DEVELOPING ARTIFICIAL INTELLIGENCE (AI) IN PERIOPERATIVE MODELS

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QUID EST HOMO?

Disclosure

- Nothing to disclose

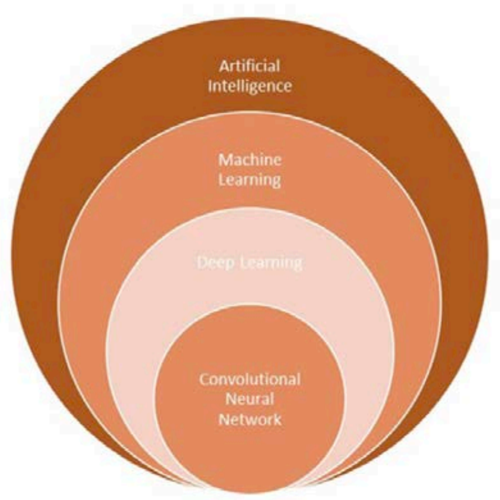
The evolution of radiology

- Imaging interpretation is based on a **qualitative evaluation** done by radiologists or clinicians
- Main limitations: subjectivity, interobserver variability, dependance on training & experience
- Advancements in medical imaging equipment, digitalization of diagnostic images, increased computational power → **Medical images can be converted into mineable data** to extract a variety of quantitative factors to produce high-dimensional data[1] → **radiomics, AI**

1) Stanzione et al., Cancers 2022

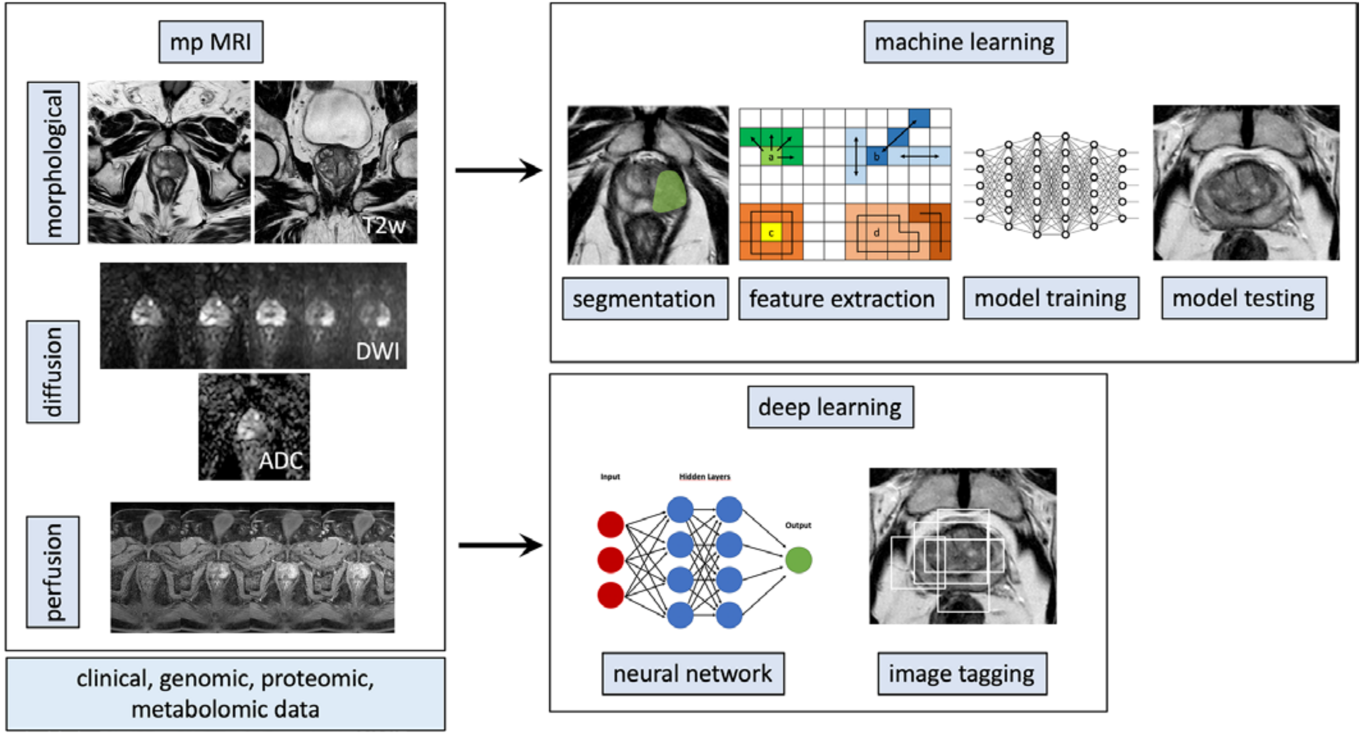
Definitions

- **Radiomics**: high-throughput image analysis to extract quantitative features (morphological, statistical and textural) that are missed by human eye → Imaging biomarkers
- **Artificial intelligence (AI)**: any computer method that performs tasks normally requiring human intelligence
- **Machine learning (ML)**: one type of artificial intelligence that develops algorithms to enable computers to **learn** from existing data to make predictions
  - Supervised VS Unsupervised
- **Deep learning (DL):** a supervised ML method that uses a specific architecture, namely interconnected layers of software-based calculators (called »neurons») to form a neural network → ability to automatically extract relevant features
- **Convolutional Neural Networks (CNN)**: deep learning models whose approach mimics the mathematic operation of convolution



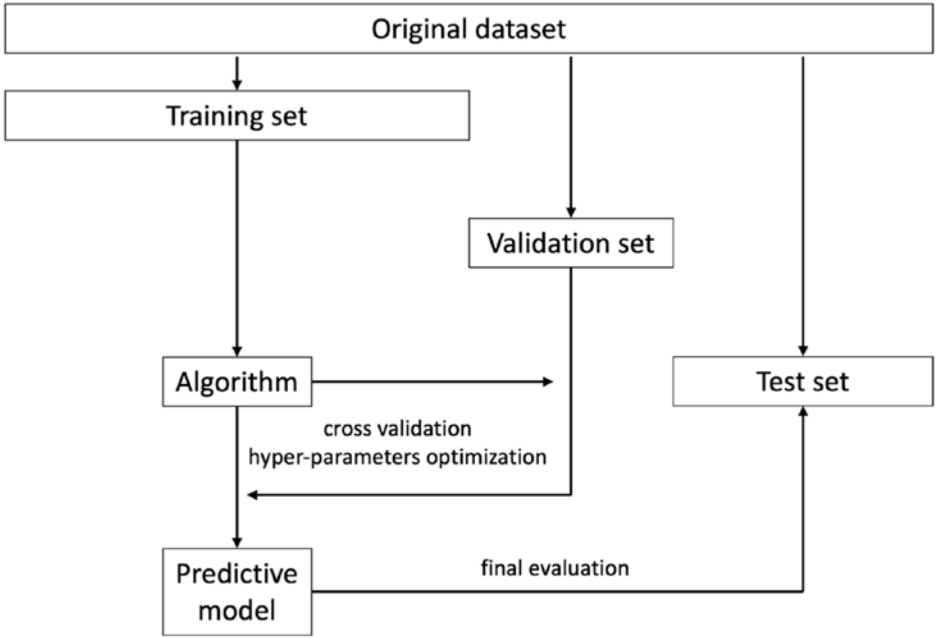
Francolini et al, Medical Oncology 2020; Zaharchuk et al, AJNR 2018

Definitions



Cuocolo et al., Eur Rad Exp 2019

AI model development



Stanzione et al., Cancers 2022

2003	1802

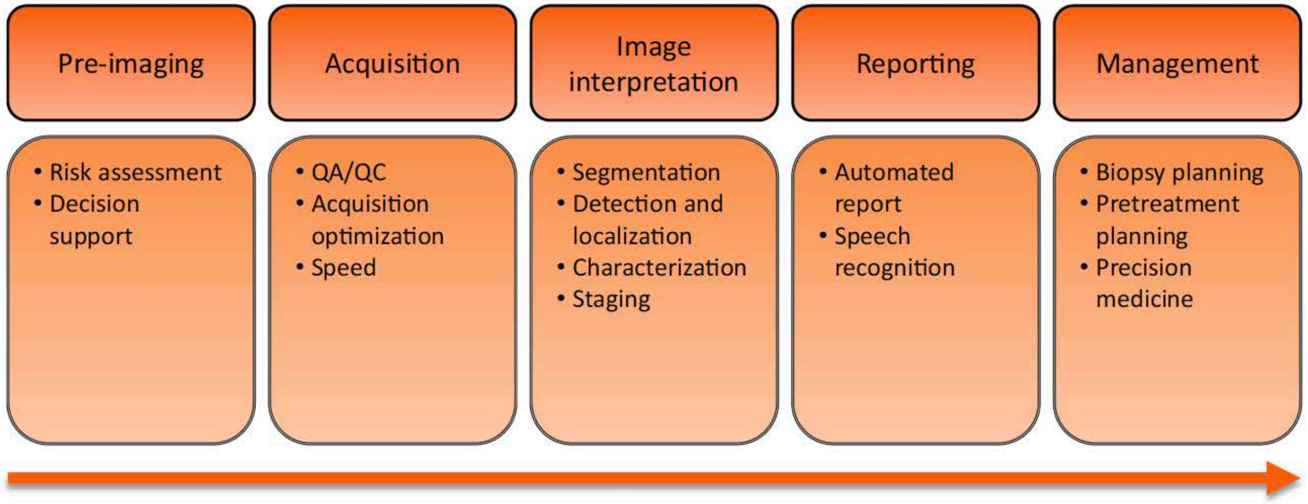
POTENTIAL AI APPLICATIONS

Brief Correspondence

Risk Stratification and Artificial Intelligence in Early Magnetic Resonance Imaging–based Detection of Prostate Cancer

Maarten de Rooij [a,*], *Hendrik van Poppel* [b], *Jelle O. Barentsz* [a]

[a] *Department of Medical Imaging, Radboud University Medical Center, Nijmegen, The Netherlands;* [b] *Department of Development and Regeneration, University Hospital KU Leuven, Leuven, Belgium*



Radiological workflow for the prostate cancer diagnostic pathway

MRI acquisition

Deep Learning Reconstruction Enables Highly Accelerated Biparametric MR Imaging of the Prostate

Patricia M. Johnson, PhD,[1*] Angela Tong, MD,[1] Awani Donthireddy, MD,[1] Kira Melamud, MD,[1] Robert Petrocelli, MD,[1] Paul Smereka, MD,[1] Kun Qian, MS,[2] Mahesh B. Keerthivasan, PhD,[3] Hersh Chandarana, MD,[1] and Florian Knoll, PhD[1]

Accelerated biparametric prostate MRI exams can be performed using deep learning methods in <4 minutes

JMRI 2022

Hötker *et al. Insights Imaging* (2021) 12:112
https://doi.org/10.1186/s13244-021-01058-7

Insights into Imaging

ORIGINAL ARTICLE Open Access

Improving workflow in prostate MRI: AI-based decision-making on biparametric or multiparametric MRI

Andreas M. Hötker[1*], Raffaele Da Mutten[1], Anja Tiessen[1], Ender Konukoglu[2] and Olivio F. Donati[1]

To develop and validate an artificial intelligence algorithm to decide on the necessity of DCE sequences

Table 1 Performance of reader 3 (technician) and the artificial intelligence in correctly deciding on the necessity of contrast injection in the validation set ($n = 100$) with the consensus of two experienced radiologists (*R*1 and *R*2) as reference standard.

	DCE necessary	DCE not necessary	Agreement	AUC (95% CI)	Sensitivity	Specificity
Consensus (*R*1/*R*2)	36/100 (36%)	64/100 (64%)	Ref	Ref	Ref	Ref
Technician (*R*3)	70/100 (70%)	30/100 (30%)	0.55	0.765 (0.669–0844)	63.9%	89.1%
Artificial Intelligence (AI)	56/100 (56%)	44/100 (44%)	0.54	0.881 (0.801–0.937)	94.4%	68.8%

Agreement: kappa with Consensus as reference standard; AUC: Area-under-the-curve; Sensitivity and Specificity of the artificial intelligence based on ROC analysis with a maximized Youden index and high sensitivity to avoid re-examinations

Integrating AI in clinical routine could render the requirement for on-table monitoring obsolete by performing contrast-enhanced MRI only when needed

AI for cancer detection and characterization

- PCa:
  - Metanalysis on 12 studies: AUC 0.86 (95% CI, 0.81–0.91)
  - AI can improve diagnostic accuracy and interreader agreement, and reduce reporting time
- Bladder cancer:
  - Metanalysis on 12 studies for prediction of MIBC: AUC 0.86-0.97. Predicting grade: 83% accuracy
  - AI cystoscopy
- Renal cancer:
  - Discrimination of benign VS malignant, RCC subtype, Chr-RCC VS Oncocytoma, Fuhrman grade prediction, Prognosis: all reported good performance of the AI-based models
- […]

Common issues in AI-radiomics literature

Insufficient quality of the studies:

- Mainly retrospective and prone to selection biases[1]
- No standardization in study design and reporting[2]
  - Heterogeneity: patient cohorts, standard of reference, methodology[1,2,3,4]
  - Average RQS among 74 radiomics studies: 23%[3]
- Only a minority of studies has generalizability assessment, have clinical utility evaluation and have sufficient transparency[5]

- Not sufficiently tested in multicenter studies and of head-to-head comparisons with radiologists[2]

1-Huang et al., Frontiers in Oncology 2022; 2- Cuocolo et al., 2020; 3- Stanzione et al., EJR 2020; 4- Turkbey et al., AJR 2022; 5- Kocak et al. AJR 2020

CHALLENGES IN AI

Challenges in AI

Artificial Intelligence for Automated Cancer Detection on Prostate MRI: Opportunities and Ongoing Challenges, From the *AJR* Special Series on AI Applications

Baris Turkbey, MD[1], Masoom A. Haider, MD[2,3,4]

AJR *AJR* 2022; 219:188–194
American Journal of Roentgenology

Genitourinary Imaging · Special Series Review

- Limitations of existing prostate MRI AI research include **numerous sources of methodologic heterogeneity**, **bias in model validation** and **lack of evidence of clinical translation**.
- Future investigations incorporating large-scale diverse multi-institutional training and testing datasets are needed.

TABLE 1: Currently Available Commercial Prostate MRI Artificial Intelligence (AI) Solutions in the United States and Europe

AI Product	Company	AI Application: Prostate Gland Segmentation	AI Application: Lesion Detection	Regulatory Status: Approved by U.S. FDA	Regulatory Status: Passed Conformity Assessment per Regulation (EU) 2017/745
Prostate MR	Siemens Healthineers	Yes	Yes	Yes	Yes
Quantib Prostate	Quanitib	Yes	Yes	Yes	Yes
OnQ Prostate	Coretchs.ai	Yes	No	Yes	No
PROView	GE Healthcare	Yes	Yes	Yes	Yes
Qp-Prostate	Quibim	Yes	No	Yes	No
JPC-01 K	JLK	No	Yes	No	Yes

The myth of generalisability in clinical research and machine learning in health care

Joseph Futoma, Morgan Simons, Trishan Panch, Finale Doshi-Velez*, Leo Anthony Celi*

- Machine learning systems consist in a set of rules that were trained to operate under certain contexts and rely on certain assumptions: **they might work seamlessly at one centre but fail altogether somewhere else**
- The demand for universal rules (**generalisability**) may result in systems that *sacrifice strong performance at a single site for systems with mediocre or poor performance at many sites*
- **Long-term increase in training data**

Heterogeneity

Segmentation

Image pre-processing

Resampling
Normalization
Discretization
Image filtering
- Wavelet
- Laplacian of Gaussian

Feature extraction

Shape
Intensity
Texture

Feature selection

Unsupervised methods
- Feature reproducibility assessment
- Variance analysis
- Pairwise correlation analysis

Supervised methods
- Wrapper methods
- Filter methods

Dimensionality reduction

- Principal component analysis

Data pre-processing

- Feature scaling
- Missing values
- Class imbalance

Model tuning and training

- Cross validation

Model testing

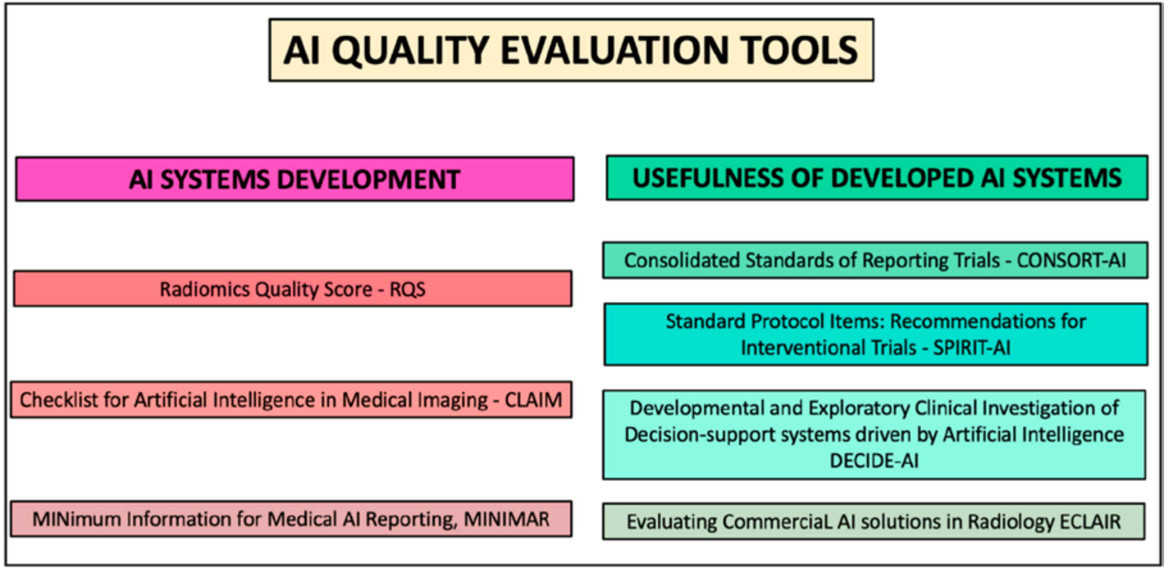
Patient selection

Standard of reference

Stanzione et al., Cancers 2022

Quality evaluation tools

- AI and radiomic guidelines to allow standardization and critical evaluation by researchers, reviewers and clinical practitioners



Stanzione et al., 2022

Clinical translation

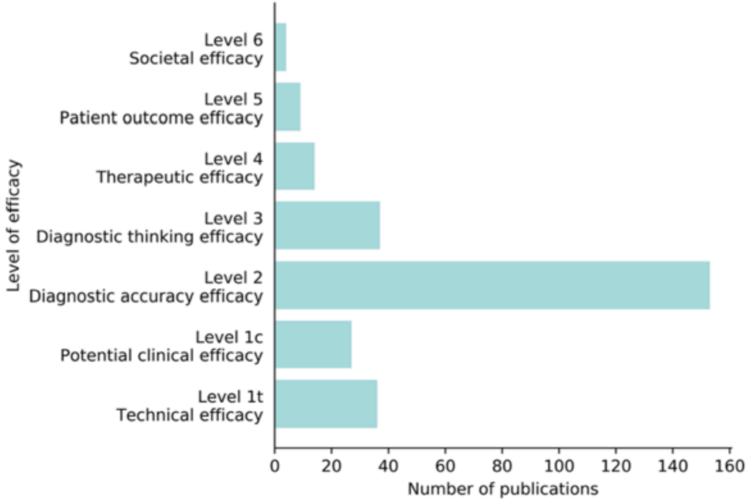
European Radiology (2021) 31:3797–3804
https://doi.org/10.1007/s00330-021-07892-z

IMAGING INFORMATICS AND ARTIFICIAL INTELLIGENCE

Artificial intelligence in radiology: 100 commercially available products and their scientific evidence

Kicky G. van Leeuwen[1] · Steven Schalekamp[1] · Matthieu J. C. M. Rutten[1,2] · Bram van Ginneken[1] · Maarten de Rooij[1]

- Artificial intelligence in radiology is still in its infancy even though already 100 CE-marked AI products are commercially available.
- Only 36 out of 100 products have peer-reviewed evidence of which most studies demonstrate lower levels of efficacy.



Clinical translation

- 690 radiologists completed the survey (229 institutions in 32 countries) who had practical clinical experience with an AI-based algorithm.

- **The use of AI-powered algorithms in clinical radiology today is limited because the impact of these tools on the reduction of radiologists' workload remains unproven.**

European Society of Radiology (ESR)
Insights into Imaging (2022) 13:107
https://doi.org/10.1186/s13244-022-01247-y

Insights into Imaging

STATEMENT Open Access

Current practical experience with artificial intelligence in clinical radiology: a survey of the European Society of Radiology

European Society of Radiology (ESR)*

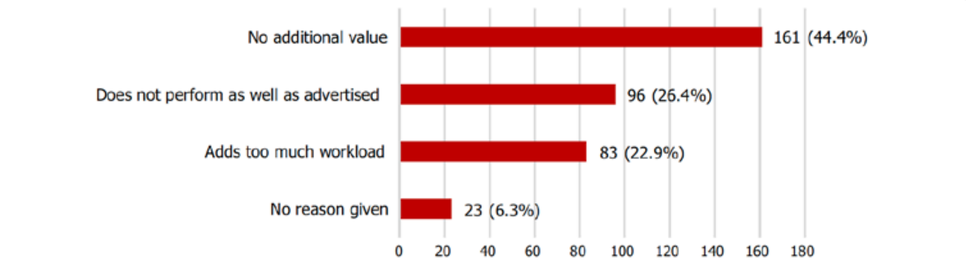


Fig. 2 Reasons given by 363 of all 690 participants of the survey (regardless of their experience with AI-based algorithms in clinical workflow) for not intending to acquire a certified AI-based algorithm for their clinical practice

npj Digital Medicine

www.nature.com/npjdigitalmed

ARTICLE OPEN

Check for updates

Do as AI say: susceptibility in deployment of clinical decision-aids

Susanne Gaube[1,2,12], Harini Suresh[3,12], Martina Raue[2], Alexander Merritt[4], Seth J. Berkowitz[5], Eva Lermer[6,7], Joseph F. Coughlin[2], John V. Guttag[3], Errol Colak[8,9,13] and Marzyeh Ghassemi[10,11,13]

- Impact of AI advice on physician (radiologists)
- General tendency for participants to **agree** with advice, particularly for physicians with **less task expertise**
- **Physicians across expertise levels often failed to dismiss inaccurate advice**
- Receiving AI advice upon request may help mitigate the over-reliance problem

Take home messages

- **AI is here to stay.** It will have a huge impact on radiologic workflow.
- It represents an unique opportunity to **improve the efficiency** of clinical and radiological workflows, increasing physicians' performance and reducing workload
- **Rigorous methodology** is fundamental to perform and interpret AI studies, and to set realistic expectations on AI tools
- Clinical knowledge **must** drive AI development to address clinically relevant needs

ONGOING AI RESEARCH @OSR

THE ROLE OF ARTIFICIAL INTELLIGENCE IN THE ASSESSMENT OF MULTIPARAMETRIC RESONANCE OF THE PROSTATE IN PROSTATE CANCER PATIENTS

Background

European Radiology (2021) 31:3797–3804
https://doi.org/10.1007/s00330-021-07892-z

IMAGING INFORMATICS AND ARTIFICIAL INTELLIGENCE

Artificial intelligence in radiology: 100 commercially available products and their scientific evidence

Kicky G. van Leeuwen[1] · Steven Schalekamp[1] · Matthieu J. C. M. Rutten[1,2] · Bram van Ginneken[1] · Maarten de Rooij[1]

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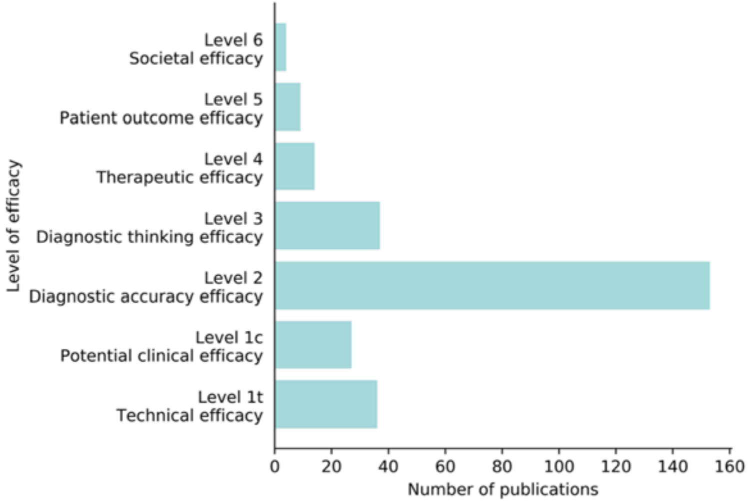
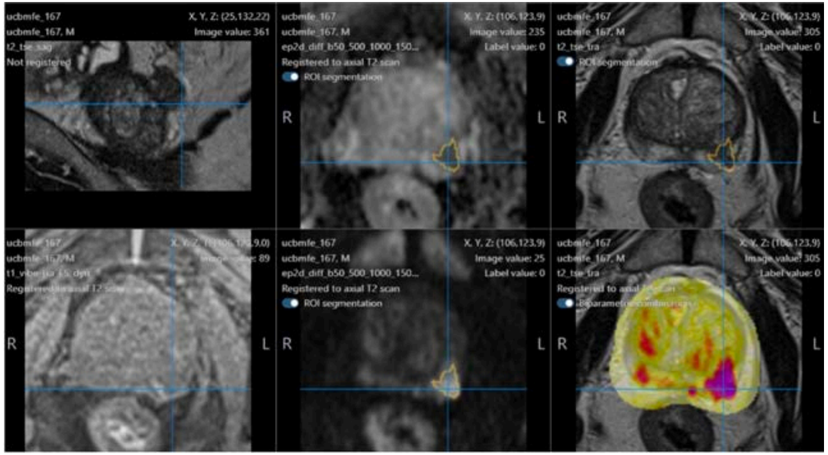
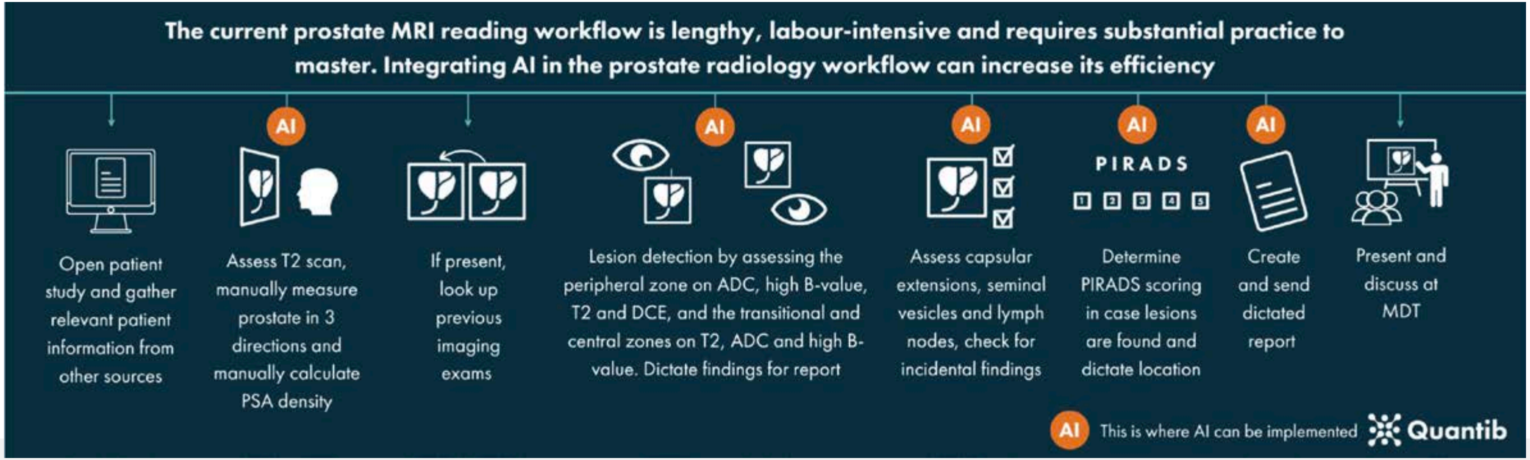


Quantib Prostate





Quantib Prostate

Article

Quantib Prostate Compared to an Expert Radiologist for the Diagnosis of Prostate Cancer on mpMRI: A Single-Center Preliminary Study

Eliodoro Faiella [1,2], Daniele Vertulli [1], Francesco Esperto [3], Ermanno Cordelli [4], Paolo Soda [4], Rosa Maria Muraca [2], Lorenzo Paolo Moramarco [2], Rosario Francesco Grasso [1], Bruno Beomonte Zobel [1] and Domiziana Santucci [1,2,4,*]

Biparametric prostate MRI: impact of a deep learning-based software and of quantitative ADC values on the inter-reader agreement of experienced and inexperienced readers

Stefano Cipollari[1] · Martina Pecoraro[1] · Alì Forookhi[1] · Ludovica Laschena[1] · Marco Bicchetti[1] · Emanuele Messina[1] · Sara Lucciola[1] · Carlo Catalano[1] · Valeria Panebianco[1]

- Improved **diagnostic accuracy** of inexperienced reader compared to experienced reader
- **Reduced reading/reporting** time of both experienced and inexperienced reader

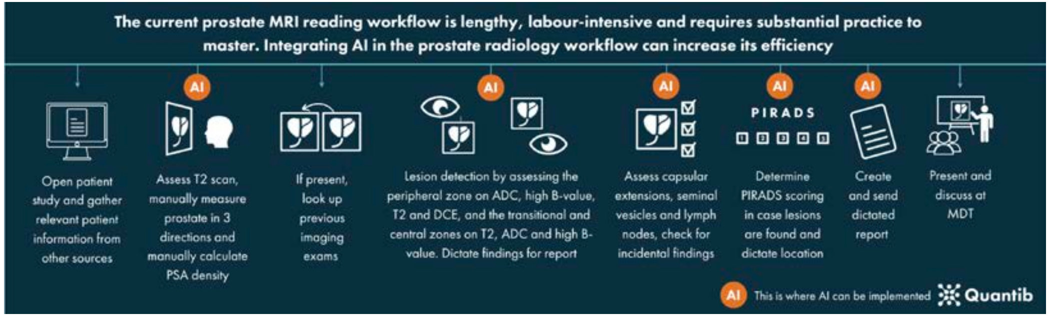
Overview

- Aim: to investigate the implementation of a digital platform available on the market, **Quantib Prostate** (Quantib B.V. Rotterdam, The Netherlands) in the radiology workflow of prostate MRI with regards to time-efficiency, inter-observer agreement and diagnostic performance, compared with the traditional radiologist approach.
- Study design: single centre, multi-reader, retrospective study
- Trial participants: **200 men** undergoing MRI +/- targeted biopsy for clinically suspected Pca
- N. of readers: 3 experienced radiologists, 2 non-experienced radiologists, 2 urologists

Patient characteristics

- Inclusion criteria:
  - 1. Men at least 18 years of age referred with clinical suspicion of prostate cancer
  - 2. Men who have undergone mpMRI +/- subsequent targeted plus random systematic prostate biopsies at OSR
  - 3. Available pathological report with details regarding the site of positive cores and grade group
  - 4. Serum PSA ≤20ng/ml
  - 5. Patient who underwent a 1.5T mpMRI with or without endorectal coil with PI-RADS compliant protocol
- Exclusion criteria:
  - 1. Prior treatment for prostate cancer
  - 2. Prior diagnosis of prostate cancer
  - 3. Men in whom artifact would reduce the quality of the MRI

Workflow



1. **Current workflow without Quantib Prostate:**
   - Visual assessment in AGFA Enterprise PACS
   - Dictation done in dictation software
   - Information provided in dictated report:
     - General findings of image features of the prostate gland
     - Prostate volume
     - PSA density
     - Total number of lesions
     - Dimensions and volume of each lesion
     - ADC value of each lesion
   - Fusion biopsy preparation done by urologists
     - Read images, read report, use BK fusion system for biopsy preparation

1. **Workflow with Quantib Prostate:**
   - Quantib Prostate 2.0 research version
     - Two user-interaction workflow steps (PSA Density, and mpMRI analysis)
     - Copy-paste text template to radiology report
     - Output: PDF report, prostate and lesion segmentation format

Time needed to complete the workflow will be recorded

Outcomes of interest

- Primary aim: **to compare the diagnostic accuracy of radiologists +/- Quantib Prostate** for the detection of clinically significant PCa (ISUP ≥2) at biopsy
- Secondary aims:
  - to compare the **reporting time** of radiologists +/- Quantib Prostate;
  - to compare **interobserver agreement** of radiologists +/- Quantib Prostate;
  - to compare the **net benefit** of Quantib Prostate on diagnostic accuracy for experienced radiologists VS non-experienced radiologists and urologists

Updates

- Readers' training with Quantib Prostate is expected to be completed by the end of December 2022
- Estimated start: January 2023
- Estimated time for completion: 1 year

ARTIFICIAL INTELLIGENCE APPLIED TO MULTIPARAMETRIC BLADDER MRI FOR PREDICTING PATHOLOGICAL COMPLETE RESPONSE AT RADICAL CYSTECTOMY (COLUMBIA-AI)

Multiparametric Magnetic Resonance Imaging as a Noninvasive Assessment of Tumor Response to Neoadjuvant Pembrolizumab in Muscle-invasive Bladder Cancer: Preliminary Findings from the PURE-01 Study

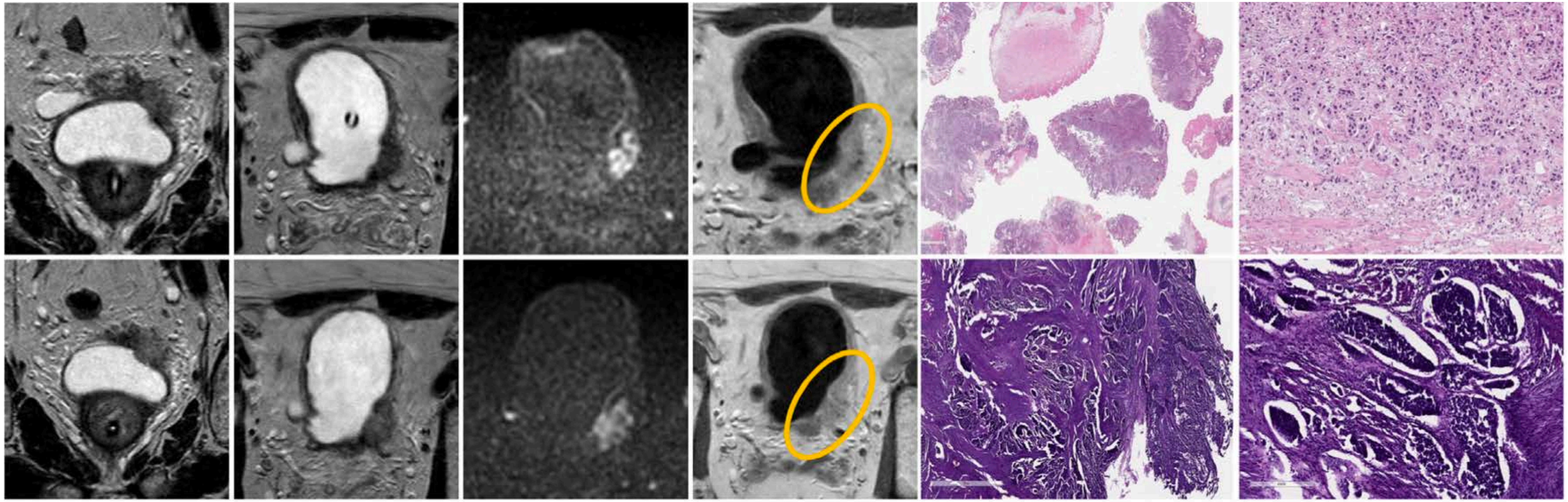
Andrea Necchi[a,], Marco Bandini[b,†], Giuseppina Calareso[a,†], Daniele Raggi[a], Filippo Pederzoli[b], Elena Farè[a], Maurizio Colecchia[a], Laura Marandino[a], Marco Bianchi[b], Andrea Gallina[b], Renzo Colombo[b], Nicola Fossati[b], Giorgio Gandaglia[b], Umberto Capitanio[b], Federico Dehò[b], Patrizia Giannatempo[a], Roberta Lucianò[b], Andrea Salonia[b], Russell Madison[c], Siraj M. Ali[c], Jon H. Chung[c], Jeffrey S. Ross[c,d], Alberto Briganti[b,e], Francesco Montorsi[b,e], Francesco De Cobelli[e,f,‡], Antonella Messina[a,‡]*

Background

- Immunotherapy has opened revolutionary roads in early-stage disease and likely a change in the way we conceive multimodal treatments in MIBC
- **mpMRI is an effective tool to predict pT0 after neoadjuvant immunotherapy**, and could represent the future standard for treatment assessment
- AI in bladder cancer can be applied in two main scenarios:
  - At the time of **cystoscopy**: to better identify the presence or absence of a malignant lesion and thus clinical complete response to neoadjuvant treatments
  - On **imaging (mpMRI):** to improve the performance and standardization of pT0 prediction

Background

- Current data on AI for imaging in bladder cancer is scarce and very heterogeneous
- <u>No study to date focuses on AI for post-treatment assessment using mpMRI</u>



1 – Necchi et al., Eur Urol 2020

Background

At our center we have two main ongoing collaborations:

- With **Owkin Inc** to evaluate the response to neoadjuvant pembrolizumab based on the analysis of mpMRIs and pathology slides
- With **Columbia University** to evaluate radiomic features that correlate with complete response

Overview

- Aim: to apply **AI algorithms to predict response to neoadjuvant pembrolizumab** on **mpMRI of the bladder**.
- Patient population: **160 patients (320 mpMRIs)** treated with anti-PD1 immunotherapy in the context of the **PURE-01 study** (NCT02736266). All patients received 3 cycles of neoadjuvant pembrolizumab and then underwent radical cystectomy. All patients were studies by means of a bladder mpMRI before and after the neoadjuvant treatment.
- Inclusion and exclusion criteria: all patients that were enrolled in the PURE-01 trial (n=160) are eligible for this retrospective study.

Study design

- Single center, non-randomized, retrospective, observational study
- Primary endpoint: correlation between mpMRI findings, and pathologic complete response.
- mpMRIs will be analysed to extract **radiomic features** associated with pT0, to predict response to neoadjuvant pembrolizumab. A **machine learning algorithm** based on selected features will be **trained** and **validated** in different sub-sets of randomly selected patients within the PURE-01 dataset. The algorithm will be then **tested** on a third subset scans.
- The predictive ability of the model will be evaluated by means of the ROC-AUC against clinical predictors.
- These predictors will be used as covariates in a **multivariable logistic regression** that predicts pT0 (absent versus present).
- A Satisfactory machine learning algorithm will be the one that outperforms in terms of discrimination and net benefit (evaluated through the decision curve analysis) known clinical predictors of response.

Updates

- Ongoing…

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