical ontologies SNOMED-CT & LOINC (semantic)
- Transformation to FHIR data model (structural)
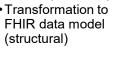
DATA SHARING through INCISIVE REPOSITORY
- Prepare and monitor data availability

INCISIVE achievements

AI toolbox: AI models & pipelines, including FL mechanism

4 cancer types

Hybrid Data Repository infrastructure

>3.7M cancer images

9.3k de-identified patients

Data interoperability framework (methodology and tools)

9+ data providers

9/9 data providers integrated / federated repository

Data sharing framework (methodology and tools)
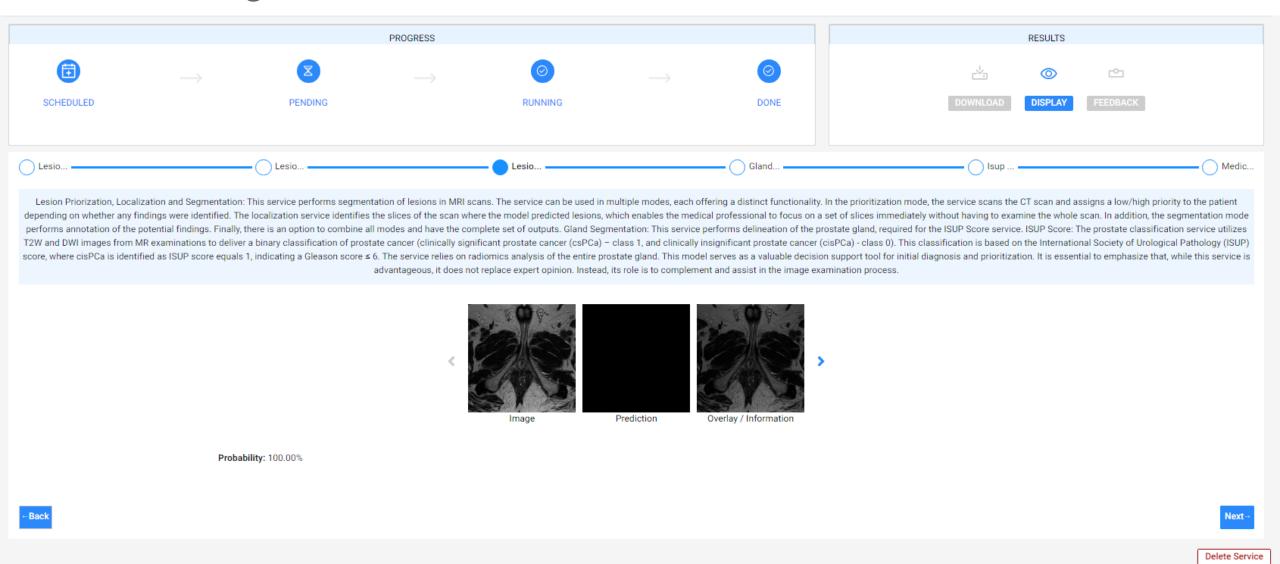
Lesion localisation
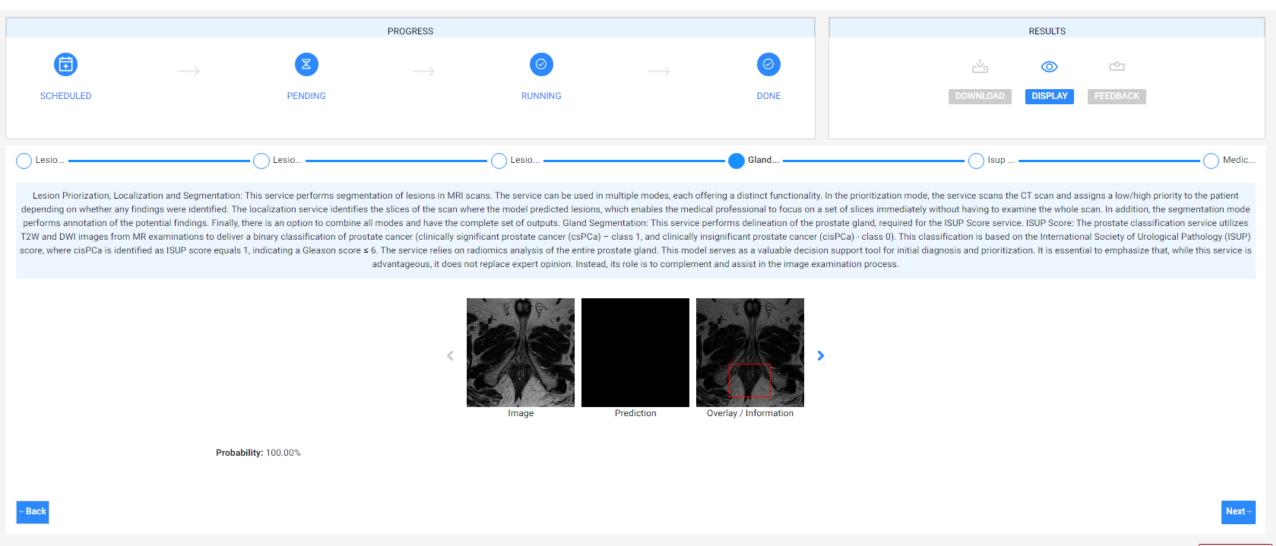
Lesion segmentation
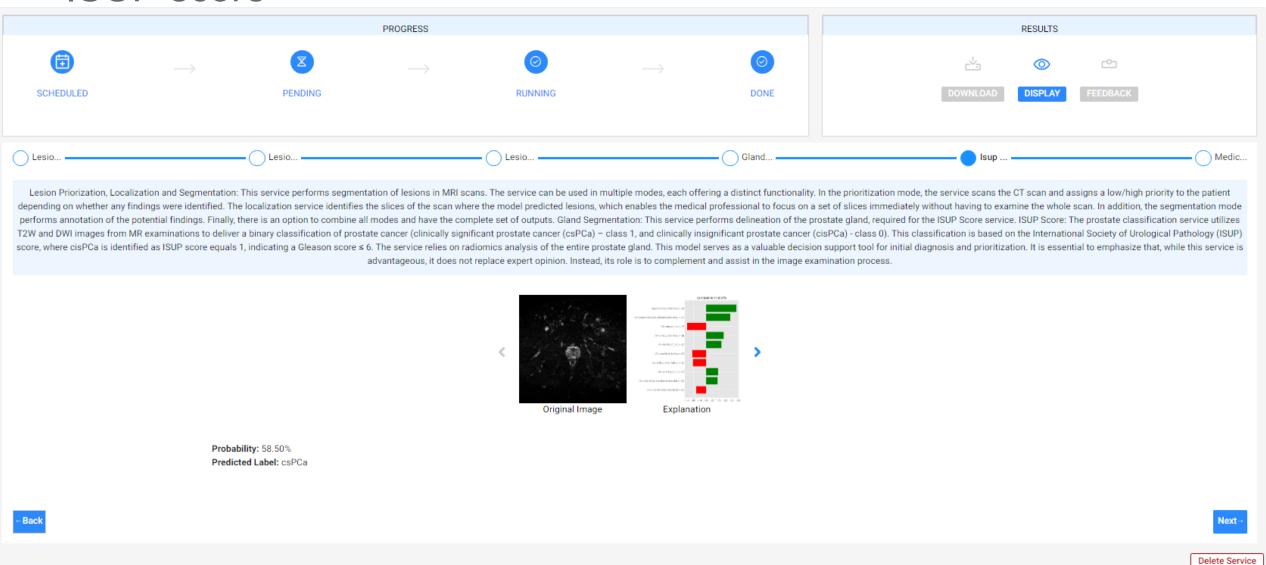
Gland segmentation

ISUP score

INCISIVE
Improving cancer diagnosis and prediction with AI and big data

Clinical Report

Report Generator

Health Care Professional Name
Lourdes Mengual

Health Care Professional Role
DATA PROVIDER,MEDICAL PERSONNEL

Health Care Institute
IDIBAPS

Contact
lmengual@ub.edu

Report Focus

Organ
Prostate

Examination Modality
Magnetic Resonance Imaging (MRI)

Report Identifier

Report Date Created
22/10/24

INCISIVE
Improving cancer diagnosis and prediction with AI and big data

Summary report

The prostate tissue exhibits no discernible pathological abnormalities, indicating a healthy status without evidence of malignancy or significant abnormalities.

Disclaimer: This medical report is generated by the help of artificial intelligence models designed for cancer diagnosis. It is important to note that the information provided in this report should not be considered a substitute for professional medical advice, diagnosis, or treatment. Medical sentences and terminology are sourced from the American Cancer Society and the National Cancer Institute.
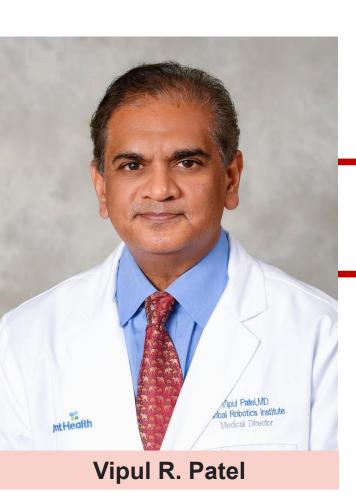
AI-assisted prostate surgery

AI-specific applications in prostate cancer surgery

Vipul R. Patel

AI for 3D models implementation
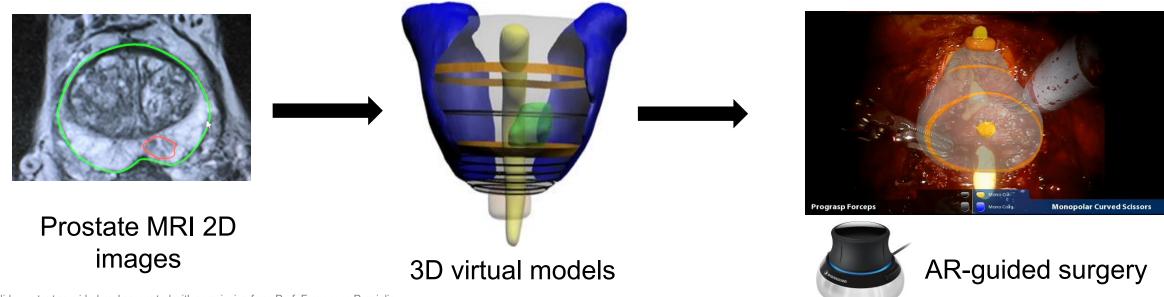
Francesco Porpiglia

How can AI improve prostate cancer surgery?

With the **current nomograms** we have a prediction **accuracy lower than 80%**
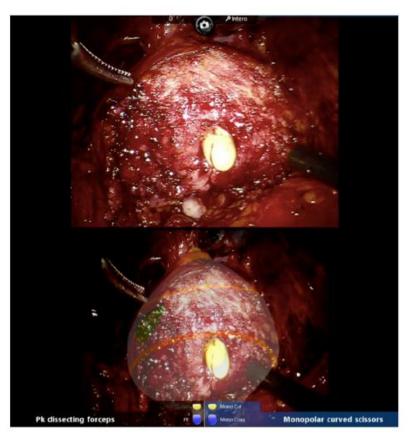
To improve expected surgical results we can use **new technologies** such as
<u>surgical navigation</u>
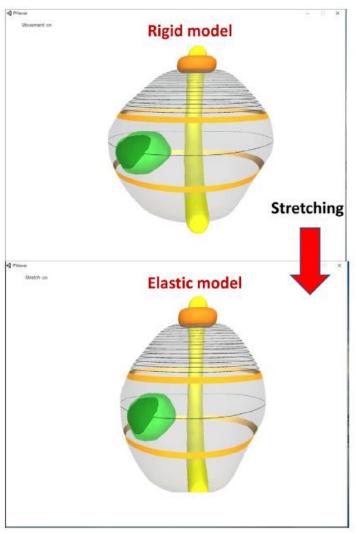
Prostate MRI 2D images

3D virtual models

AR-guided surgery

3D elastic AR robot-assisted radical prostatectomy using hyperaccuracy 3D reconstruction technology

A step further in the identification of capsular involvement
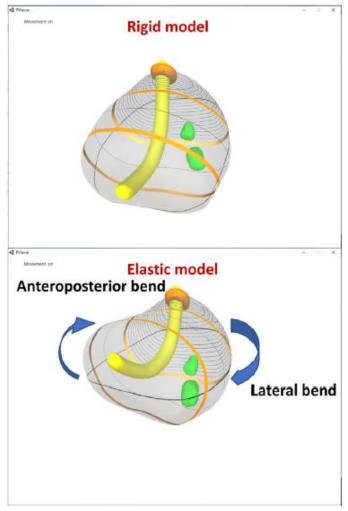
In case of posterior or anterolateral lesion, the model was mainly stretched and minimally bent

3D elastic AR robot-assisted radical prostatectomy using hyperaccuracy 3D reconstruction technology

A step further in the identification of capsular involvement
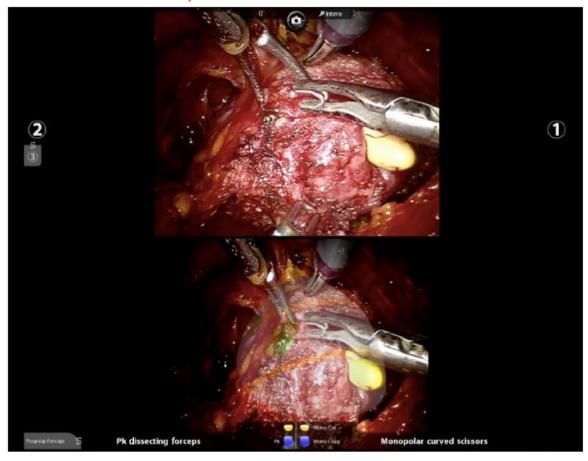
In case of posterior or posterolateral lesion, the model was stretched and mainly bent from back to front

3D elastic AR robot-assisted radical prostatectomy using hyperaccuracy 3D reconstruction technology
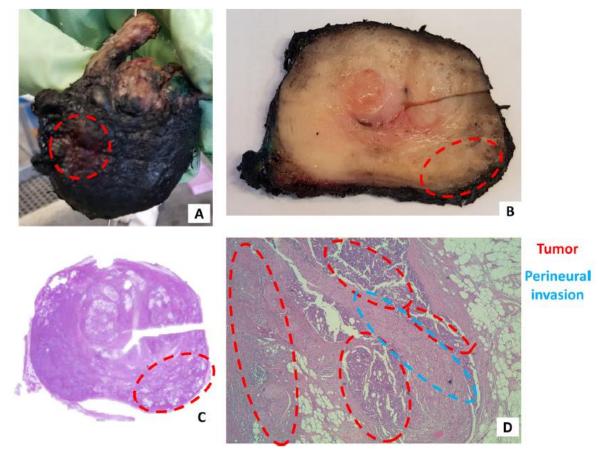
A step further in the identification of capsular involvement

The capsular involvement location resulted in being clearly visible on the surface of the opaque 3D virtual prostate model, irrespective of its location; then, the suspicious area of capsular involvement was marked on the prostate capsule with a metallic clip

3D elastic AR robot-assisted radical prostatectomy using hyperaccuracy 3D reconstruction technology

A step further in the identification of capsular involvement

Reduction of PSM from 35% to 25%

Histopathological analysis confirmed the presence of a suspicious tumour and capsular involvement at macroscopic and microscopic assessments in all the cases of the 3D AR group and in 86.9% and 47.0% of the 2D cognitive group, respectively.

Augmented reality

- **Image-guided surgery:** 3D model automatic overlapping

- Identify **real intraoperative landmarks to** anchor **virtual landmark**

- **Based on** <u>**colours and shape**</u> **of the landmark**

- Once the landmarks are identified a **software automatically links the two landmarks**
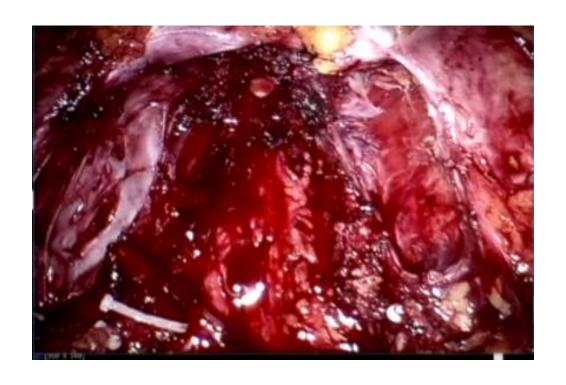
Image-guided surgery: 3D model automatic overlapping

CONVOLUTIONAL NEURAL NETWORK

- **Catheter** in the prostatic lodge **as intraoperative landmark**

- Two **convolutional neural networks** (**CNN**) approach (one for **Z-rotation and anchor point** and the other for **X-rotation**)

- **Update of the software** (**c-tracker**) allowing the **automatic anchorage** of the 3D model to the target

AI for image-guided surgery: 3D model automatic overlapping in RARP

CONVOLUTIONAL NEURAL NETWORK

RCT comparing 3D AI-Augmented Reality RARP vs MRI cognitive RARP

104 patients = 40 patients with AI-3D AR and **64** with intraoperative MRI

AD INTERIM ANALYSIS

- **AI-3D Group**: **PSM reduction of 27.5%**
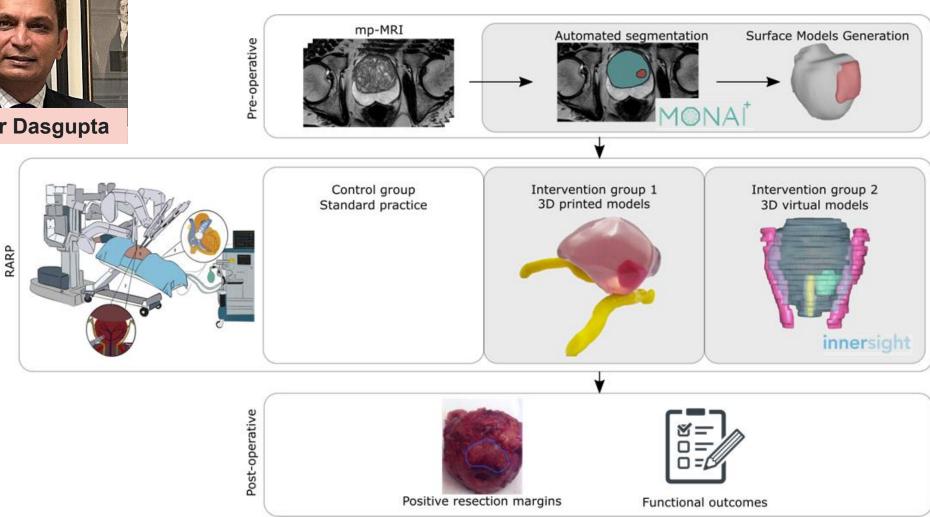
- **MRI Group**: **PSM reduction of 9.4%**

Unpublished data

Prokar Dasgupta

mp-MRI, multiparametric magnetic resonance imaging; RARP, robot-assisted radical prostatectomy.
Image of Prokar Dasgupta obtained from Wikipedia under CC0.
Figure used with permission from the Centre for Medical Engineering, King's College London. Available at: https://medicalengineering.org.uk/centre-activities/pillar-1-total-body-pet-for-cell-tracking-in-cell-based-therapies/. Last accessed: June 2025.

AI-specific applications in prostate cancer surgery

Combining AI with other **technologies**

How to further reduce PSM?
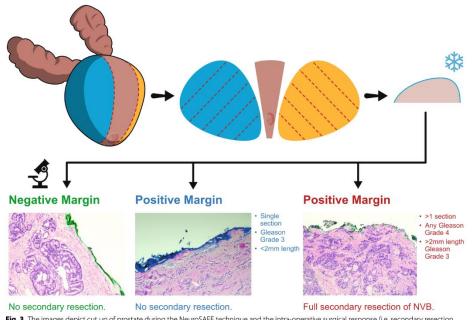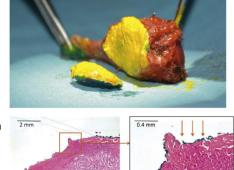
Fig. 3 The images depict cut up of prostate during the NeuroSAFE technique and the intra-operative surgical response (i.e. secondary resection (SR) or no SR) according to the margin status

New technologies for **intraoperative guidance** during RARP such as **confocal microscopy**

The **combination** of **AI 3D-guided selective biopsy** with a **real-time specimen evaluation**

European Association of Urology

Prostate Cancer

Surgeon Automated Performance Metrics as Predictors of Early Urinary Continence Recovery After Robotic Radical Prostatectomy—A Prospective Bi-institutional Study

Andrew J. Hung[a,*], *Runzhuo Ma*[a], *Steven Cen*[b], *Jessica H. Nguyen*[a], *Xiaomeng Lei*[b], *Christian Wagner*[c]

AI-specific applications in prostate cancer surgery

AI for surgical safety

AI alert systems to enhance surgical safety

Intraoperative bleeding can compromise the **surgeon's visibility**

Intraoperative A.I. system can **predict** bleeding
and **notify the surgeon of potential imminent risks (3 sec before)**
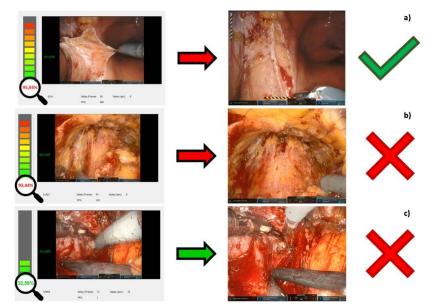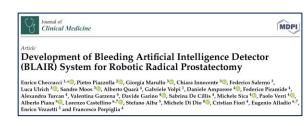
Deep learning software trained with videos (each image classified as bleeding/no bleeding)

AI, artificial intelligence.
Checcucci E, et al. *J Clin Med* 2023;12:7355.
MAT-NL-XTD-2025-00036 | July 2025

Prediction

Prostate cancer survival calculator according
to initial treatment modality

Calculating prostate cancer survival[1,2]

Predictor of survival in PCa:
7,267 patients and 19 variables.

Male, PCa:

1.	Age:	65 years
2.	Height:	176 cm
3.	Weight:	87 kg
4.	PSA:	4.9 ng/mL
5.	Prostate volume:	56 cc
6.	Nº cores (+) >12:	1 core
7.	Maximum affected (%):	10 %
8.	Gleason Score:	2 (7 = 3+4)
9.	Charlson:	2
10.	ECOG:	1
11.	Stage T:	T1c
12.	Stage N:	N0
13.	Stage M:	M0
14.	Recurrence:	No
15.	HTA:	Yes
16.	Diabetes Mellitus:	No
17.	Tuberculosis:	No
18.	Liver cirrhosis:	No
19.	Cerebrovascular disease:	No
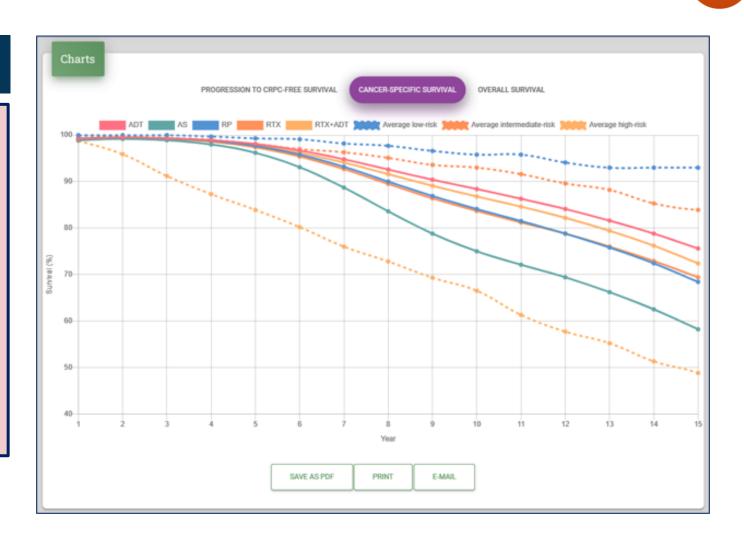
Table and figure provided by the speaker as a worked example.
ECOG, Eastern Cooperative Oncology Group; PCa, prostate cancer; PSA, prostate-specific antigen.

1. Prostate Cancer Survival Calculator According to Initial Treatment Modality [Example provided by the speaker]. Available at: https://scapcalculator.yuhs.ac. Last accessed: June 2025; 2. Koo KC, et al. *World J Urol* 2020;38:2469–2476.
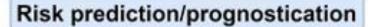
AI and prostate cancer
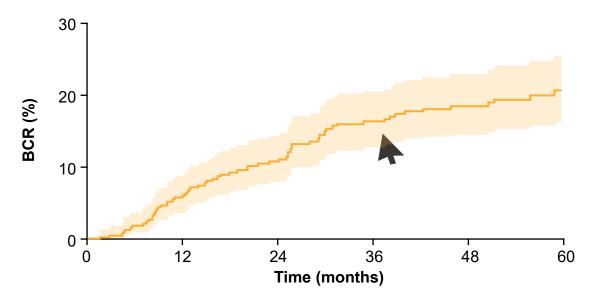
ASTRO 2023: Post-prostatectomy risk stratification of BCR using transfer learning-based multi-modal AI
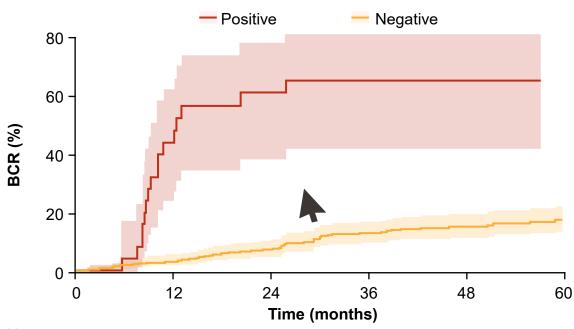
Biomarker	Pathological data source	Outcome
CAPRA-S (Cooperberg et al. 2011)	Prostatectomy	C-index = 0.73
Decipher (Erho et al. 2013)	Prostatectomy tissue	AUC = 0.75 (0.67–0.83)
Decipher + CAPRA (Nguyen et al. 2017)	Diagnostic biopsy	C-index = 0.71 (0.60–0.82)

Rate of biochemical recurrence

Biochemical recurrence rate, overall cohort

BCR according to TRAIL outcome

Can we predict pathology without surgery?

Weighing the added value of multiparametric MRI and whole prostate radiomics in integrative machine learning models
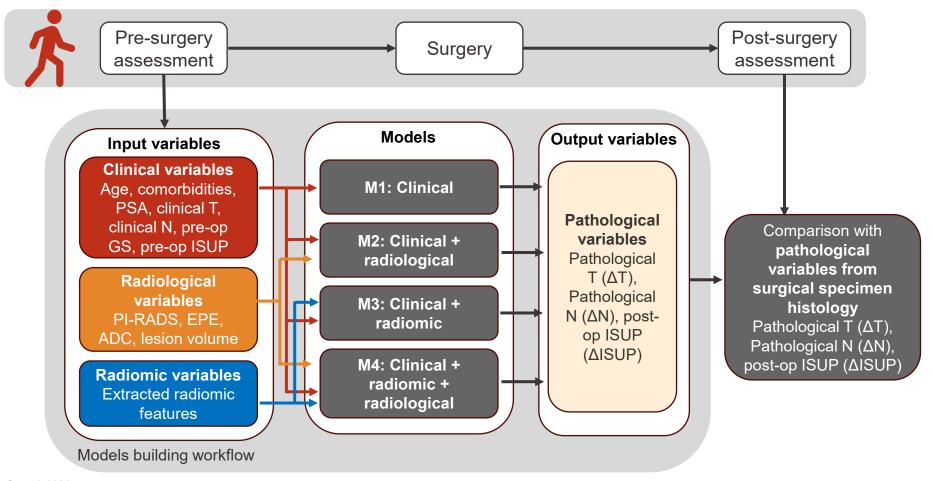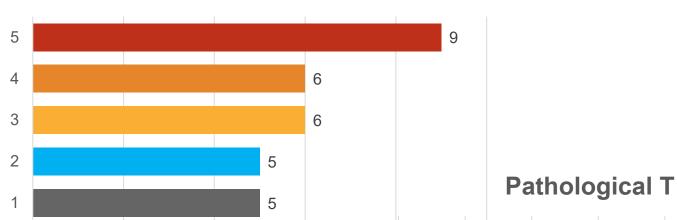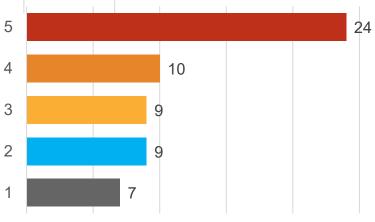
Post-op ISUP group

Group	Value
5	9
4	6
3	6
2	5
1	5

Cumulative: 31.8%

Pathological T

Group	Value
5	24
4	10
3	9
2	9
1	7

Cumulative: 59.3%

Pathological N

Group	Value
5	23
4	8
3	7
2	6
1	5
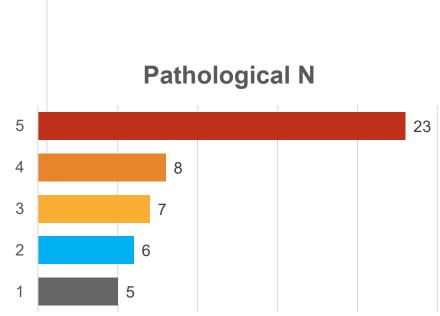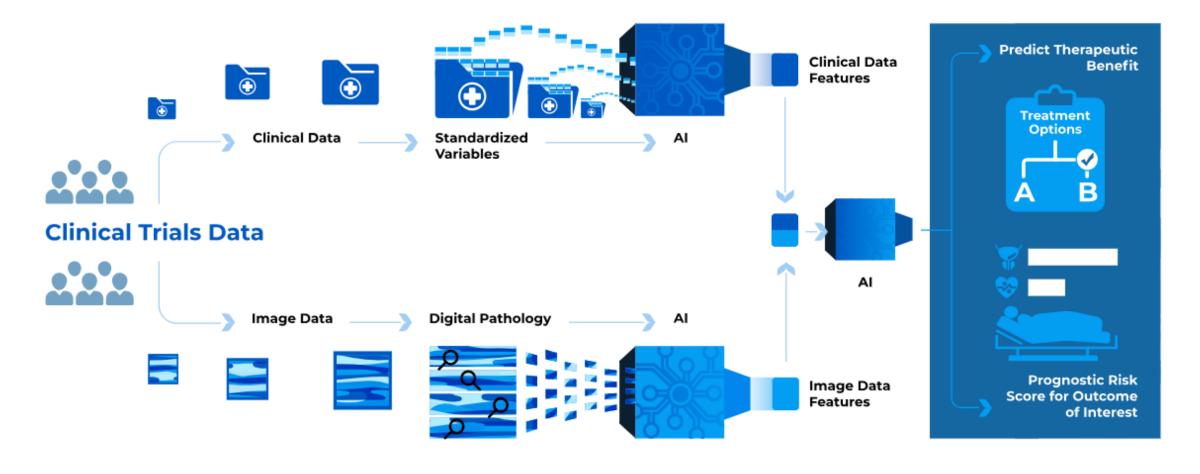
Cumulative: 48.8%

Decision making process

Multimodal AI architecture

Artificial intelligence predictive model for hormone therapy use in prostate cancer

BACKGROUND Androgen deprivation therapy (ADT) with radiotherapy can benefit patients with localized prostate cancer. However, ADT can negatively impact quality of life, and there remain no validated predictive models to guide its use.

METHODS We used digital pathology images from pretreatment prostate tissue and clinical data from 5727 patients enrolled in five phase 3 randomized trials, in which treatment was radiotherapy with or without ADT, as our data source to develop and validate an artificial intelligence (AI)–derived predictive patient-specific model that would determine which patients would develop the primary end point of distant metastasis.

AI and prostate cancer

Figure adapted from Riaz I, et al. 2024.
AI, artificial intelligence.
Riaz I, et al. *Am Soc Clin Oncol Educ Book*. 2024;44:e438516.
MAT-NL-XTD-2025-00036 | July 2025

AI and prostate cancer

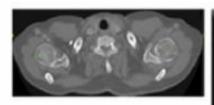Localized Disease · Biochemically Recurrent Disease · Metastatic Disease · Castrate-Sensitive · Castrate-Resistant
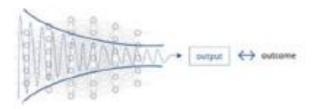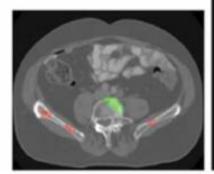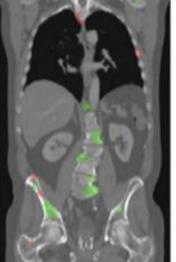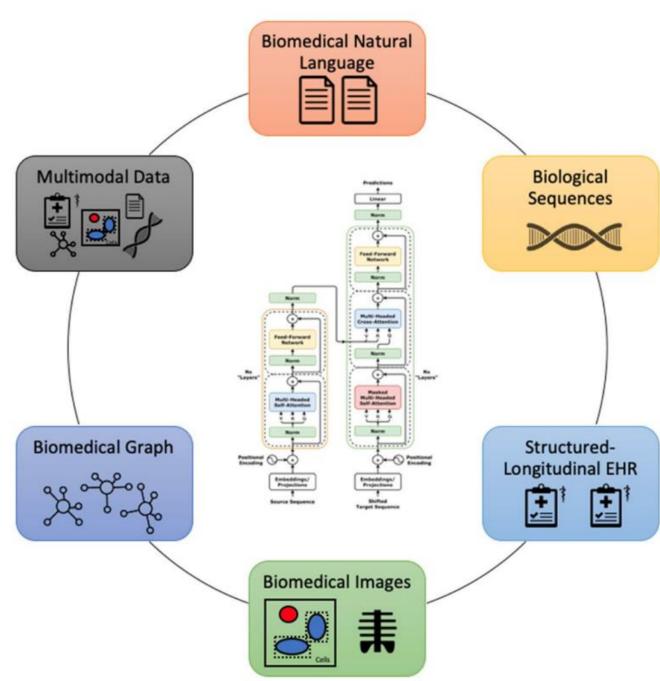
Diagnosis
- Detection of metastases
- Detection of castration resistance

Prognostication
- Risk categorization using:
  - Volume of disease
  - Timing of metastatic presentation

Outcomes ascertainment
- PSA progression
- Radiographic progression
- Treatment response

Urgently clarify how AI can be used in medicine under new EU law

By Thomas J. Hwang ✉ & Prokar Dasgupta

Please refer to the EMA SmPC for XTANDI™ (enzalutamide) via the following link: https://www.ema.europa.eu/en/documents/product-information/xtandi-epar-product-information_en.pdf

Scan/click here for the XTANDI™ UK prescribing information

Scan/click here for the XTANDI™ NL SmPC