Your Prostate in the Metaverse

The Future of Prostate Imaging

Daniel J A Margolis, MD
Associate Professor of Radiology
djm9016@med.cornell.edu

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Disclosure

Consultant for Promaxo, Inc.

Overview

Qualitative Versus Quantitative Imaging

What is Artificial Intelligence? How Can AI Be Used for Prostate Imaging?

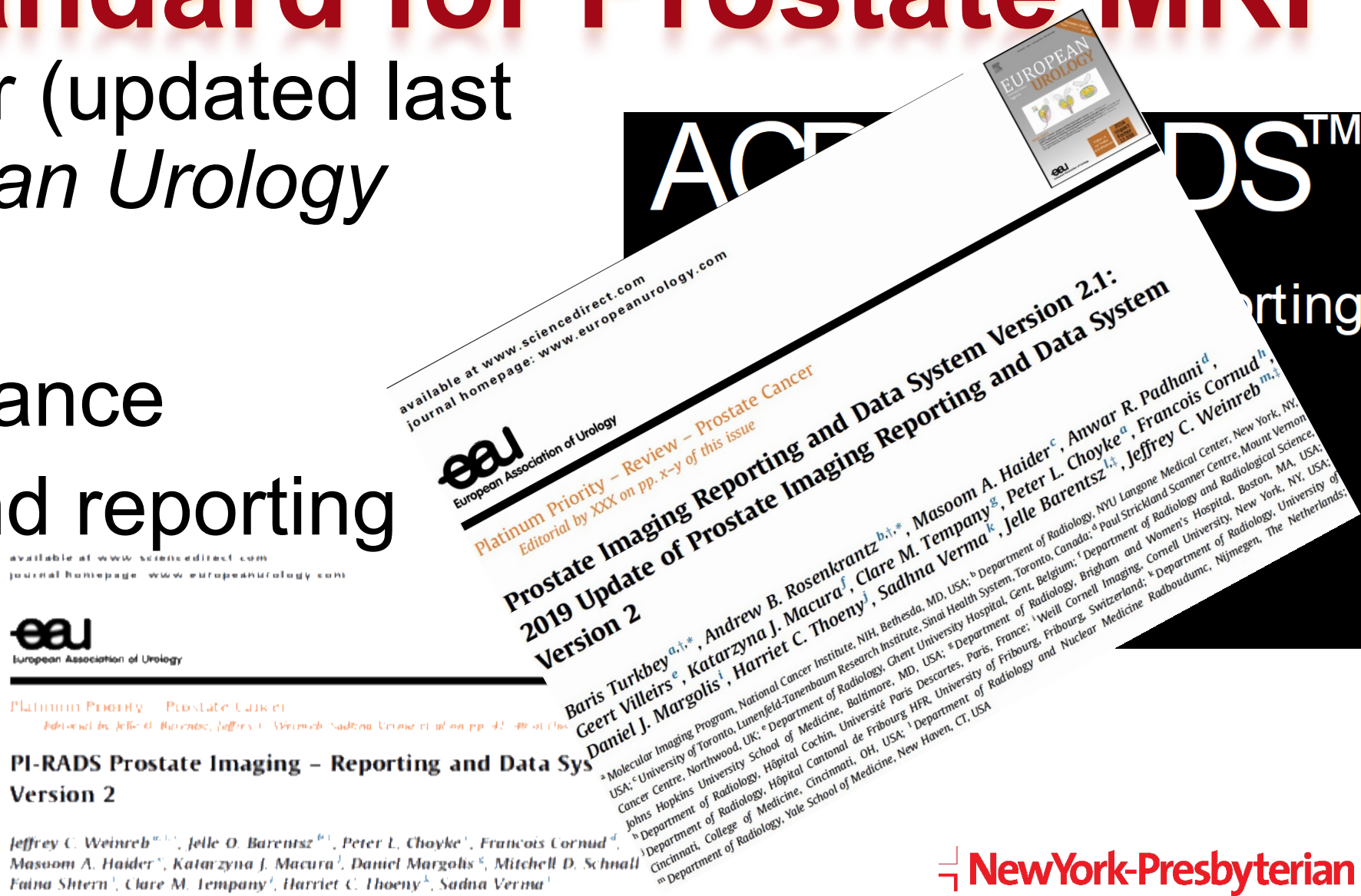
Near Term and Long Term

Prostate Imaging Reporting and Data Systems v2.1:

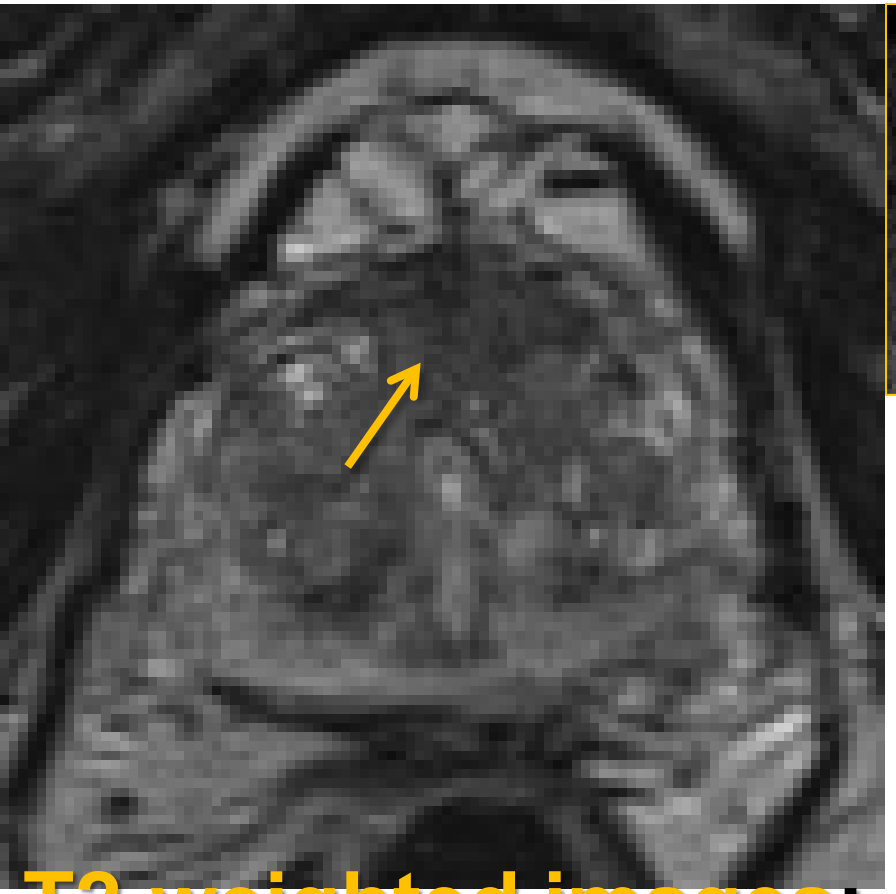
“PI-RADS”

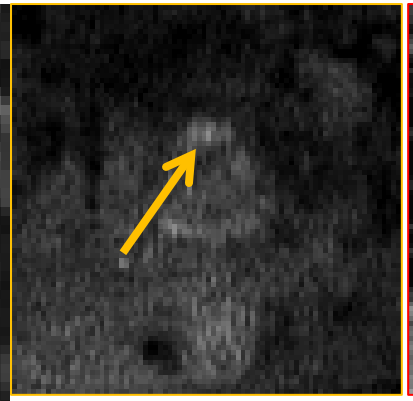
>20 publications prove PI-RADS v2 the Standard for Prostate MRI

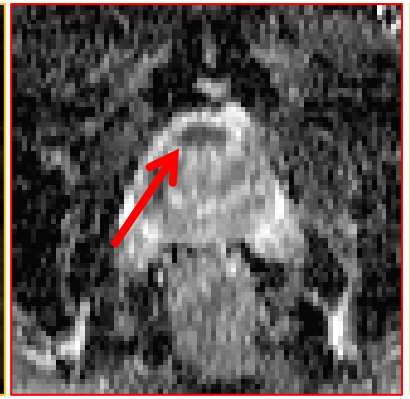
- ACR website or (updated last month) *European Urology*
- Technique
- Normal appearance
- Assessment and reporting
- Staging

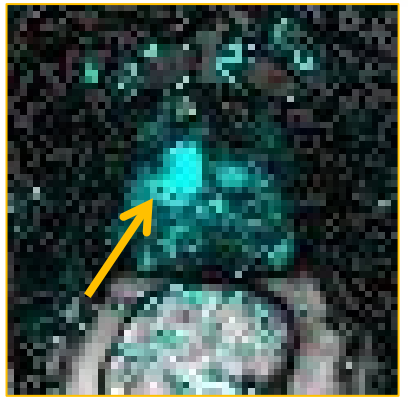


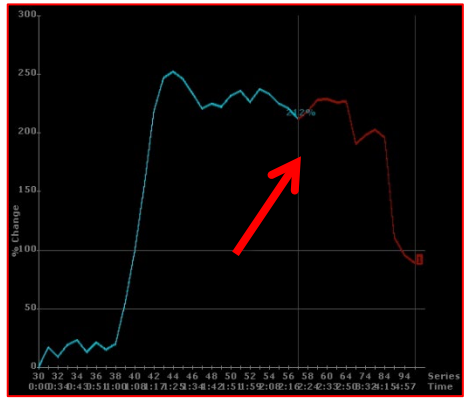
mpMRI Components









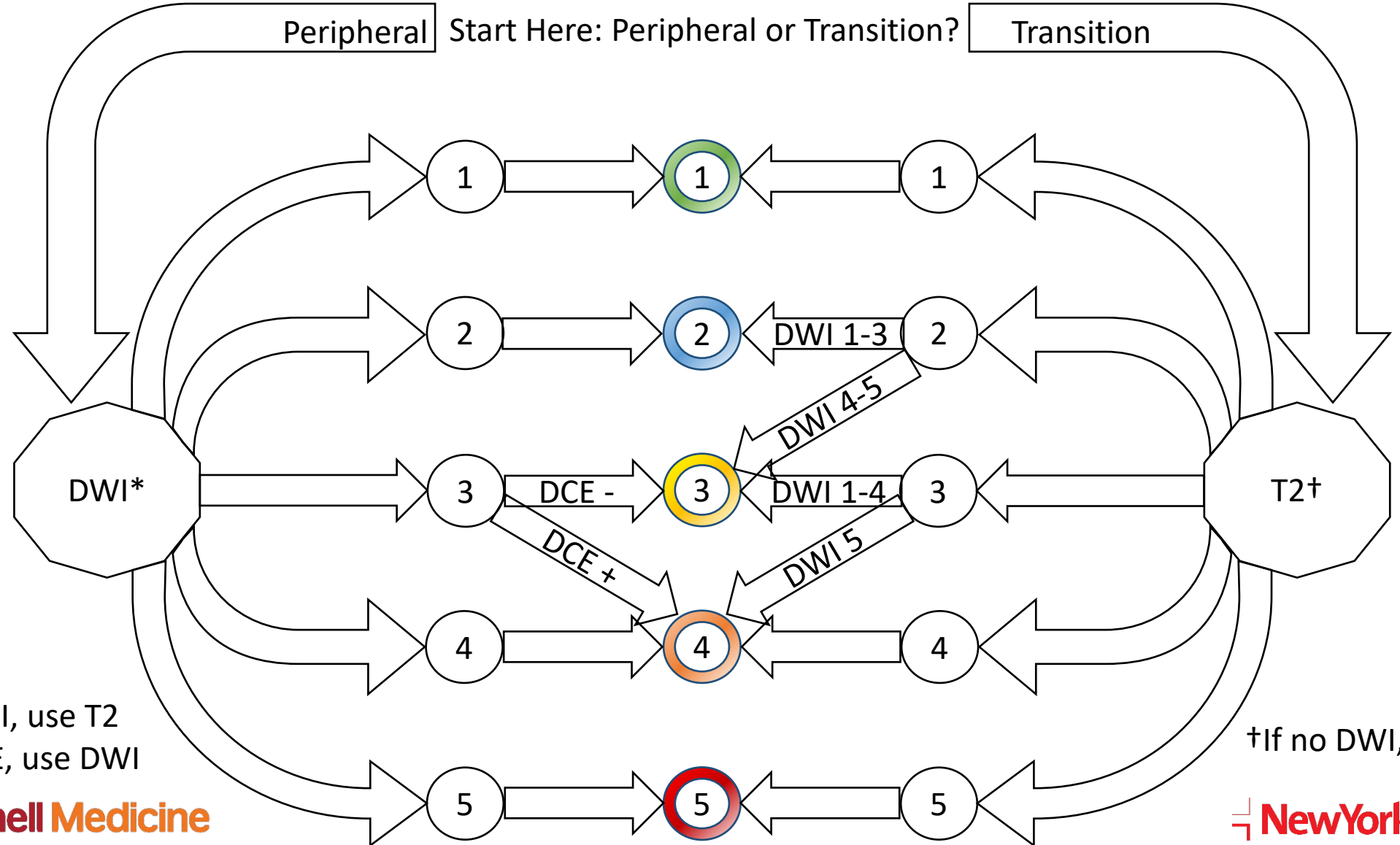


T2-weighted images: transition zone characterization & staging

Diffusion-weighted imaging + **apparent diffusion coefficient map**: most specific

Dynamic contrast-enhanced perfusion imaging with optional **enhancement curve**: most sensitive

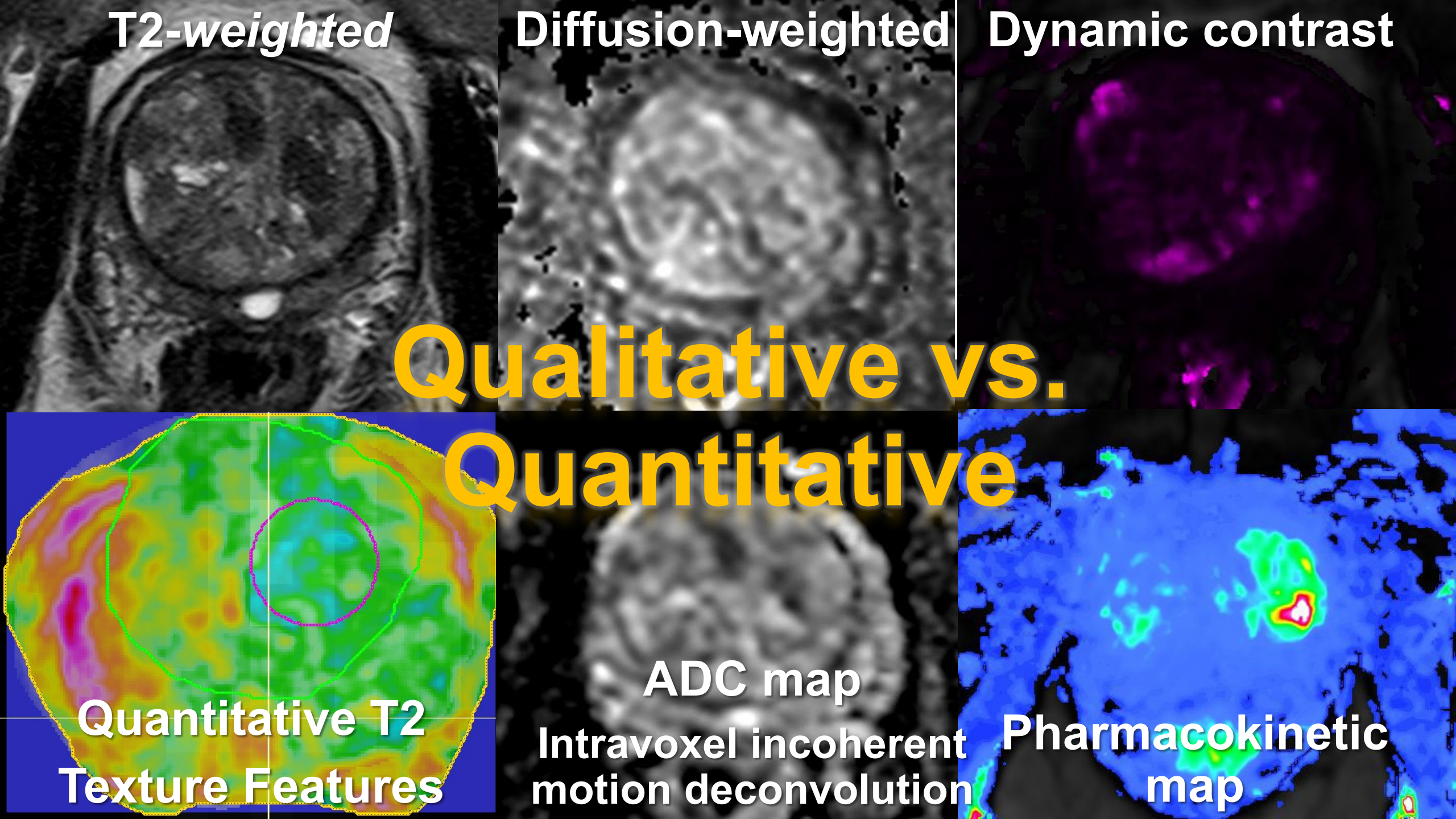
Assess Based on Flow Chart



*If no DWI, use T2
If no DCE, use DWI

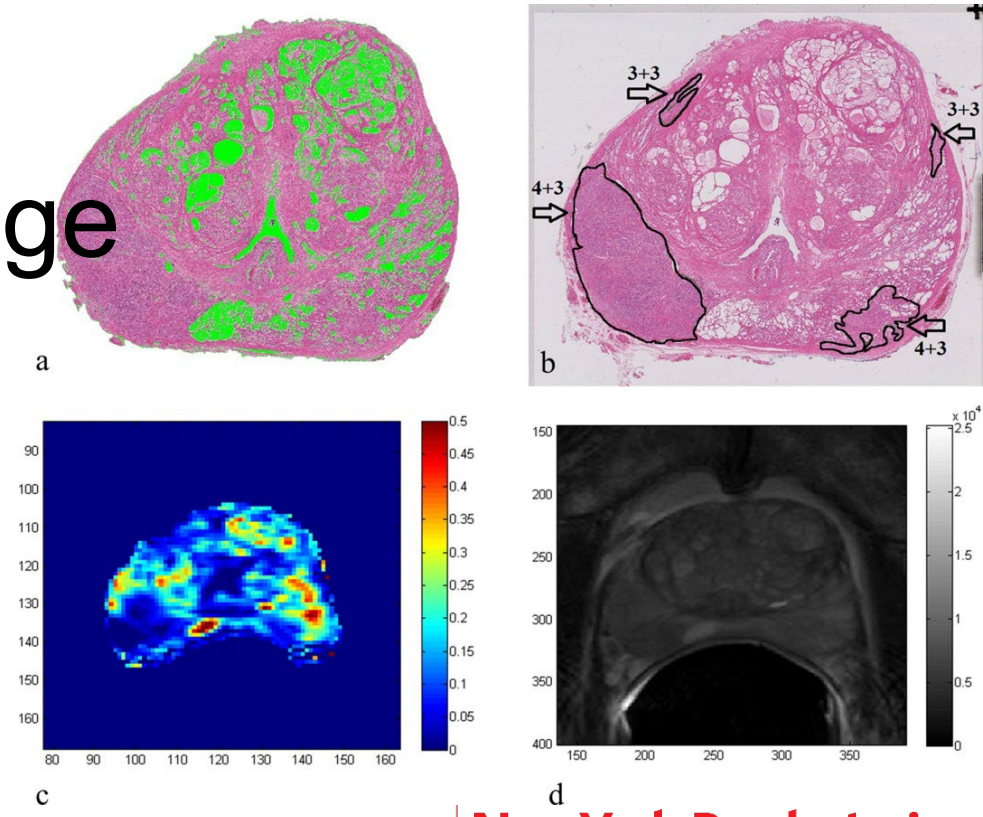
†If no DWI, use DCE

Qualitative vs. Quantitative Imaging


T2-*weighted*
Diffusion-weighted
Dynamic contrast
Qualitative vs. Quantitative
Quantitative T2 Texture Features
ADC map
Intravoxel incoherent motion deconvolution
Pharmacokinetic map

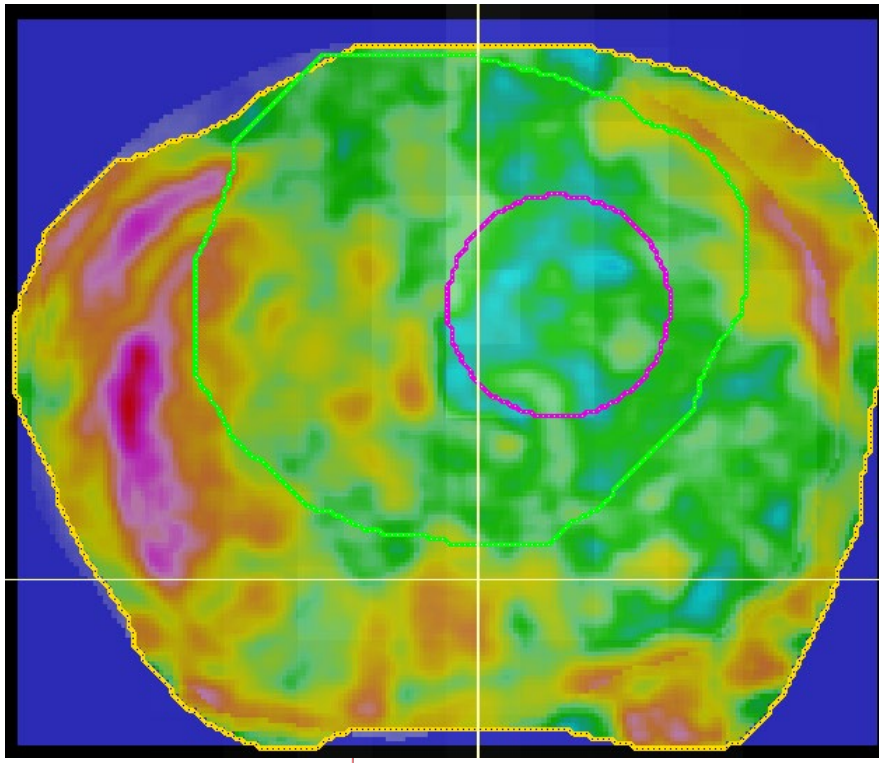
Quantitative T2

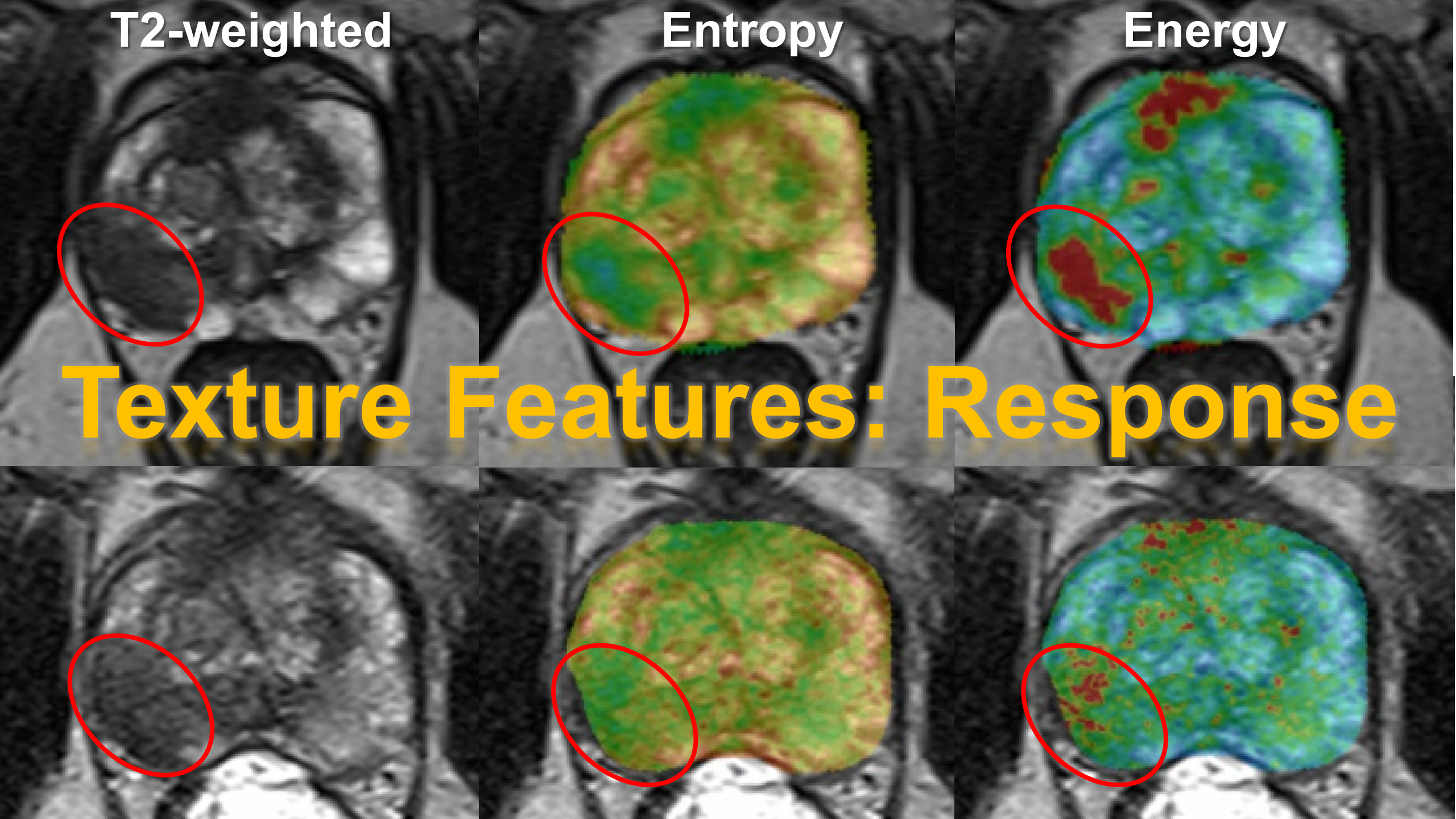
- Quantitative T2 measurement: time consuming 2-4x
- T2 of cancer << normal tissue, high << low grade
- No significant detection advantage
- Lower resolution



T2 Texture Features

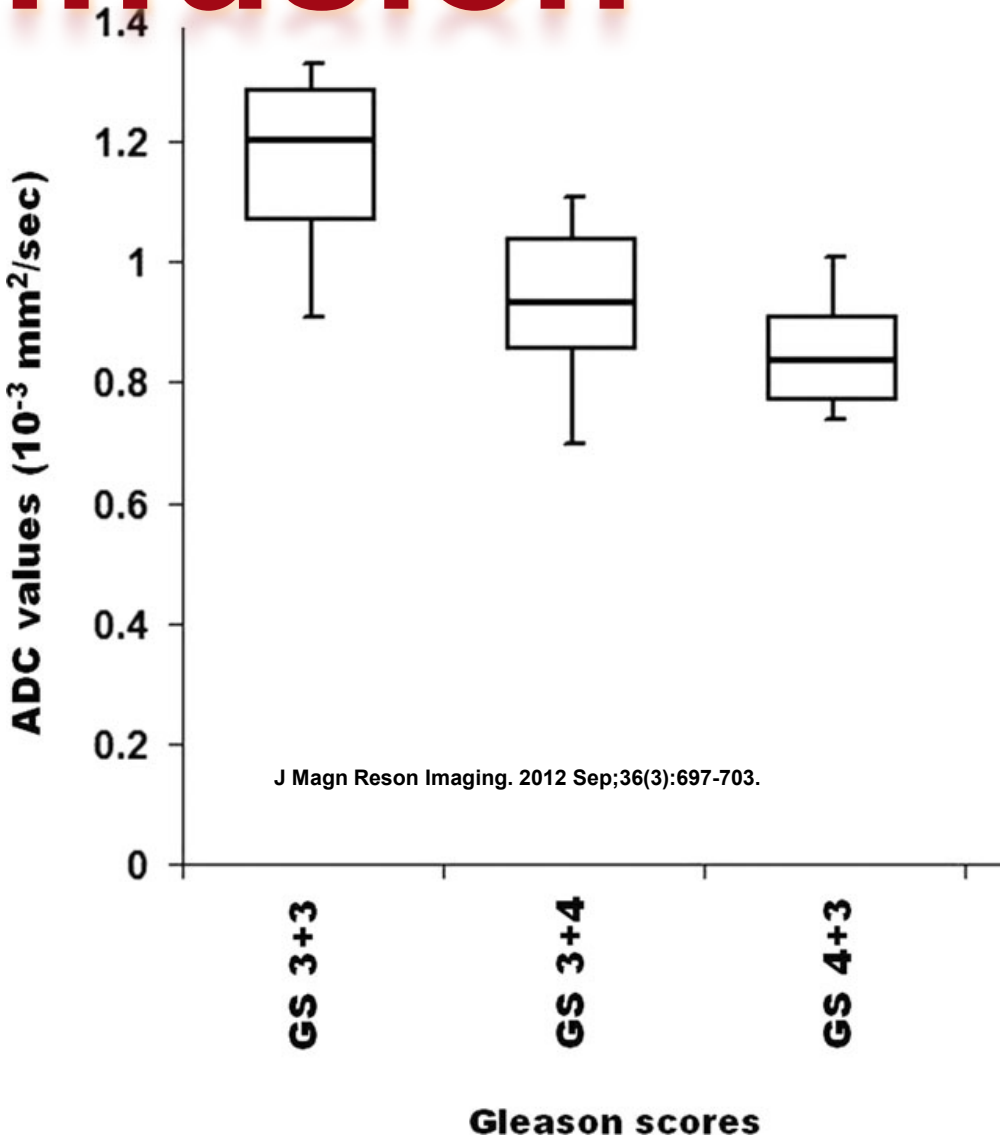
- ***Quantitative*** analysis of ***qualitative*** T2WI
  - All post-processing = no extra scan time
- Second-order: energy, entropy
- High-order: Haralick, Gabor
- Detection similar to ADC




T2-weighted
Entropy
Energy
Texture Features: Response

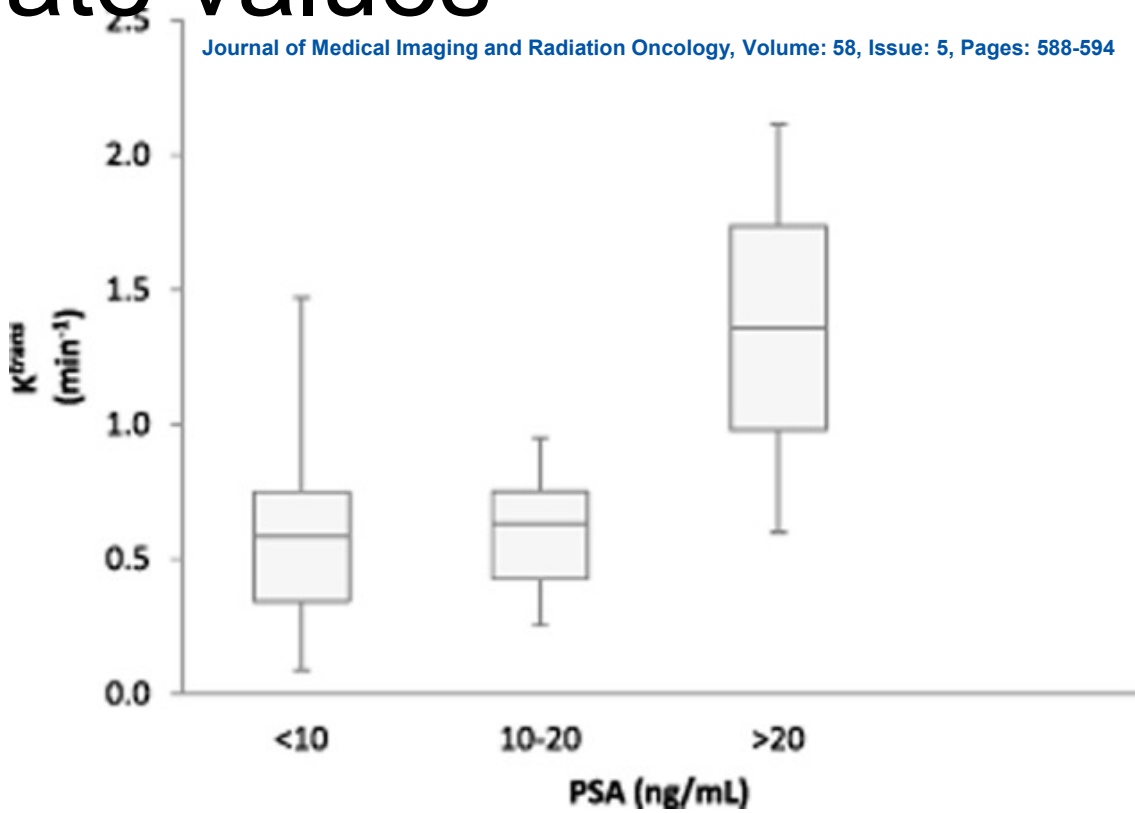
Quantitative Diffusion

- ADC is the slope of diffusion intensities
- monoexponential model
  ADC = $-\ln [S/S(0)]/b$
- One of the first validated quantitative metrics
  - However, overlap with prostatitis and hyperplasia



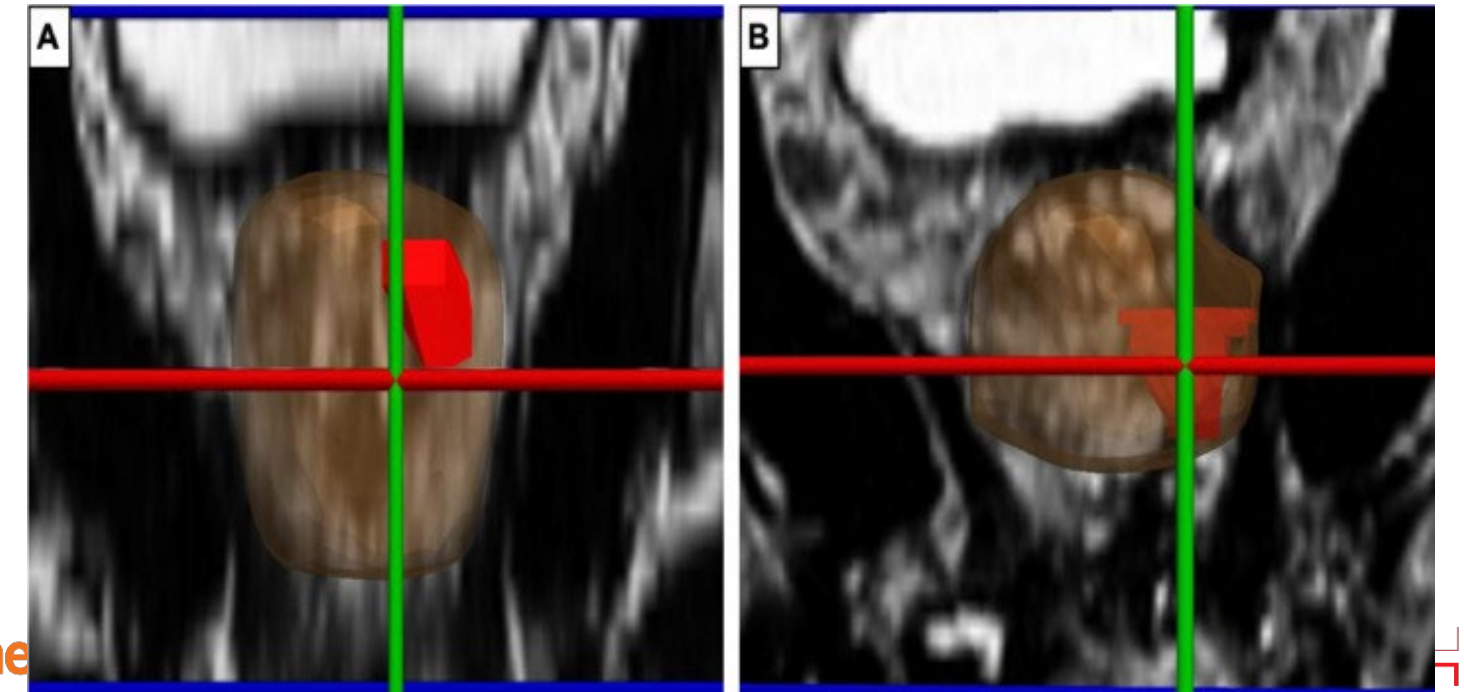
Quantitative Perfusion

- Based on dynamic contrast-enhancement
- Many workstations will generate values
  - K^{trans}
  - K_{ep}
  - V_e
- These detect cancer, too
  - But can be model-dependent



Quantitative 3D Size Change

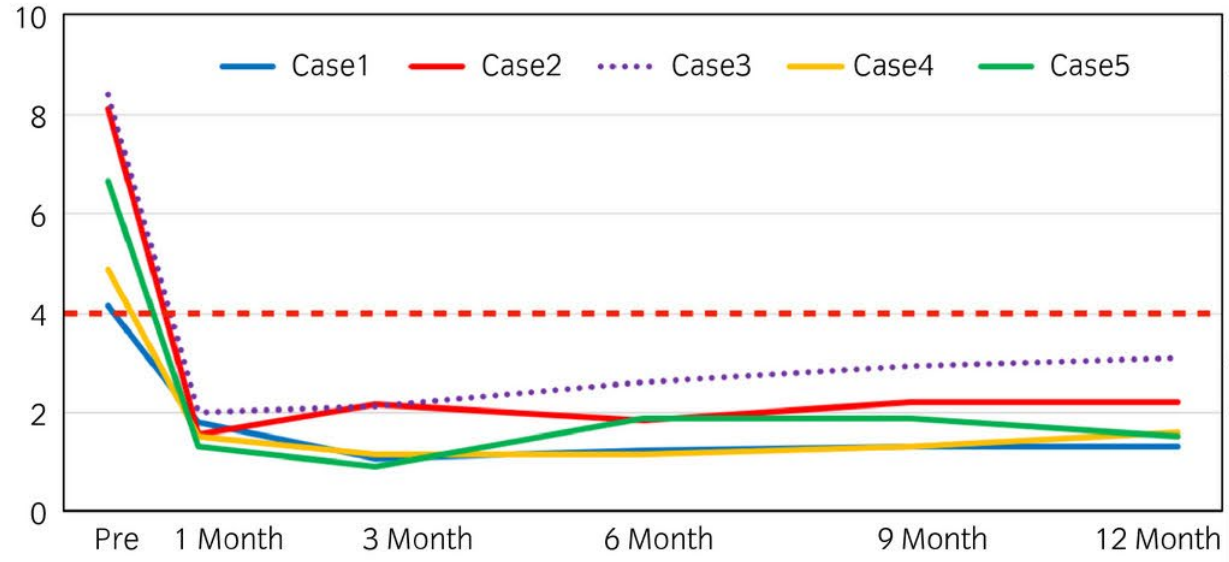
- Al Hussein *et al* Urology. 2020 Apr;138:98-105
- Pre- and post-treatment
- Shape of treatment zone + whole prostate changes



Size + Biochemical Change

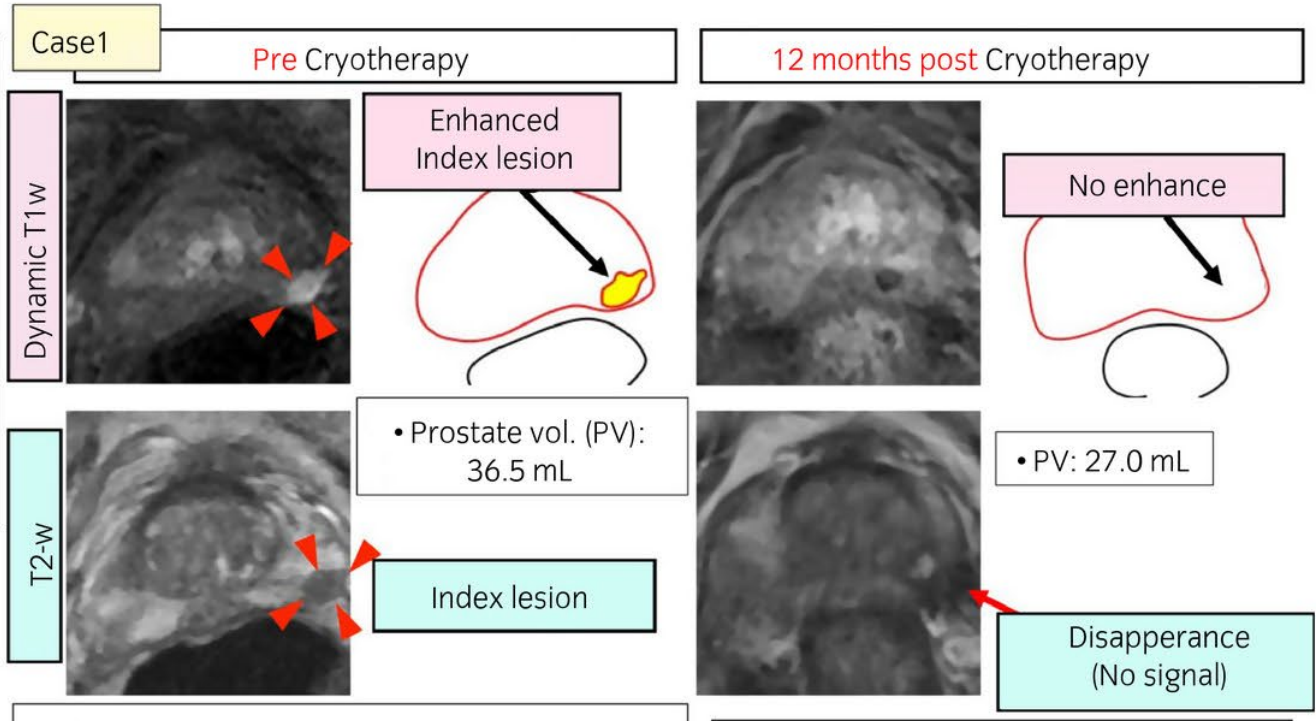
- Inoue Int J Urol. 2019 Feb;26(2):317-319

(a)



	Pre	1 Month	3 Month	6 Month	9 Month	12 Month
PSA (ng/mL)	6.63	1.55	1.17	1.85	1.86	1.58
Decrease rate of PSA	-	76%	75%	71%	72%	69%

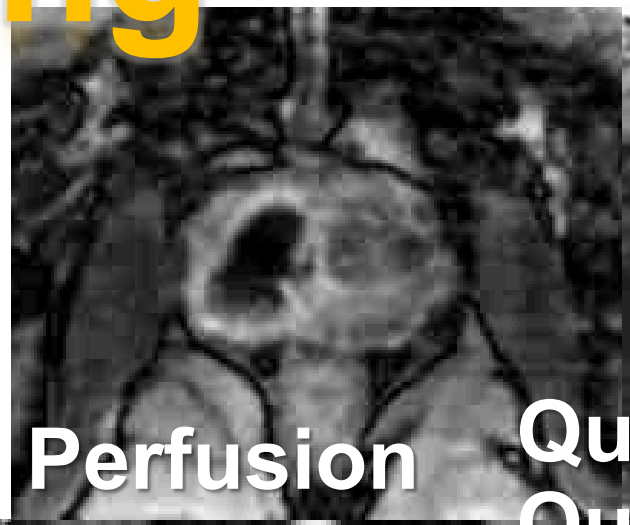
(b)

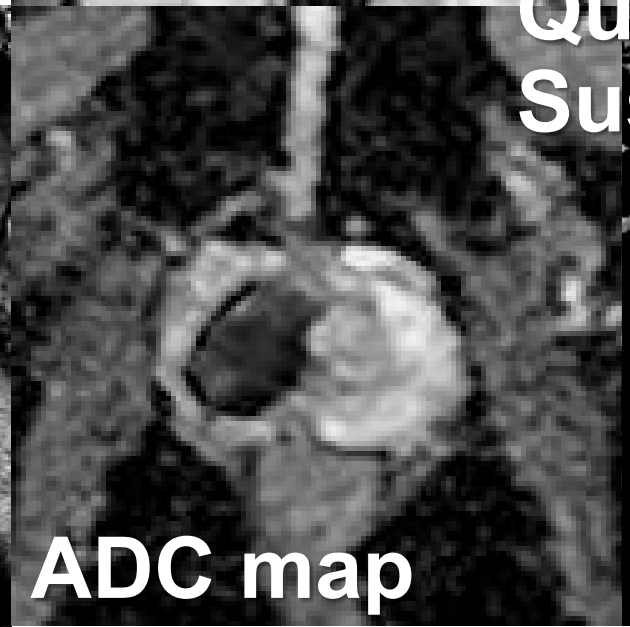


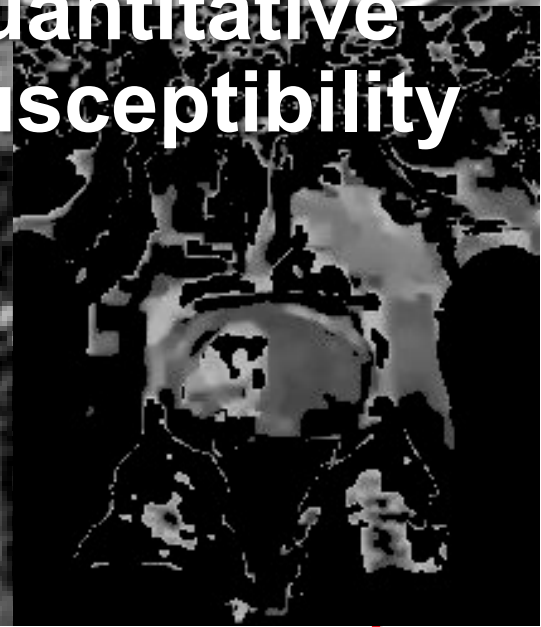
Future Directions

Susceptibility-Weighted Imaging

- Quantifies magnetic susceptibility
- Best correlates to mineral deposition
- Potentially identifies hemorrhage



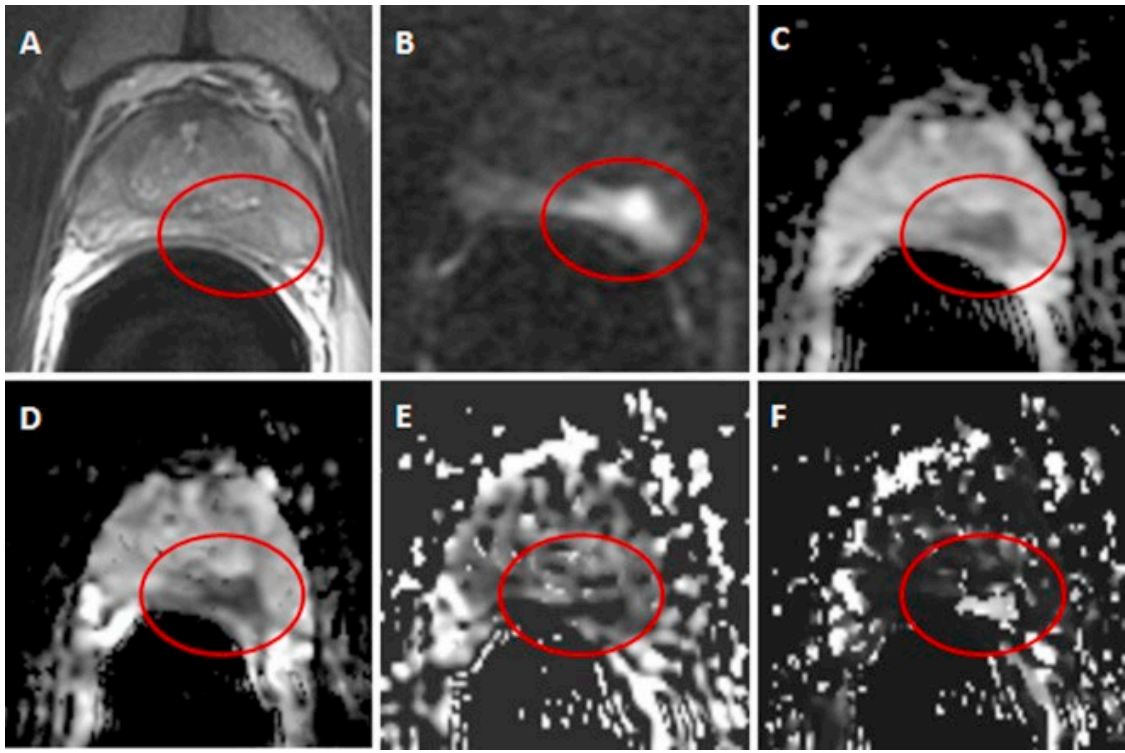




Complex Diffusion Imaging

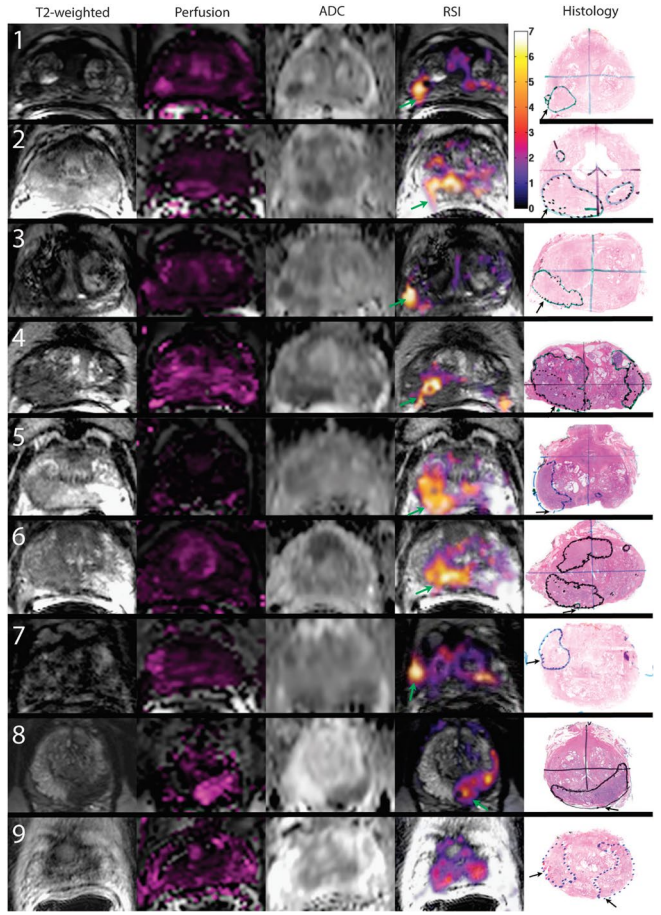
- Intravoxel incoherent motion (IVIM) deconvolution
  - *D* molecular diffusion
  - *f* fractional perfusion
  - *D** perfusion-diffusion
- Diffusion kurtosis
  - High b-value signal deviation
- Both show variable improvement over ADC

A. T2
B. DWI
C. ADC
D. *D*
E. *f*
F. *D**



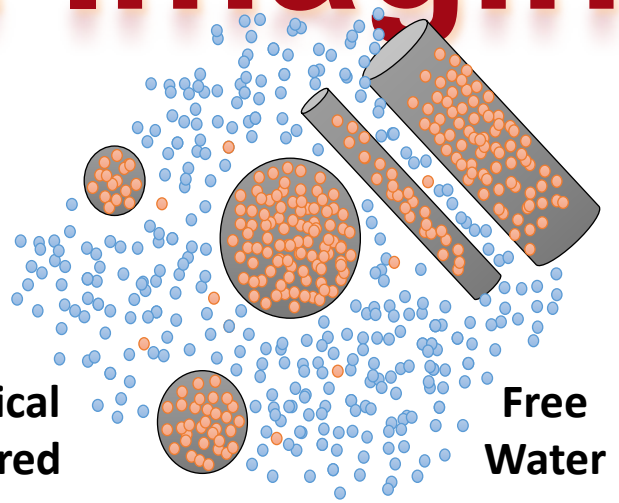
Advanced Diffusion

- Complex acquisition can discriminate cell types
  - Restriction-spectrum imaging
  - Luminal water imaging (also T2)
  - VERDICT
- Improved performance vs. ADC alone
- RSI FDA approved soon
- U Chicago, VERDICT research only

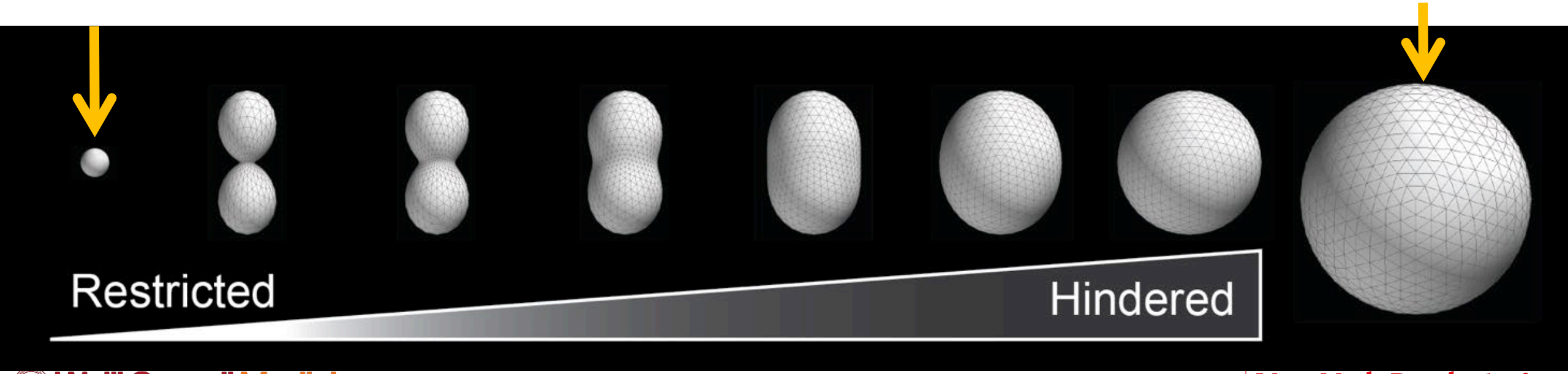


Restriction Spectrum Imaging

Apparent Diffusion "Spectrum"

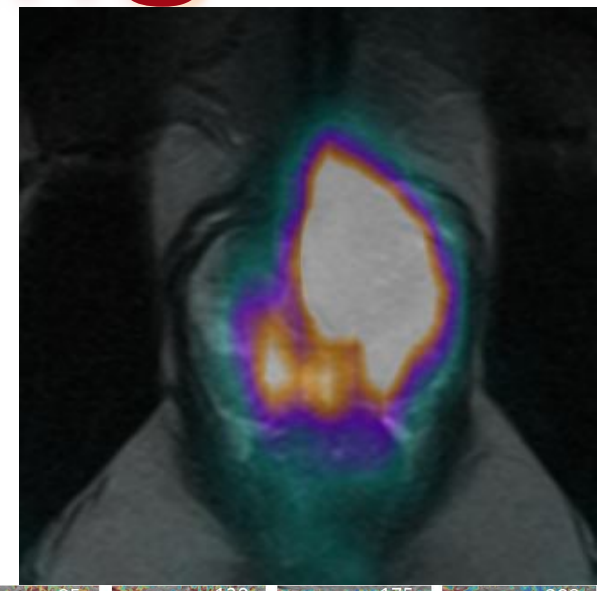


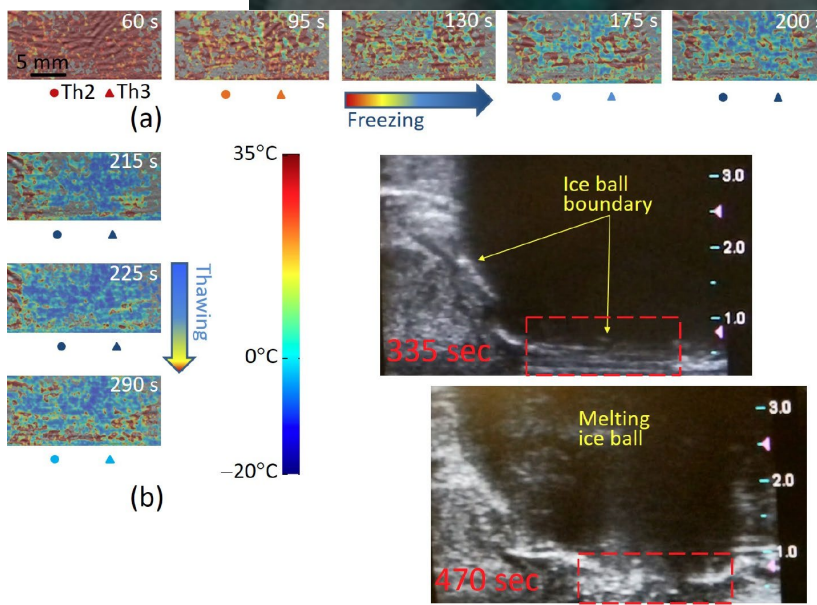
Spherical Restricted | **Cylindrical Restricted** | **Cylindrical Hindered** | **Spherical Hindered** | **Free Water**



Combination Imaging

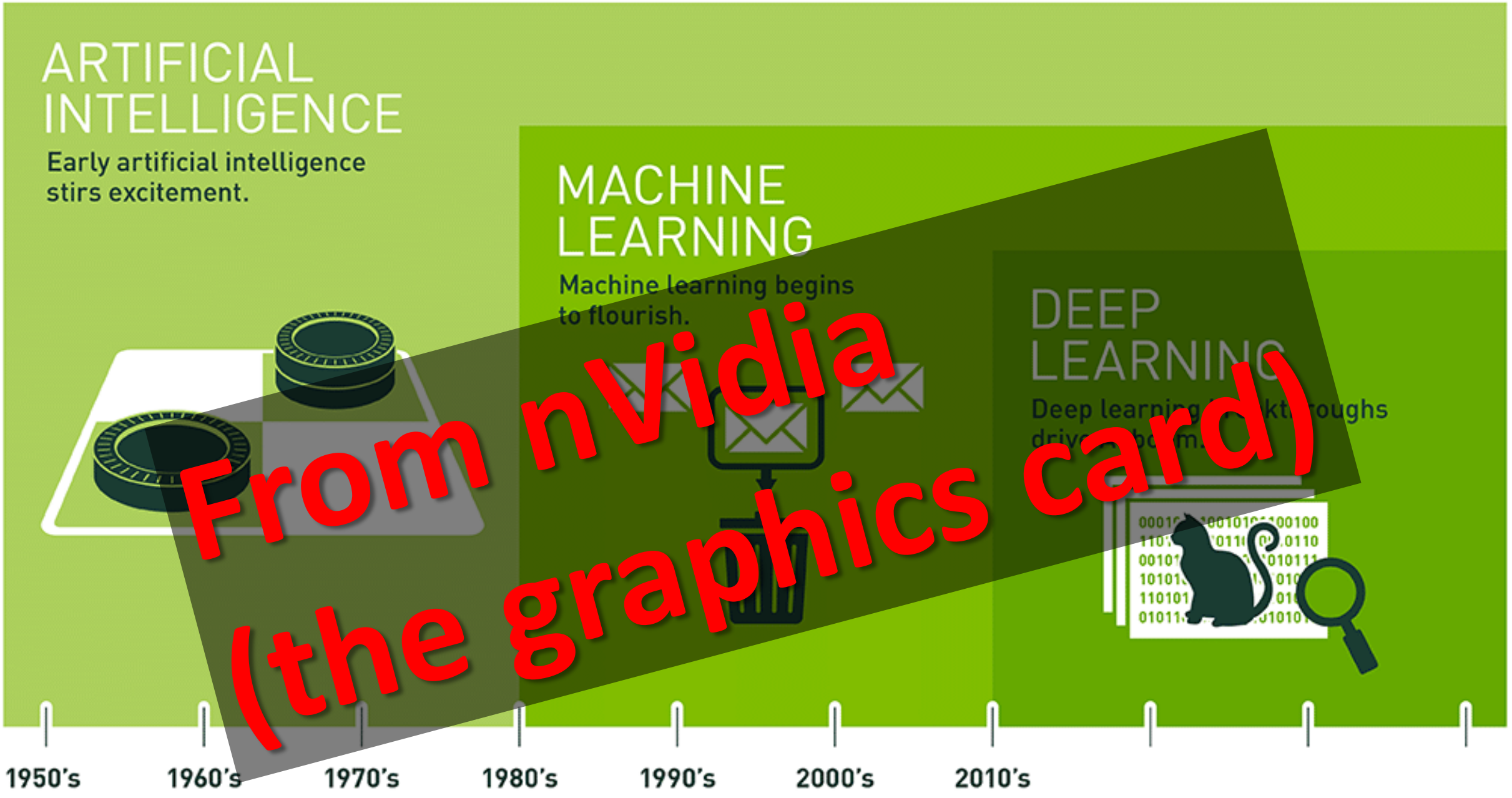
- PSMA PET-MRI
  - Local + regional detection for recurrence
  - Performance of PSMA undetermined
- Thermoacoustic imaging
  - Petrova *et al* Phys Med Biol. 2018 Mar 21;63(6):064002
  - Combination of grayscale ultrasound and temperature measurement





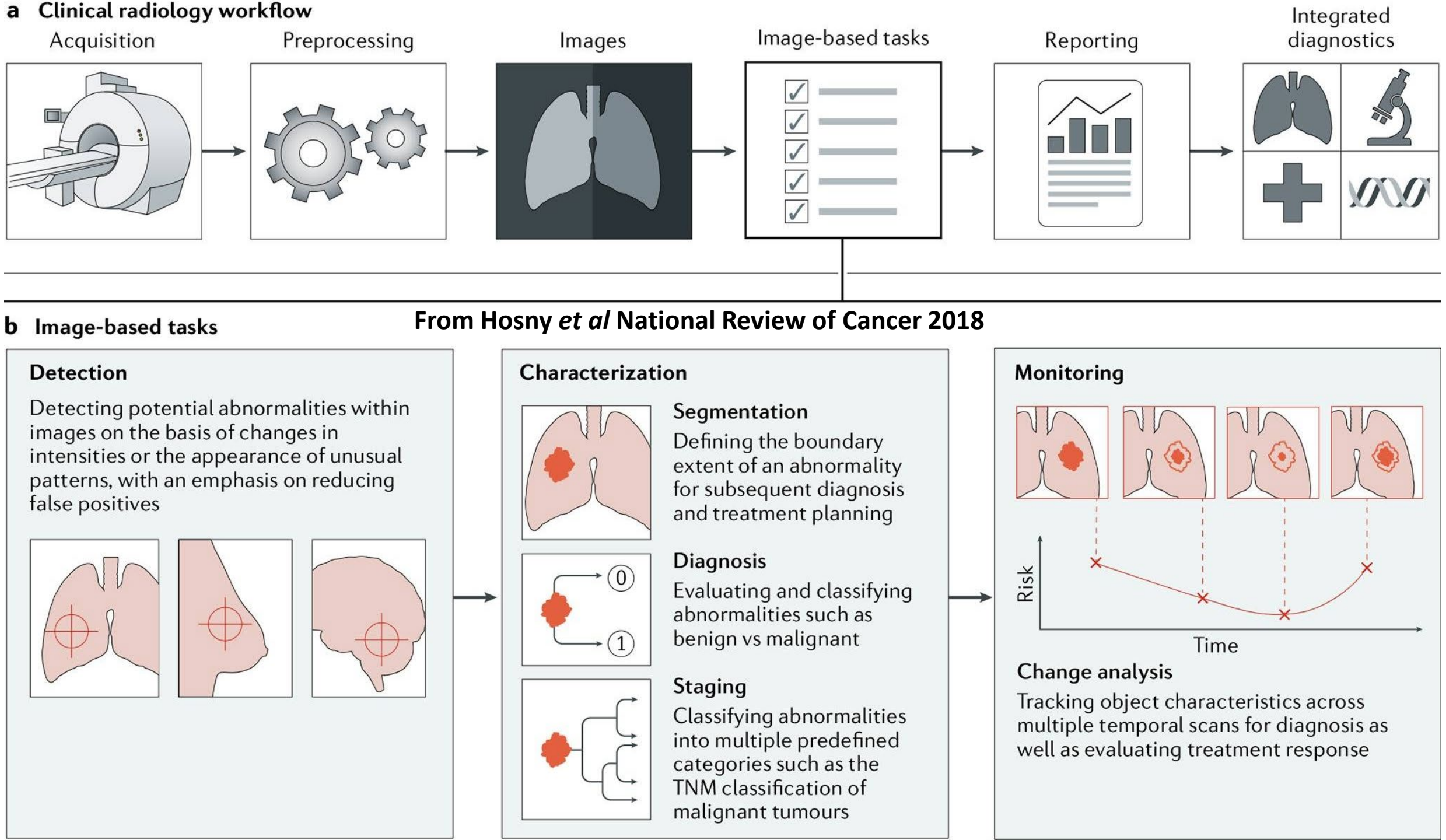
What is Artificial Intelligence?

How Can AI Be Used for Prostate Imaging?



From nVidia (the graphics card)

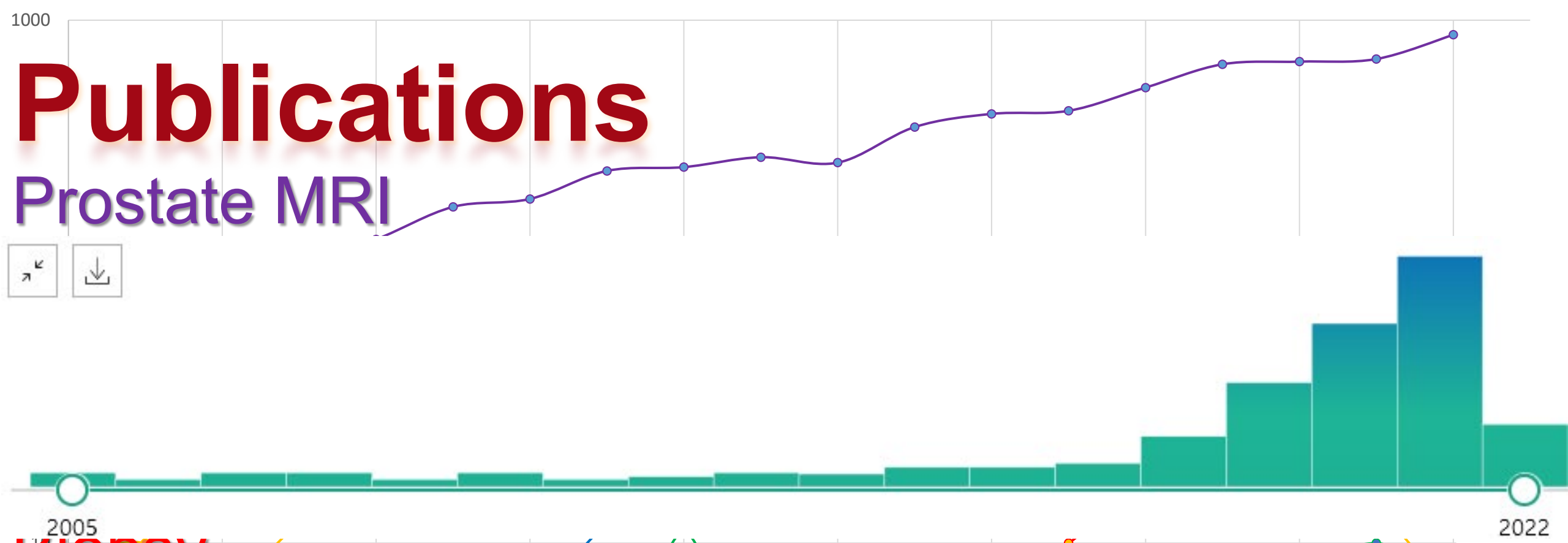
Since an early flush of optimism in the 1950s, smaller subsets of artificial intelligence – first machine learning, then deep learning, a subset of machine learning – have created ever larger disruptions.



From Hosny *et al* National Review of Cancer 2018

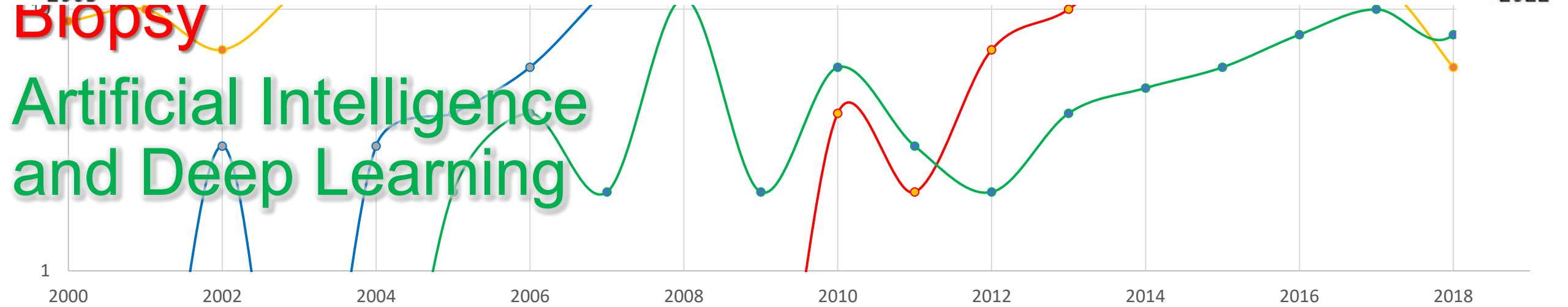
Publications

Prostate MRI



Biopsy

Artificial Intelligence and Deep Learning

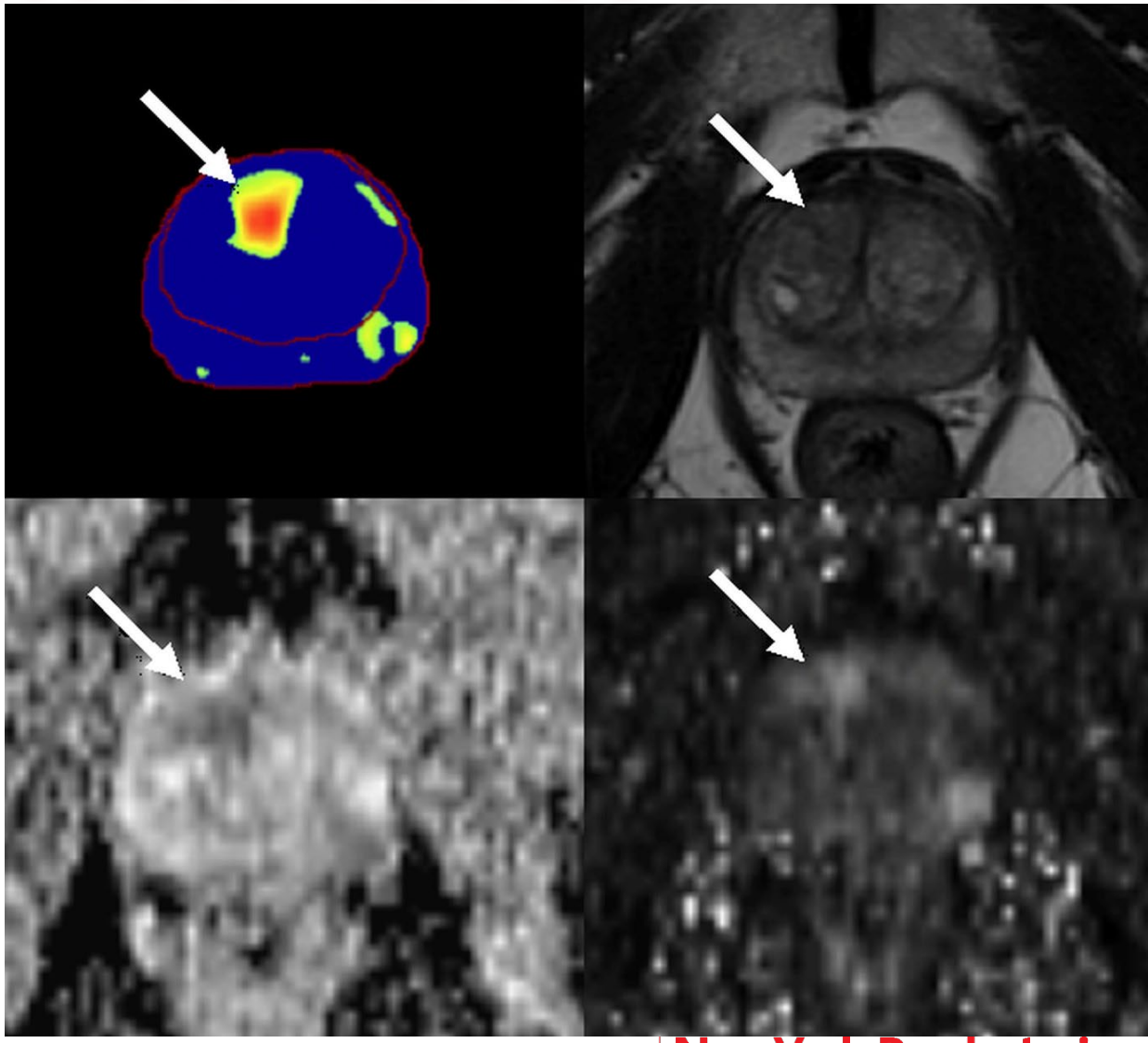


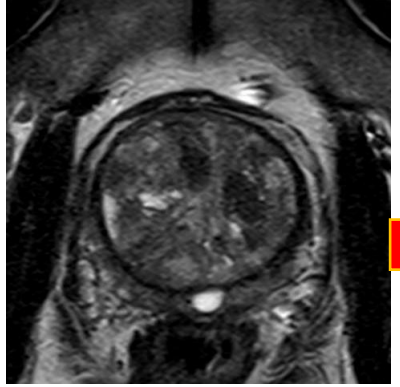
Weill Cornell Medicine

NewYork-Presbyterian

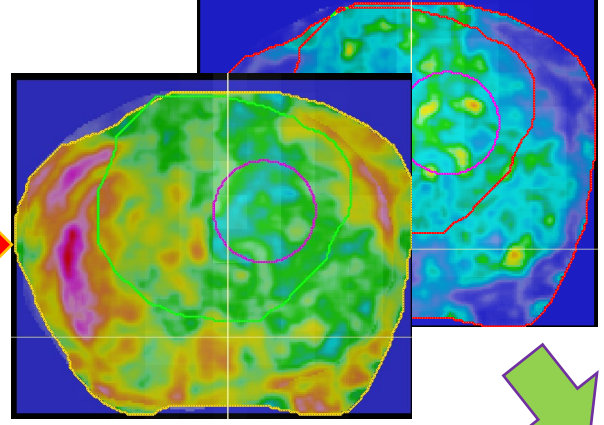
AI for Prostate MRI?

- But of course!
- Many commercial solutions being developed
- Approach is varied
  - Guided vs. holistic
  - T2 only vs. multiple series
  - Target vs. whole prostate
- Best use: QC?

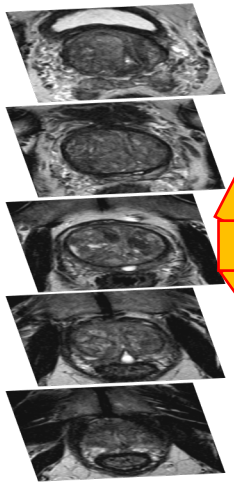




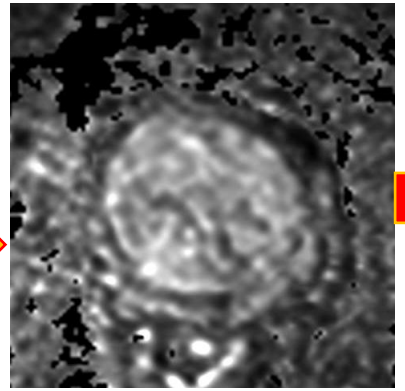
Qualitative T2-weighted anatomic imaging



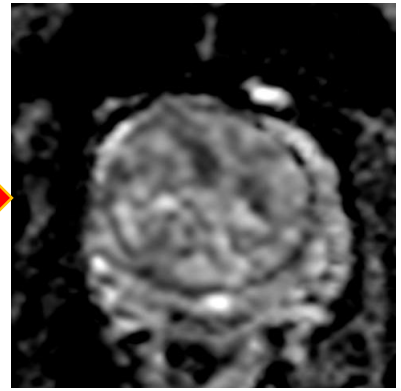
Quantitative texture analysis



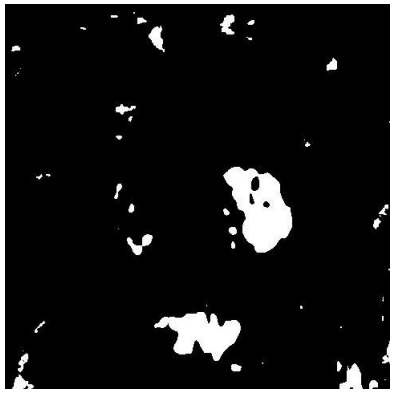
Volumetric, multi-parametric MRI of the prostate. For each axial "slice…"



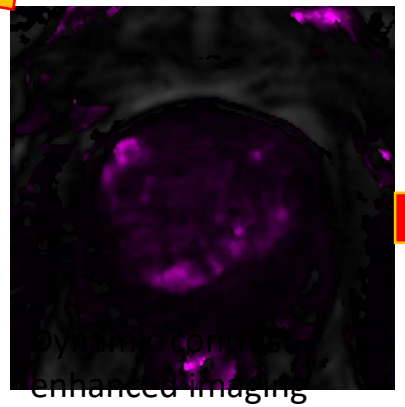
Diffusion-weighted imaging



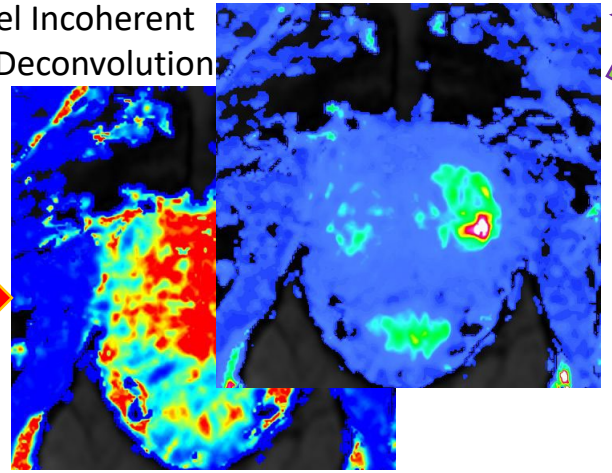
Intravoxel Incoherent Motion Deconvolution



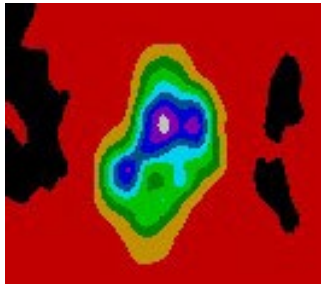
Thresholding and 3D segmentation



Dynamic contrast enhanced imaging



Pharmacokinetic perfusion maps



Correlation map of cancer aggressiveness

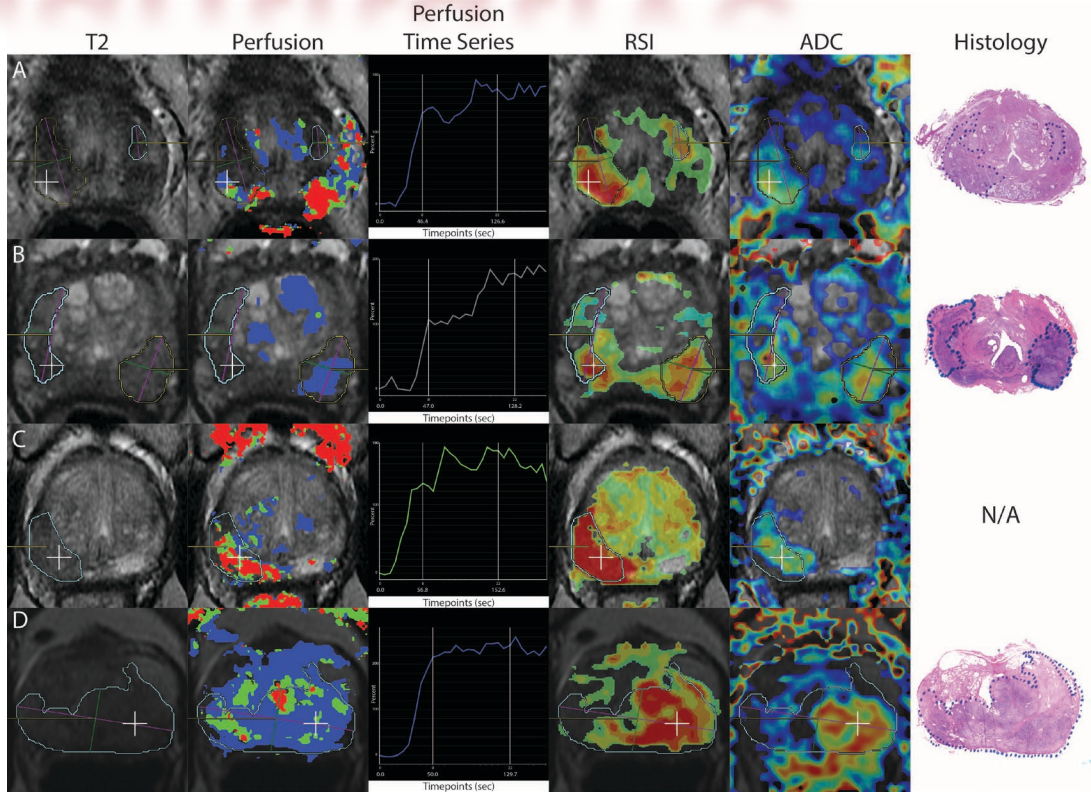
Weill Cornell Medicine

NewYork-Presbyterian

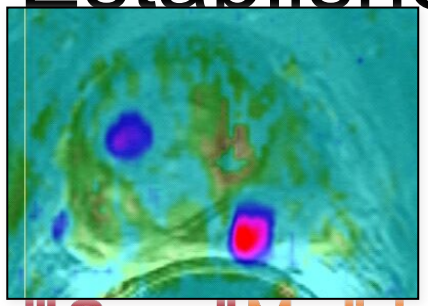
Near Term and Long Term

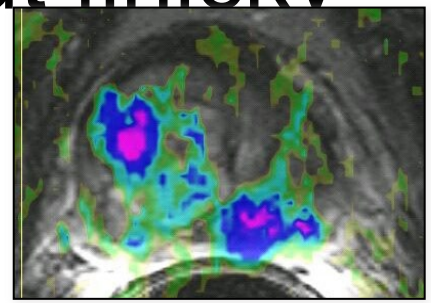
Near Term: Quantitative

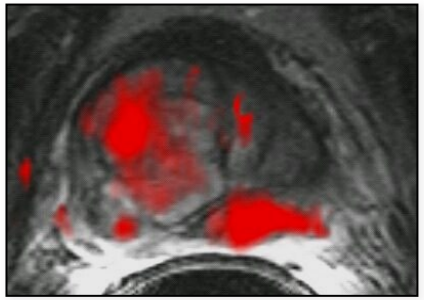
- Restriction Spectrum Imaging
  - Best non-contrast scan?



- Dynamic Contrast Modeling
  - Established, but finicky

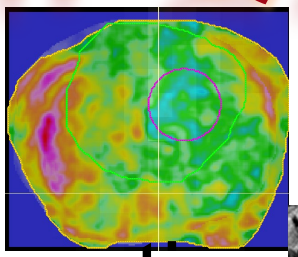


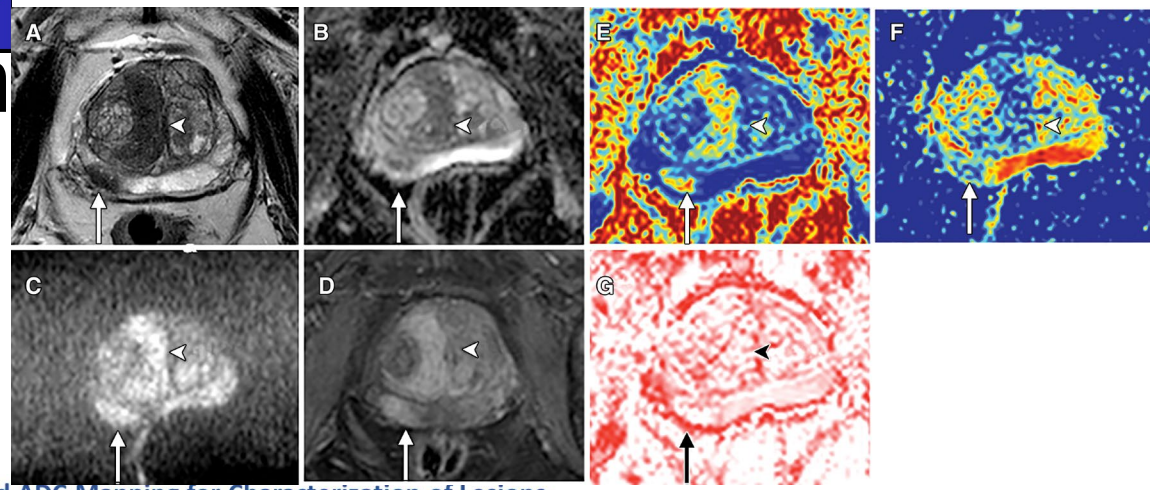




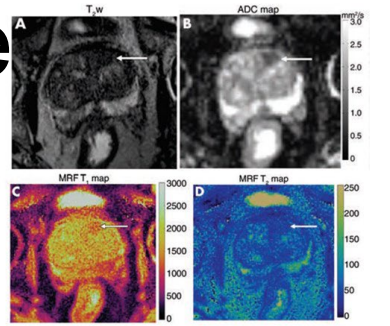
Long Term: Quantitative

- T2 Texture Features
  - Answer looking for a question
- VERDICT
  - Validated but not available
- "MRI Fingerprinting"
  - Multiple scans at once
  - Validated in brain





MR Fingerprinting and ADC Mapping for Characterization of Lesions in the Transition Zone of the Prostate Gland



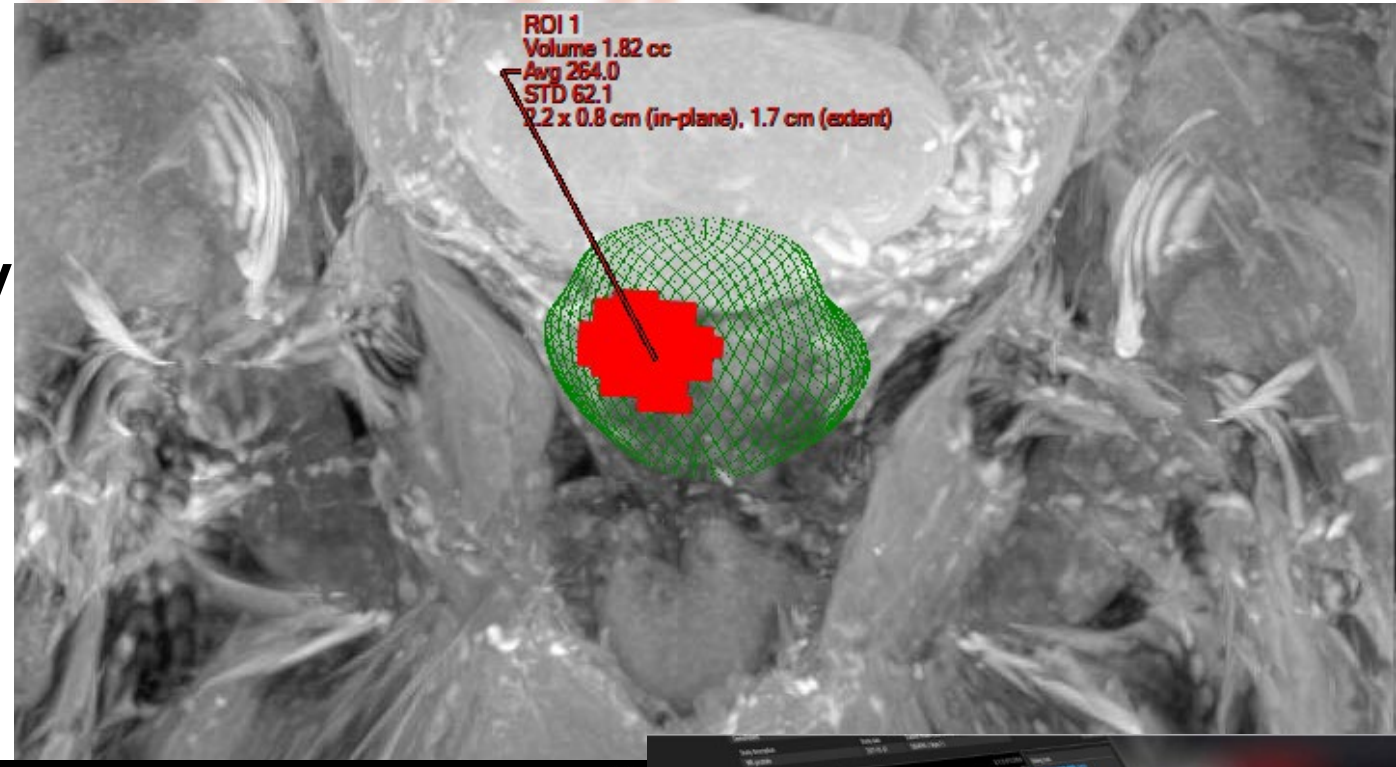
T2-weighted MRI, ADC mapping, and T1 and T2 MR fingerprinting mapping from targeted biopsy–proven prostate cancer.

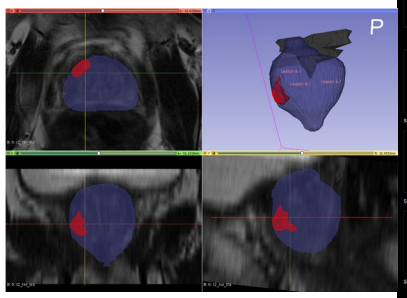
- For Prostate Imaging Reporting and Data System (PI-RADS) category 3 lesions, noncancers had longer T1 relaxation times than cancers (1630 msec vs 1430 msec respectively; *P* = .006).
- The diagnostic performance of T1 relaxation time at MR fingerprinting for PI-RADS category 3 cancers from noncancers was AUC = 0.79.
- A combination of MR fingerprinting–based T1 relaxation time and ADC mapping can help differentiate transition zone cancers from noncancers (AUC = 0.94).

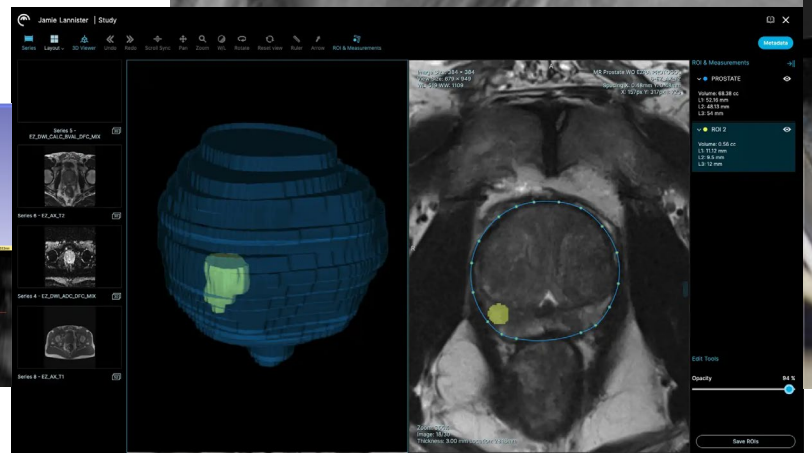
Panda A et al. Published Online: July 23, 2019
https://doi.org/10.1148/radiol.2019181705
Radiology

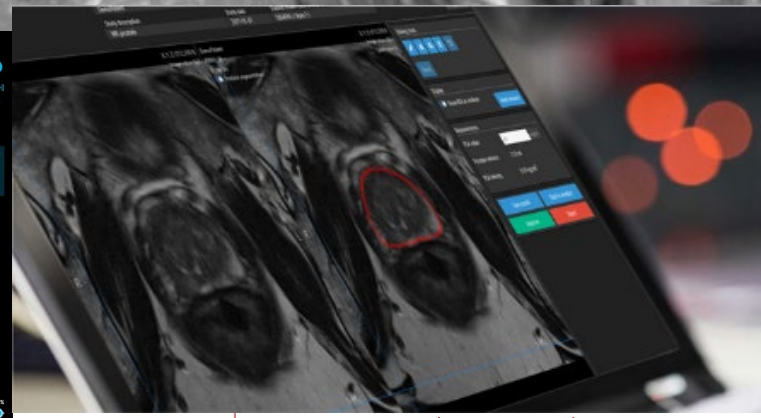
Near Term: AI

- Prostate segmentation
  - Widely used for UroNav
  - Semi-automatic lesion segmentation
- Multiple companies
  - Promises, promises
  - Results?









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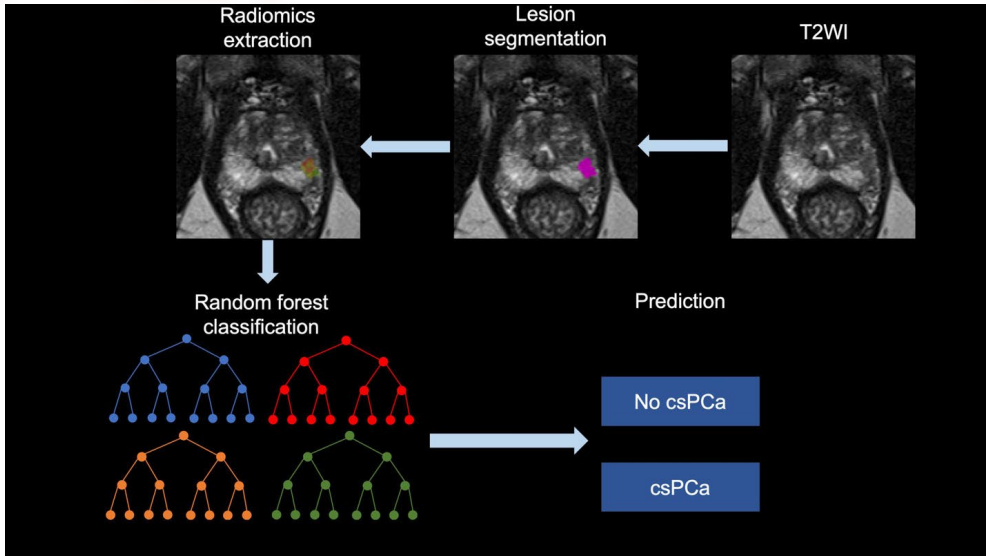
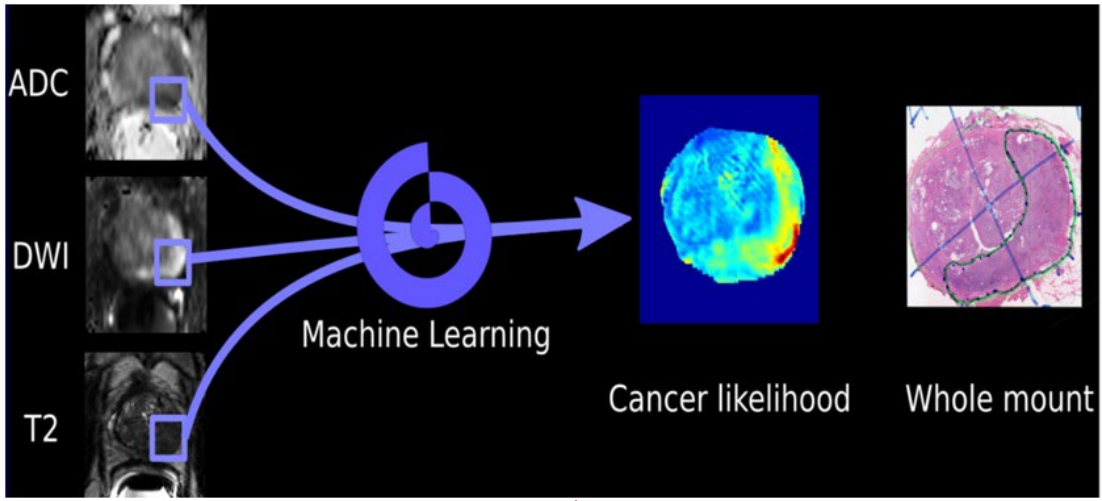
Long Term: AI

- Suspicion grading
  - Many publications
- Management guidance
  - Replacement for 4Kscore?
- Quality Control
  - During the scan itself
- Profession Society Guidance
  - From the PI-RADS committee!





Take Home Points

- Quantitative MR and Artificial Intelligence are here
  - ADC and segmentation
- The combination will solve many issues
  - Faster scans (no contrast)
  - More accurate classification (significant vs. not)
  - Compensation for experience
  - Quality control
  - Management guidance

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Thank you.
Questions?

Daniel J A Margolis, MD

Associate Professor of Radiology

djm9016@med.cornell.edu

Weill Cornell Medicine

NewYork-Presbyterian