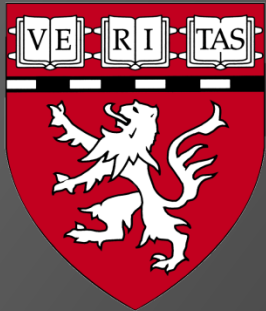


“REINVENTING RADIOLOGY IN THE TWENTY-FIRST CENTURY”

Michigan Radiological Society: Centennial Gala and
Education Event
October 23, 2021

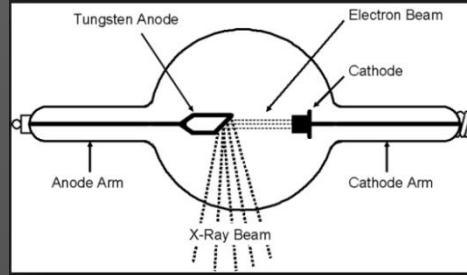


James H Thrall MD
Chairman Emeritus
Department of Radiology
Massachusetts General Hospital
Distinguished Juan M Taveras Professor of Radiology
Harvard Medical School



A Quick Trip Down Memory Lane

Prelude to the 21st Century



1895—1970: THE ERA OF X-RADIOLOGY

$$e^x = 1 + \frac{x}{1!} + \frac{x^2}{2!} + \frac{x^3}{3!} + \dots, \quad -\infty < x < \infty$$

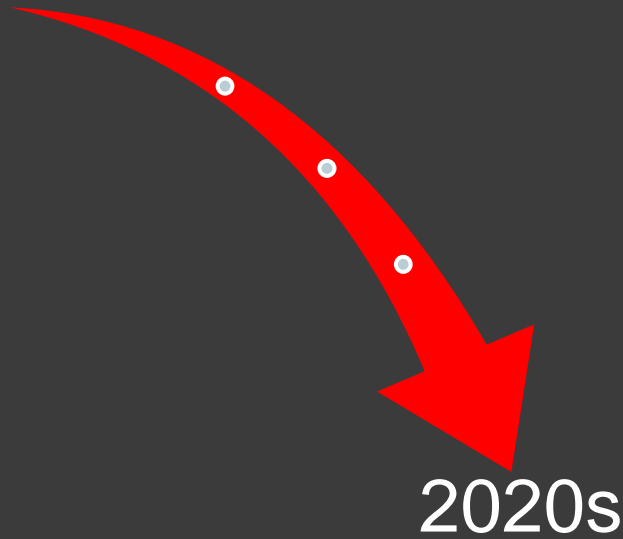
- Radiography
- From plates to film
- Frontal tomography—limited view angle
- Contrast media
- Fluoroscopy
- Angiography
- Automated film processing
 - 1940s— 40 minutes
 - 1950s— 9 minutes
 - 1960s— 90 seconds

Analog imaging

**Images regarded as
“Pictures”**

**1965—1985: Era of New
Modality Development And
Implementation**

- Ultrasound
- NM SPECT
- NM PET
- CT
- MRI
- Digital angio



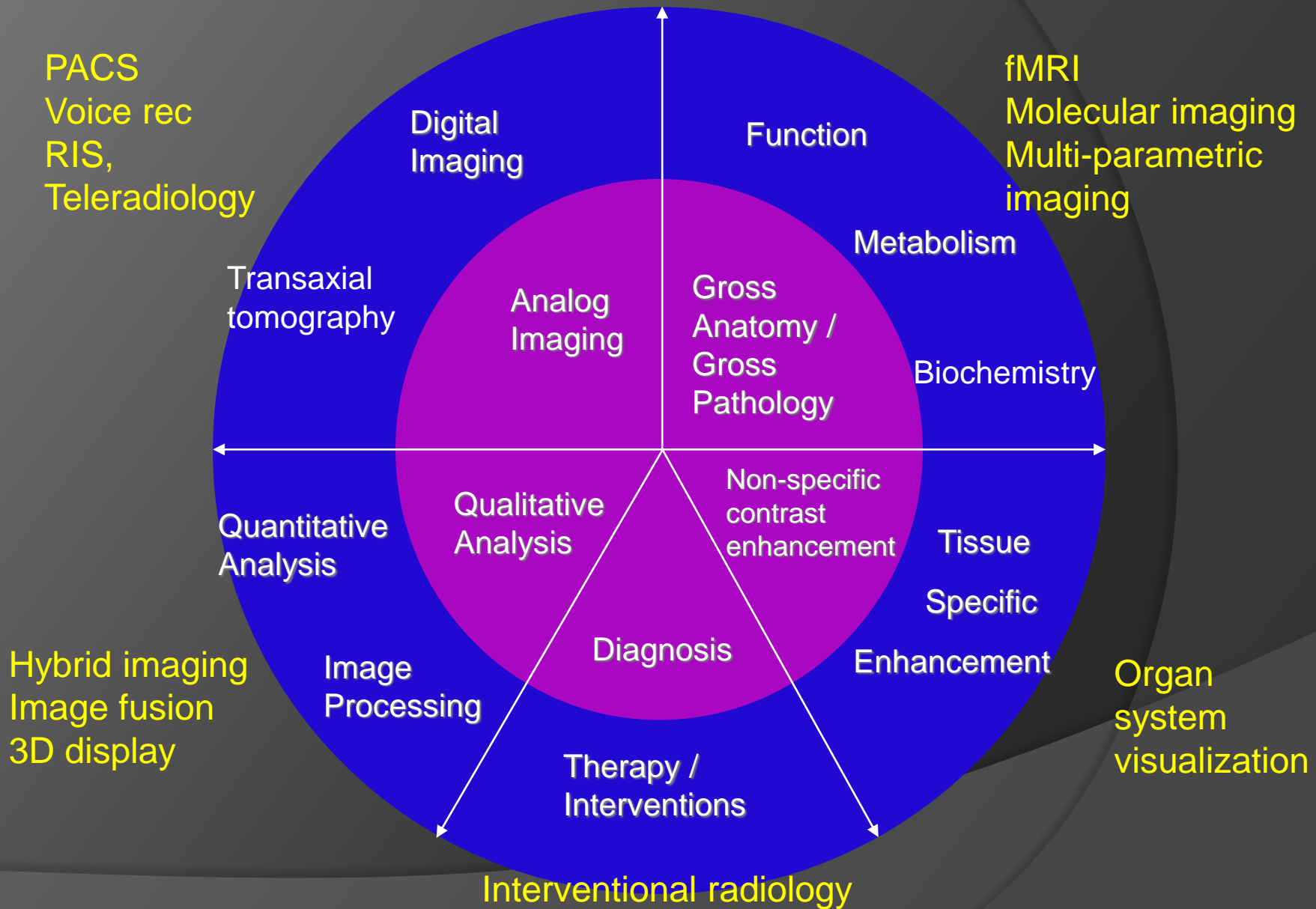
80--85% of
imaging RVUs

**1980—2000 ERA OF
FUNDAMENTAL
TRANSFORMATIONS**

HISTORIC THEMES IN MEDICAL IMAGING



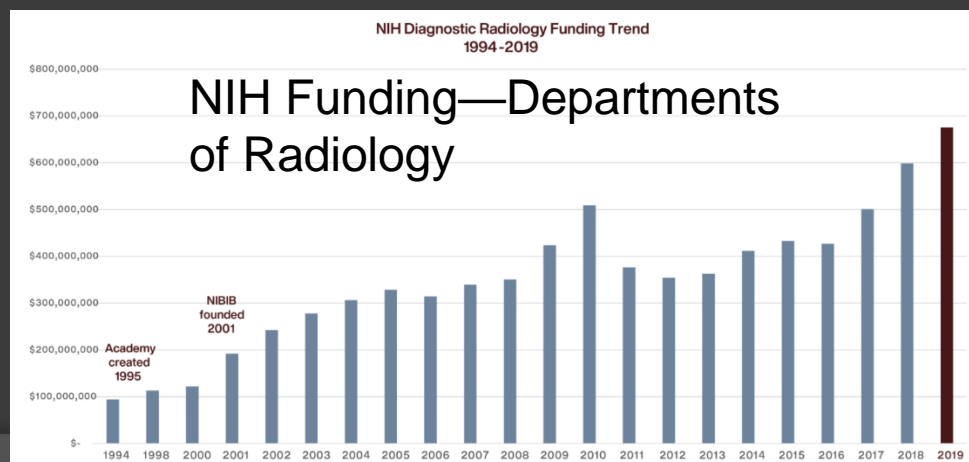
Key Transformations in Radiology



- Digital images become regarded as “Data”—pixels are numbers
- Imaging “biomarkers” conceptualized—parameters that radiology can detect and measure

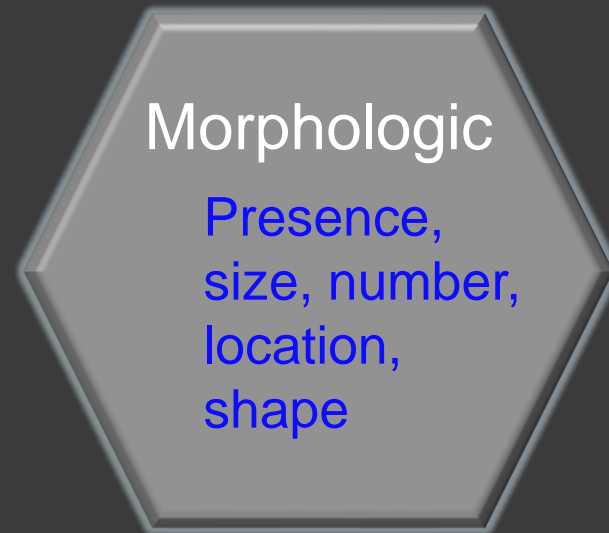
- Molecular imaging
- Functional Imaging

Basis for the rise of radiology in biomedical research



From Academy for Radiology Research

Imaging Biomarkers-- 1965



Imaging biomarker: Any image finding that establishes the presence, location or severity of disease or otherwise characterizes normal and diseased tissues

Imaging Biomarkers-- 2005

Morphologic

Presence,
size, number,
location,
shape, texture

Micro environmental

Vasculature,
perfusion,
diffusion,
Ktrans, pH, O₂
extraction

Functional

Organ function—
EF, CO, GFR, Cell
function,
fMRI,

Metabolic

Glucose,
CMRO₂,
Protein
synthesis

Molecular

Molecular target
localization (MI)
Molecular
content (MRS),
Gene expression

What's left?

**21ST CENTURY:
REINVENTION CONTINUES**

21st Century

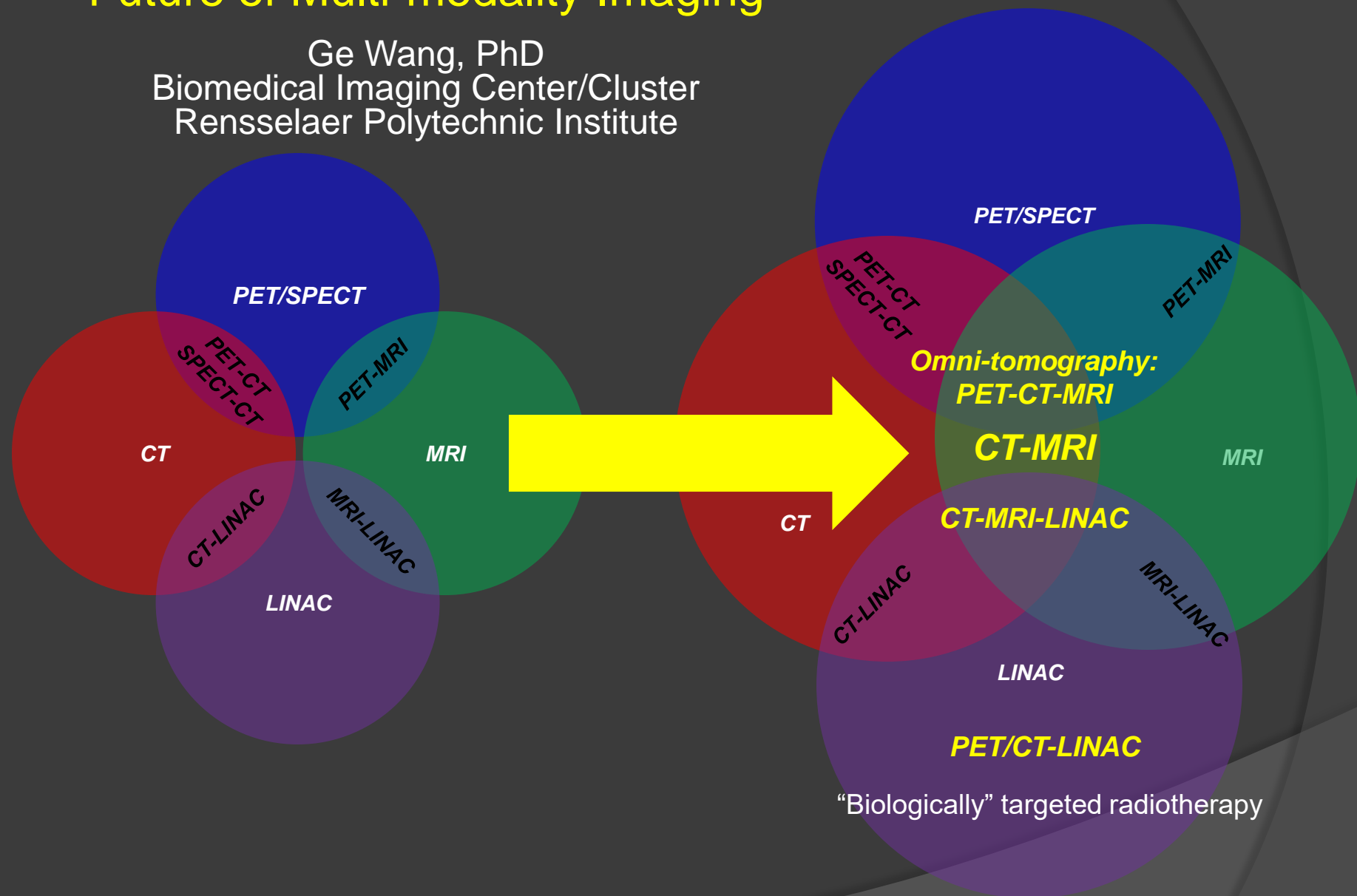
New and Improved Imaging Methods

All Existing Methods Continue To Be Improved

- ⦿ Faster— 5 min head MRI
- ⦿ Lower radiation dose— 1.0 mSv, 2.0 second heart CCTA
- ⦿ Image fusion
- ⦿ Multi-parametric imaging— prostate MRI
- ⦿ High Tech bedside imaging—CT, MRI
- ⦿ “Omni tomography” -- Hybrid imaging
- ⦿ ...

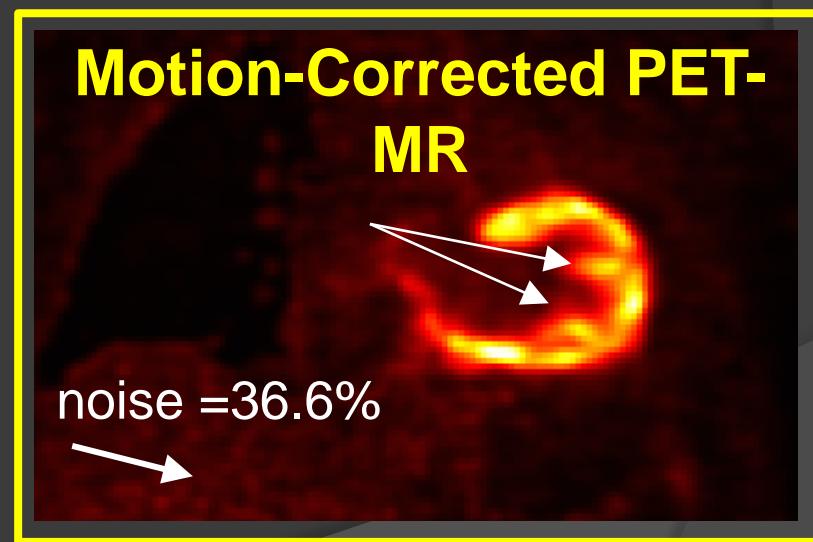
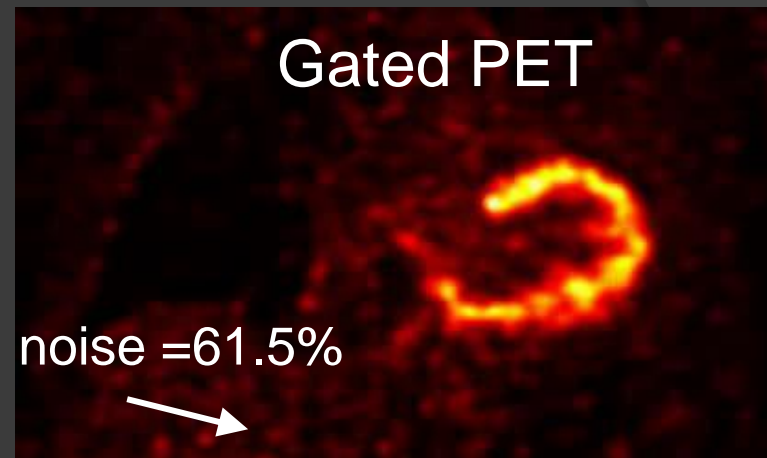
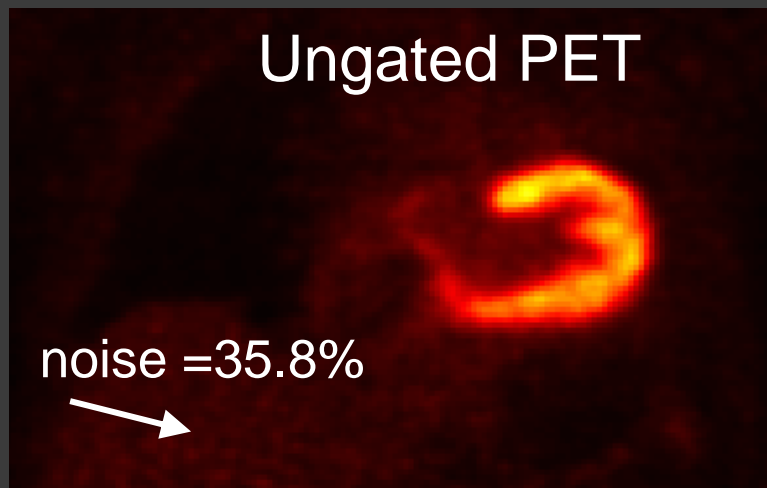
Future of Multi-modality Imaging

Ge Wang, PhD
Biomedical Imaging Center/Cluster
Rensselaer Polytechnic Institute

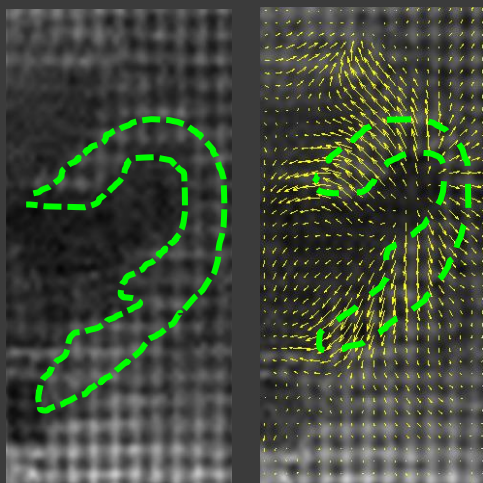


“Omni-tomography”

Impact of Respiratory and Cardiac Motion in PET-MR



Measurement of cardiac motion by MR tagging



**tMR-
End-
diastole**

**tMR-
End-
systole**



Courtesy Dr G. El Fakhri



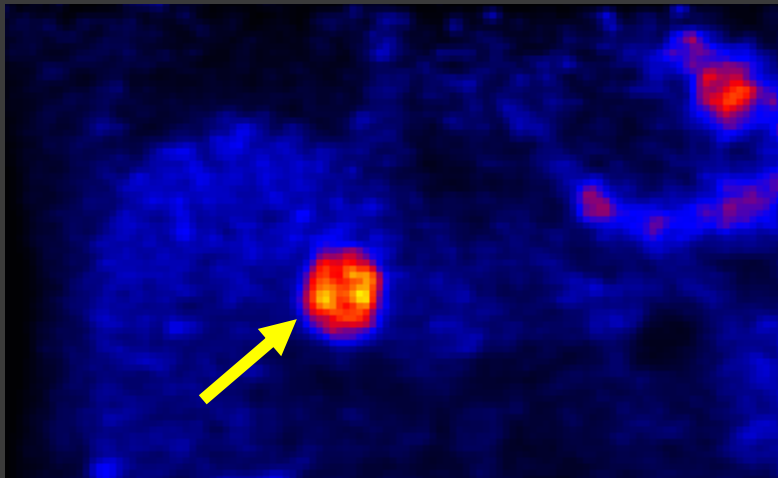
Gordon
Center
Medical
Imaging

Simultaneous PET/MR in hepatic cancer

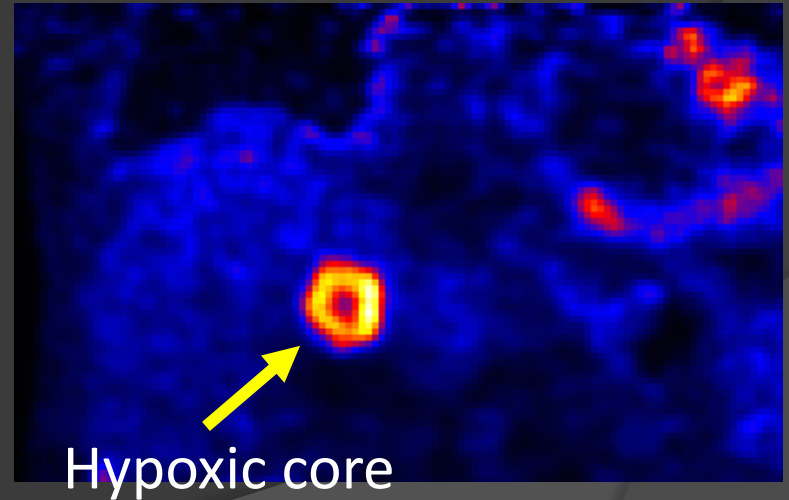
MR (T1w)



PET-CT

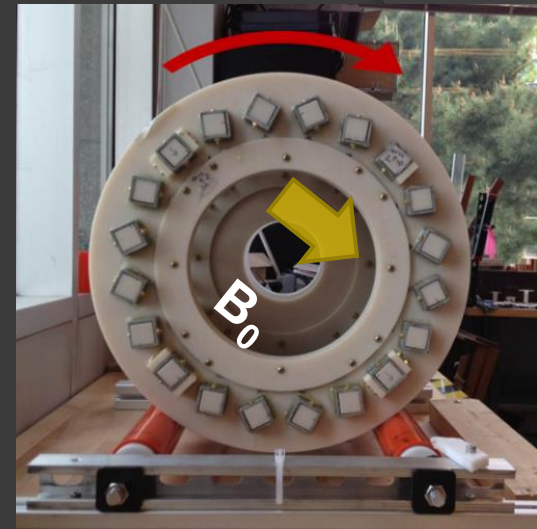


PET-MR
(Motion + PSF correction)

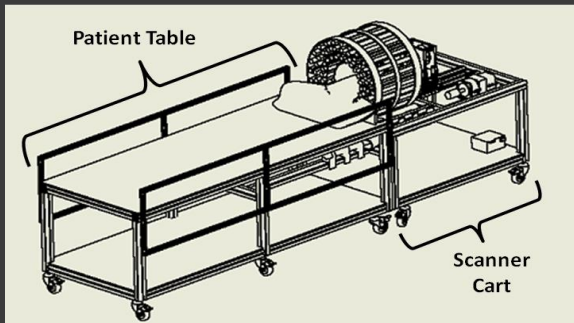


Portable MRI

- Magnet: rotating permanent magnet (Halbach cylinder)
- Low-power: no gradient coils or amplifiers
- Lightweight: < 100 kg
- Safe: low-field magnet (77mT)
- No cooling requirements
- Low-cost: ~\$25,000



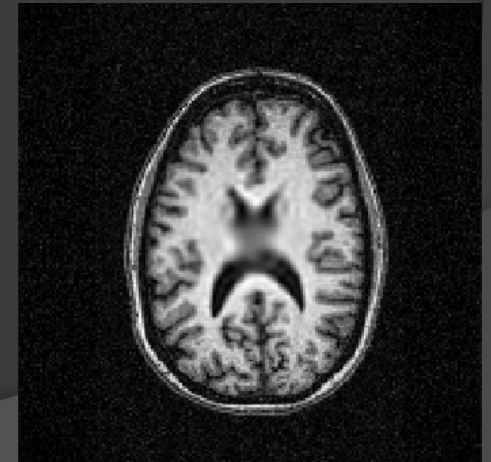
Prototype rotating magnet



Experimental image



Simulation of brain image with prototype magnet



SCALED SIMULATION

Proposed portable MRI scanner

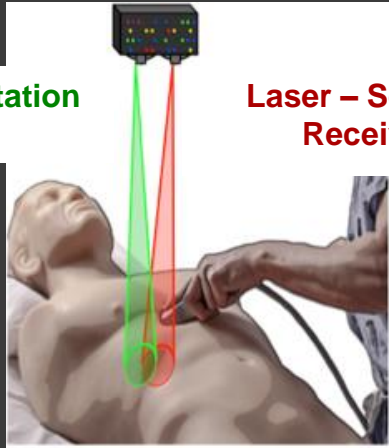
Clarissa Zimmerman Cooley, Jason P. Stockmann, Matthew S Rosen, Lawrence L. Wald, Martinos Center—MGH, MIT, Harvard

Non-Contact Laser-Ultrasound (NCLUS) for Medical Imaging

Optical – Excitation Source

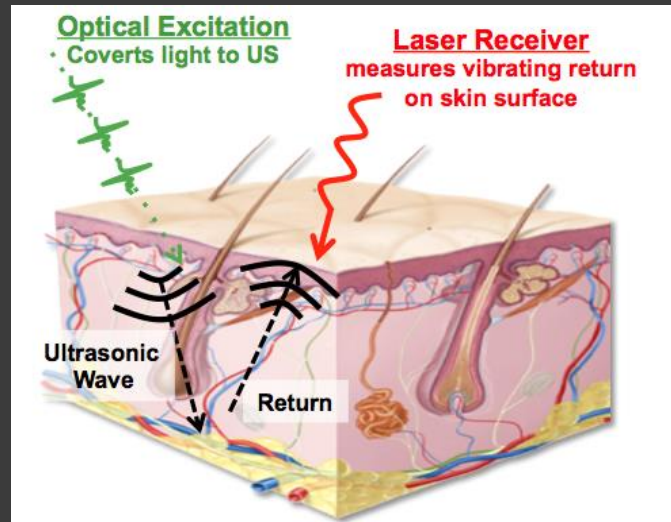
Laser – Sensing Receiver

**Standoff Laser
Ultrasound System
Concept**



NCLUS Advantages

- Operator independent-- mitigates operator variability
- enables higher confidence in change detection
- Requires no gels, skin prep or probe sterilization
- Applicable to healthy or burned skin, traumatized body areas, open surgical regions, others
- Low cost, easily portable
- Imaging capability competitive with MRI and CT



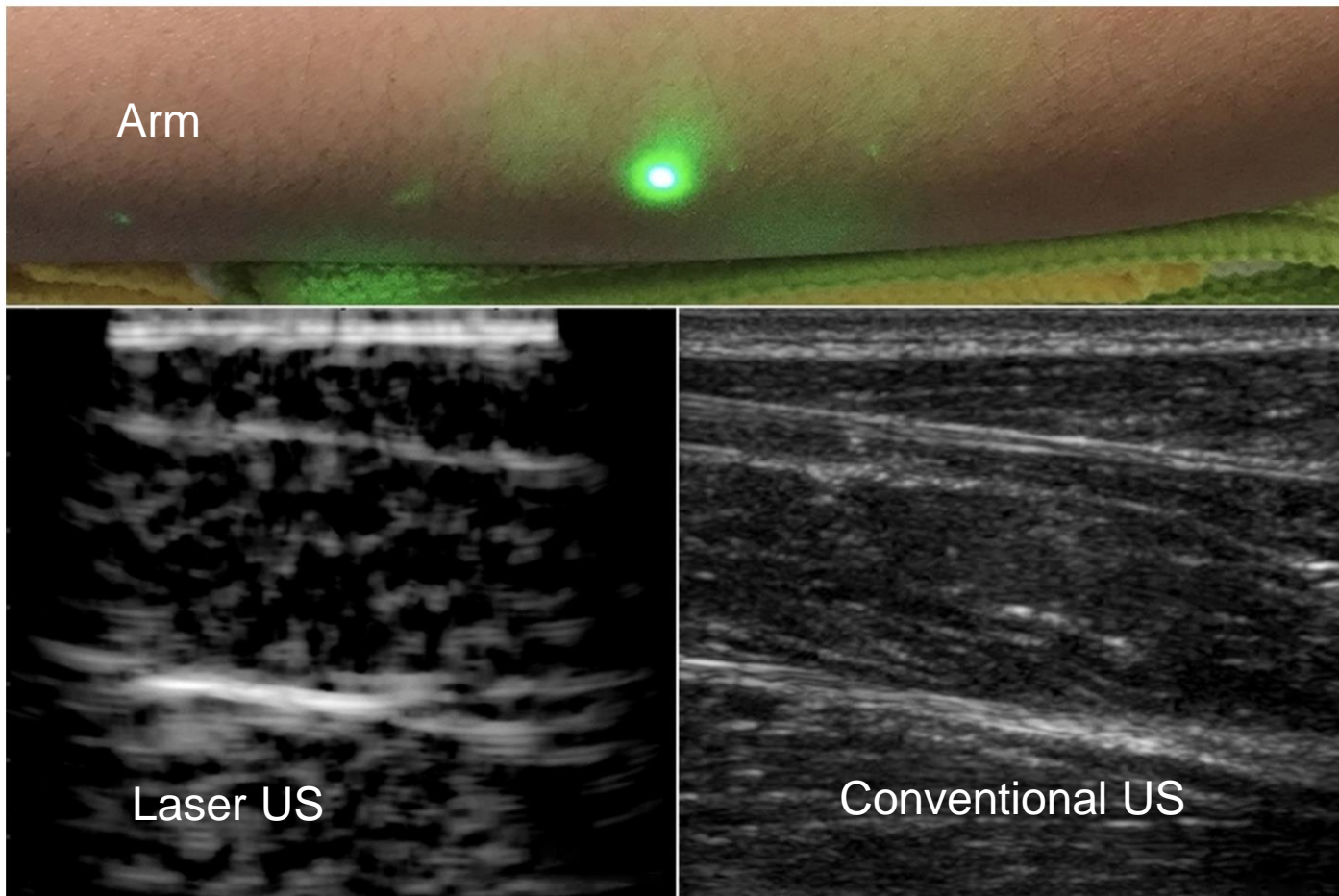
Lincoln Lab, MGH, and MIT developing non-contact optical ultrasound imaging system for portable field forward and in-hospital environments

Researchers produce first laser ultrasound images of humans

Technique may help remotely image and assess health of infants, burn victims, and accident survivors in hard-to-reach places.

Jennifer Chu | MIT News Office

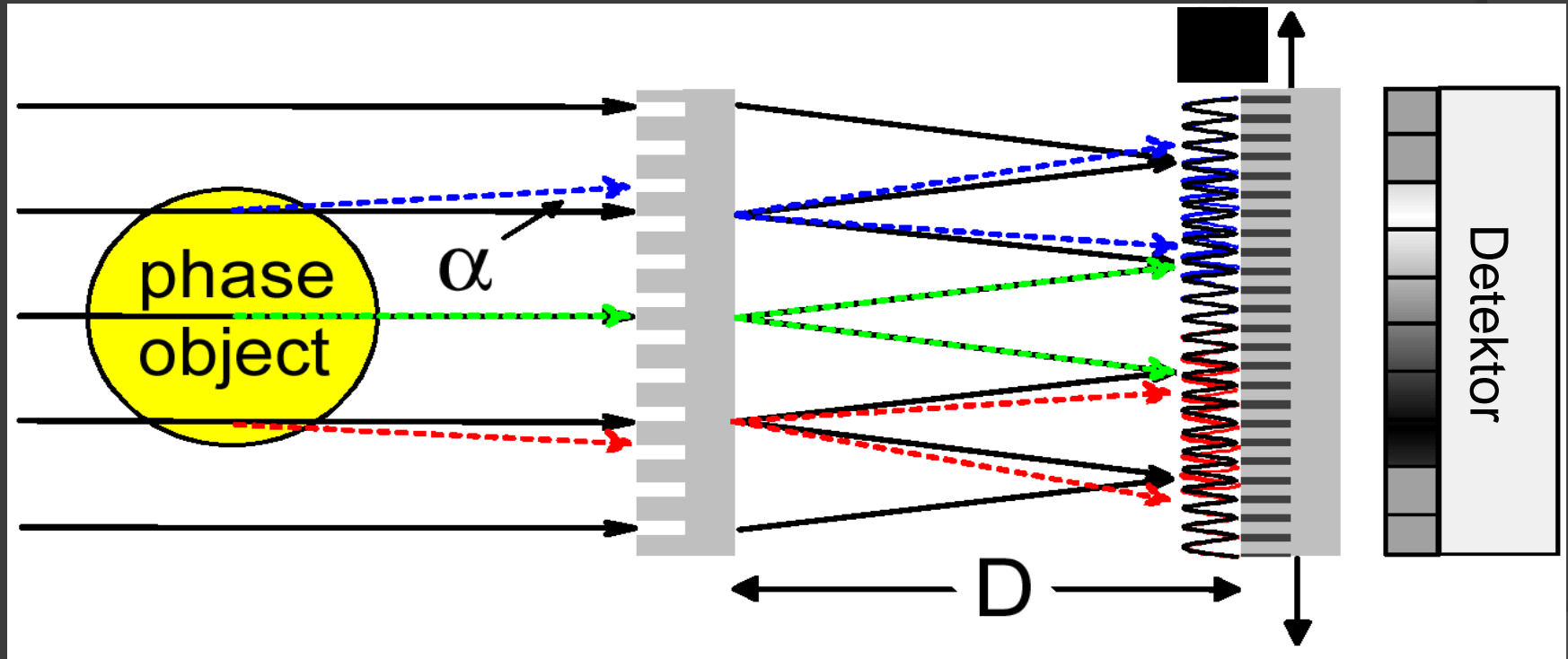
December 19, 2019



Phase-Contrast Imaging: X-Ray Optical Gratings

phase grating

analyzer grating



Momose et al | Optics Express | 2003

Weitkamp et al | Optics Express | 2005

Pfeiffer et al | Physical Review Letters | 2005

X ray Phase Contrast Imaging

Material	μ (cm ⁻¹) at 60keV	Φ (cm ⁻¹) at 60keV	Ratio
H2O	0.2061	195.5	949
dH2O	0.2267	215.1	949
Ethenol	0.1582	156.6	990
Glycerin	0.2477	140.7	568
Fat	0.1793	180.7	1008
Liver	0.2174	205.2	944
Sources:			
ICRP (1975)			~1000:1 contrast advantage for soft tissues
Woodard and White (1986)			

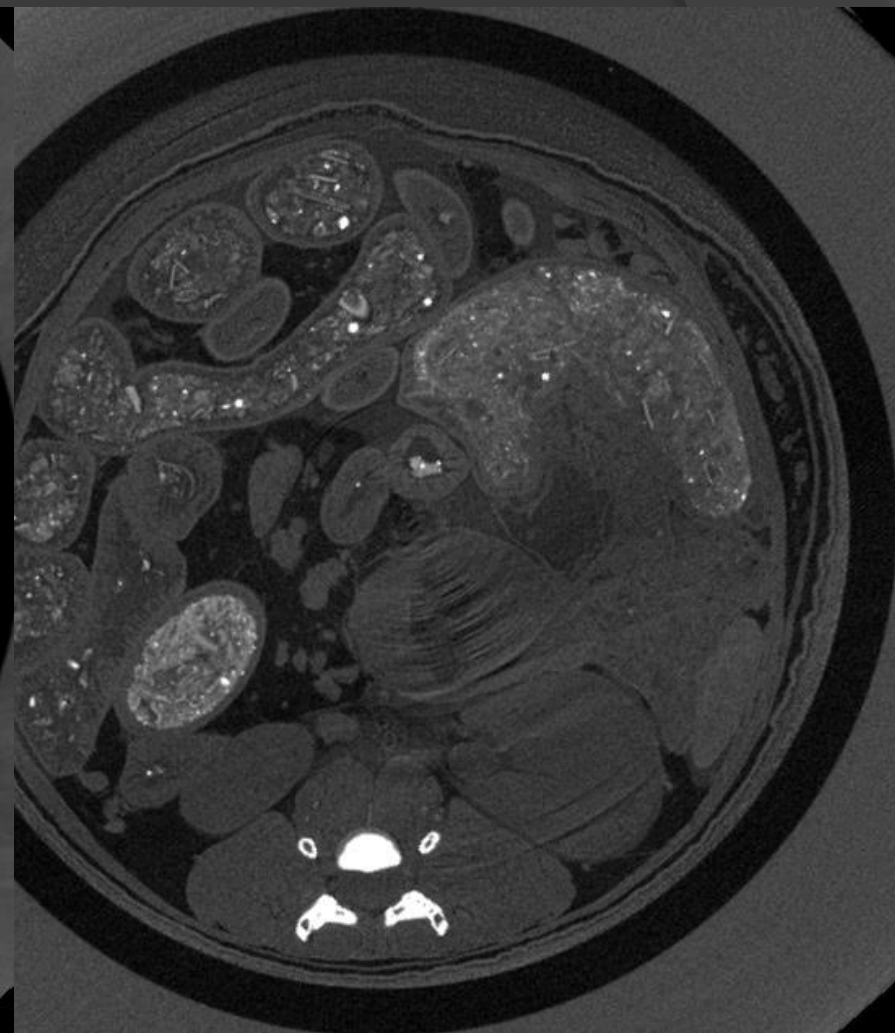
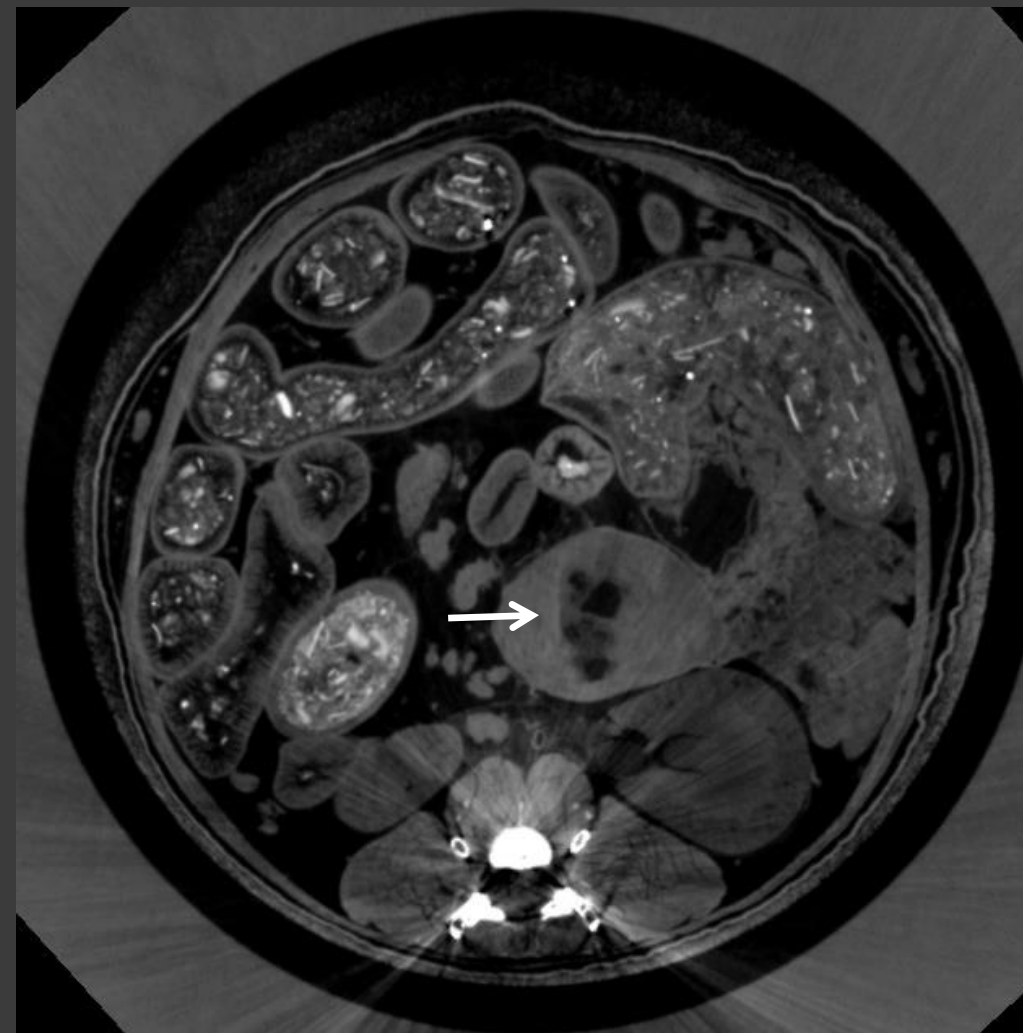
First Phase Contrast Image with MGH/MIT Portable Phase Imaging Device



Images courtesy of R Gupta, MGH

Phase Contrast CT

Absorption CT



21st Century

**New Information
Management Applications**

Decision Support for Radiologist Report Recommendations

Giles W. L. Boland, MD, James H. Thrall, MD, G. Scott Gazelle, MD, MPH, PhD,
Anthony Samir, MD, Daniel I. Rosenthal, MD, Keith J. Dreyer, DO, PhD, Tarik K. Alkasab, MD, PhD

Boland et al., *JACR* 2011. [http://www.jacr.org/article/S1546-1440\(11\)00442-X/fulltext](http://www.jacr.org/article/S1546-1440(11)00442-X/fulltext)

Reduce confusing variation between reports

Develop more evidence-based best practice standards

Improve adherence to them

Integrate Decision Support program seamlessly into radiologists' work process

Management of Incidental Adrenal Masses: A White Paper of the ACR Incidental Findings Committee

EC: Editor's Choice

SA-CME

William W. Mayo-Smith, MD^a, Julie H. Song, MD^b, Giles L. Boland, MD^a, Isaac R. Francis, MD^c, Gary M. Israel, MD^d, Peter J. Mazzaglia, MD^e, Lincoln L. Berland, MD^f, Pari V. Pandharipande, MD, MPH^g

Abstract

The ACR Incidental Findings Committee presents recommendations for managing adrenal masses that are incidentally detected on CT or MRI. These recommendations represent an update to the adrenal component of the *JACR* 2010 white paper on managing incidental findings in the adrenal glands, kidneys, liver, and pancreas. The Adrenal Subcommittee, constituted by abdominal radiologists and an endocrine surgeon, developed this algorithm. The algorithm draws from published evidence coupled with expert subspecialist opinion and was finalized by a process of iterative consensus. Algorithm branches categorize incidental adrenal masses on the basis of patient characteristics and imaging features. For each specified combination, the algorithm concludes with characterization of benignity or indolence (sufficient to discontinue follow-up) and/or a subsequent management recommendation. The algorithm addresses many, but not all, possible pathologies and clinical scenarios. Our goal is to improve the quality of patient care by providing guidance on how to manage incidentally detected adrenal masses.

Key Words: Adrenal nodule, incidental findings, incidentaloma

J Am Coll Radiol 2017;14:1038-1044. Copyright © 2017 American College of Radiology

How Decision Support for Radiologist Recommendations Works

Adrenal Nodule Algorithm

Radiologist sees incidental adrenal nodule at CT and enters pre-specified features (size, density, location, history)



Evidence based algorithm automatically generates a narrative report and recommendations



Benign, no follow-up



Suspicious for cancer

Nuance PowerScribe 360

File Edit View Insert Format Tools Speech Help

Save Close Wet Read Draft Correct Reject Prelim Sign Normal Discard

Fields (16)

Report

Indication
Comparison
Thorax
Liver
Spleen
Pancreas
Adrenals
Kidneys
Pelvic organs
Peritoneum
Lymph nodes
Vessels
GI tract
Bones
IMPRESSION
RECOMMENDATION

TECHNIQUE:
CT of the abdomen and pelvis WITH intravenous contrast.

Scans were continued into the pelvis to evaluate

COMPARISON: None available.

FINDINGS:
LOWER THORAX: Normal.

HEPATOBILIARY: No focal hepatic lesions. No biliary ductal dilatation.
SPLEEN: No splenomegaly.
PANCREAS: No focal masses or ductal dilatation.

ADRENALS: No adrenal nodules.
KIDNEYS/URETERS: No hydronephrosis, stones, or solid mass lesions.
PELVIC ORGANS/BLADDER: Unremarkable.

PERITONEUM / RETROPERITONEUM: No free air or fluid.
LYMPH NODES: No lymphadenopathy.
VESSELS: Unremarkable.

GI TRACT: No distention or wall thickening.

BONES AND SOFT TISSUES: Unremarkable.

IMPRESSION:

Enter Findings Mode

Properties

Fields (16)

Notes

Attachments

Auto Text

Name	Used
3D	7/2/2013 10:57 AM
Adrenal Adenoma	
Adrenal Indeterminate	
ATTENDING	
BONE CT ABL	
BONE CT Ankle W1	
BONE CT Ankle WO	
BONE CT Ankle WWO	
BONE CT ARM W	
BONE CT ARM WO	
BONE CT ARM WWO	
BONE CT Bopsy	
BONE CT Cervical W	

Prior Reports Auto Text Auto Feed

User: Dr. Stuart R. Pomerantz Drafts: 1

Structured report

Ditsel

Patient: [REDACTED]

Exam: CTABPW (16702411)

Completed: 2013-11-13T19:48:00

Pulmonary Nodule Adrenal Nodule

Adrenal Nodule

Size mm Se/lm

Side Right Left

Previously characterized ▼

Diagnostic feature ▼

Hx malignancy Yes No Unknown

Changed size ▼

Insert into Report Close without Inserting

Adrenal nodule specific template

Ditsel

Patient: 4743413 88F
Exam: CTABPW (16702411)
Completed: 2013-11-13T19:48:00

Pulmonary Nodule Adrenal Nodule

Adrenal Nodule 18 mm, Hypodense, Larger

Size mm Se/Im

Side Right Left

Previously characterized ▼

Diagnostic feature ▼

Changed size ▼

Body
In the adrenal gland (series 3, image 4), the previously seen 18 mm lesion is homogeneously low density (10 HU or less on non-contrast-enhanced images) and therefore most consistent with an adenoma.

Impression
18 mm nodule in the adrenal gland. Radiologic findings are most consistent with a benign adrenal adenoma.

Recommendation
As adrenal adenomas may be hormonally active with subclinical features, NIH guidelines suggest further evaluation for endocrine hyperfunction for most patients. Cf. Grumbach MM et al. (2003) "Management of the clinically inapparent adrenal mass ('incidentaloma')," Ann Int Med 138:424-429 and Young, W. (2007) "The incidentally discovered adrenal mass," New Engl J Med 356:601-610.

Insert into Report Close without Inserting

Characterizable Lesion

- Findings
- Impression
- Evidence-Based Clinical Recommendation

Body

In the adrenal gland (series 3, image 4) the previously seen right 18 mm lesion is homogeneously low density (10 HU or less on non-contrast enhanced images) and therefore most consistent with an adenoma.

Impression

18 mm nodule in the adrenal gland. Radiologic findings are most consistent with adrenal adenoma.

Recommendation

As adrenal adenomas may be hormonally active with subclinical features, NIH guidelines suggest further evaluation for endocrine hyperfunction for most patients. Cf. Gumbach MM et al. (2003) "Management of the clinically inapparent adrenal mass ("incidentaloma"). *Ann Int Med* 138: 424-429 and Young W (2007) "The incidentally discovered adrenal mass." *New Engl J Med* 356: 601-610

Nuance PowerScribe 360 Dictate Dictate Next SEND TO PACS: Queue Selected Current Comparison Findings-Seen-On IFAs PAGE: Referring Any CareTeam Auto-LMR QPID EDIS Page...

File Edit View Insert Format Tools Speech Help

Save Close Wet Read Draft Correct Reject Prelim Sign Normal Discard

Fields (16) Report - HOLMAN, GRACE - 16702411

Indication
Comparison
Thorax
Liver
Spleen
Pancreas
Adrenals
Kidneys
Pelvic organs
Peritoneum
Lymph nodes
Vessels
GI tract
Bones
IMPRESSION
RECOMMENDATION

TECHNIQUE:
CT of the abdomen and pelvis WITH intravenous contrast.

Scans were continued into the pelvis to evaluate ...

COMPARISON: None available.

FINDINGS:
LOWER THORAX: Normal

PANCREAS: No focal masses or ductal dilatation.

ADRENALS:
In the adrenal gland (series 3, image 4), the previously seen 18 mm lesion is homogeneously low density (10 HU or less on non-contrast-enhanced images) and therefore most consistent with an adenoma.

KIDNEYS/URETERS: No hydronephrosis, stones, or solid mass lesions.
PELVIC ORGANS/BLADDER: Unremarkable.

PERITONEUM / RETROPERITONEUM: No free air or fluid.
LYMPH NODES: No lymphadenopathy.
VESSELS: Unremarkable.

GI TRACT: No distention or wall thickening.

BONES AND SOFT TISSUES: Unremarkable.

IMPRESSION:
18 mm nodule in the adrenal gland. Radiologic findings are most consistent with a benign adrenal adenoma.

RECOMMENDATION:
As adrenal adenomas may be hormonally active with subclinical features, NIH guidelines suggest further evaluation for endocrine hyperfunction for most patients. Cf. Grumbach MM et al. (2003) "Management of the clinically inapparent adrenal mass ('incidentaloma')." Ann Int Med 138:424-429 and Young, W. (2007) "The incidentally discovered adrenal mass," New Engl J Med 356:601-610.

Enter Findings Mode

Properties
Fields (16)
Notes
Attachments

Key stroke entry of text into structured report

Simultaneous Multi-Field Inserts

- Findings Field (nodule-specific subfield)
- Impression
- Recommendation

21st Century

Integrating the IT Forest

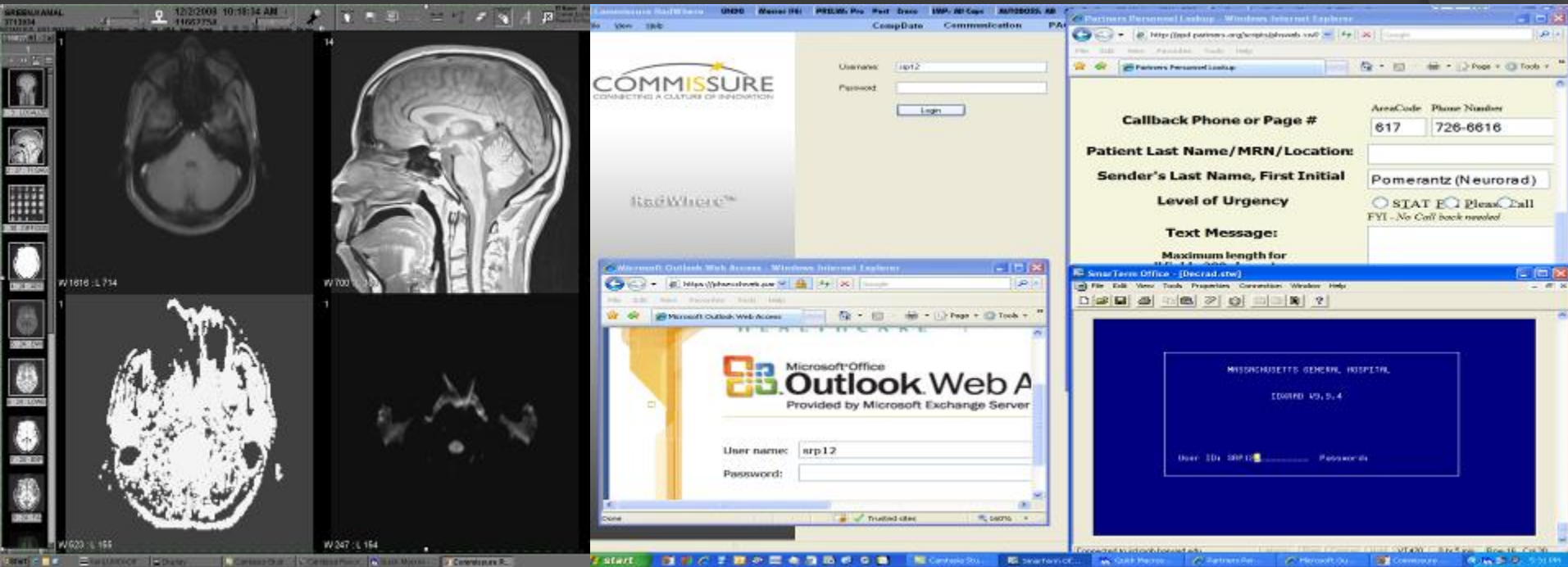
The Radiologist's Ergonomic Nightmare

Interpretation often navigated through 2 keyboards, 2 mice, 3-4 monitors, and a hand-held microphone



The Technology Integration Challenge:

Efficiency is degraded by the **isolated** manner in which the numerous imaging and informatics applications currently operate

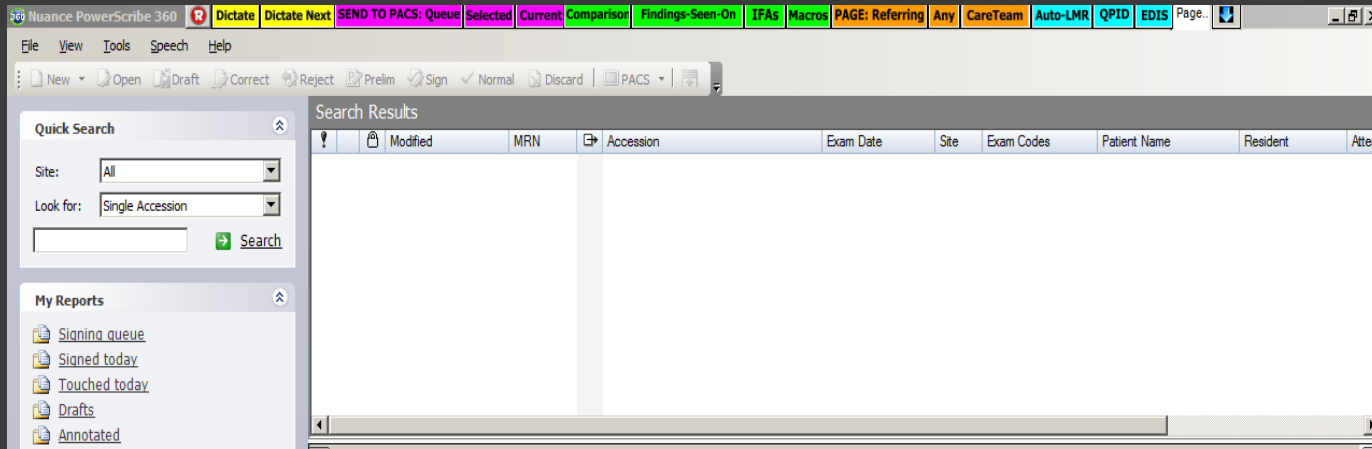


Radiologists and other clinicians experience **physical and mental fatigue, waste time and make errors** -- continual re-entry of the same patient information into separate PACS, RIS, EMR, Dictation/Voice Recognition, Email, Paging, Teaching File, and Research Database applications

RADFUSION: Context-sensitive IT and Work Process Integration

- **INTEGRATION**: meshwork of customized flexible conduits for automated information exchange between all informatics applications
- **CONTEXT-SENSITIVE**:
 - Radiologist- name, section, role (staff, trainee), phone number
 - Location – reading room, station, phone number
 - Patient – name, MRN, location, care team, allergies, meds, other EHR data
 - Study – exam type, date, modality, side, comparison studies
 - Referring physician– phone number, pager number, location
- **SEAMLESS**
 - Mediated either by a common interface (RadFusion Toolbar) OR
 - Appearing organic to the native applications
- **Author: Stewart Pomerantz, MGH Radiology**

RadFusion Toolbar Functions



- RadFusion Integration into Radiology Workflow
- RadFusion Toolbar “hung” on Nuance PowerScribe 360 Dictation application

Dictate

Worklist Transfer

Report Inserts

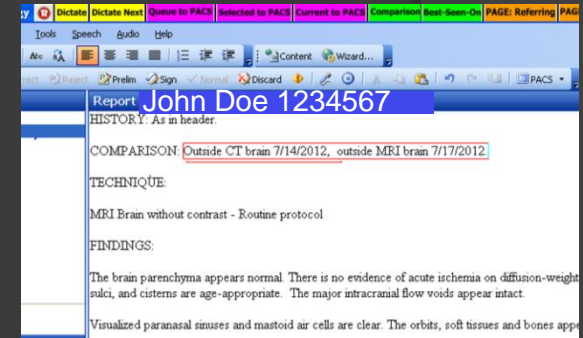
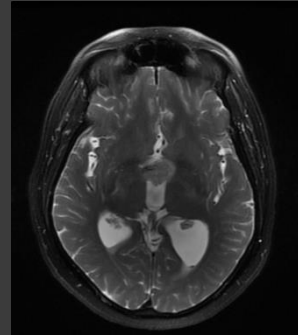
AutoPaging

Patient Refs

- Loads report to dictate for current case in PACS
- Transfers work list in Nuance to PACS
- Insert contextual text (e.g. Comparison study Date) into report
- Pages referring clinician with Critical Findings Alert
- LMR/QPID view for patient of study being dictated

1-Click Contextual Paging

- Extract context from current study
 - PACS or Open dictation report
- Page Appropriate Physician
 - Referring Clinician (outpatient)
 - Responding House Officer (EW or inpatient)
- Transmit both Radiologist and Patient Context
 - Who is Calling? - Radiologist Name/Service
 - Where? – Phone #
 - Calling About
 - Patient Name
 - MRN
 - Study Name & Date & Time



Callback Phone or Page #	AreaCode	Phone Number
	617	726-6616
Patient Last Name/MRN/Location:	John Doe 1234567	
Sender's Last Name, First Initial	Pomerantz (NeuroRad)	
Level of Urgency	<input type="radio"/> STAT <input type="radio"/> FYI <input checked="" type="radio"/> Please Call FYI - No Call back needed	
Text Message:	IMPORTANT RADIOLOGY FINDINGS re:John Doe 1234567 MRIBrainWo 8/31/2012 5:18 PM. Please call - Pomerantz (NeuroRad)	
Maximum length for all fields: 200 characters		
<input type="button" value="Send Page"/>	<input type="button" value="Cancel"/>	

Example: 1-Click Contextual Critical Results Paging

- Extract context from current study
 - PACS or Open dictation report
- Page Appropriate Physician
 - Referring Clinician (outpatient)
 - Responding House Officer (EW inpatient)
- Auto-insert Radiologist and Context
 - Who is Calling? - Radiologist Name/Service
 - Where? – Phone #
 - Calling About
 - Patient Name
 - MRN
 - Study Name & Date & Time
- Insert documentation into report automatically

The screenshot displays a medical reporting software interface. On the left, there is a small window showing a CT scan of the chest. The main window shows a dictation report for 'John Doe' with the following text:

Report John Doe 1234567
HISTORY: As in header.
COMPARISON: Outside CT brain 7/14/2012, outside MRI brain 7/17/2012.
TECHNIQUE:
MRI Brain without contrast - Routine protocol

The interface includes a menu bar with options like 'Dictate', 'Dictate Next', 'SEND TO PACS: Queue', 'Selected', 'Current', 'Comparison', 'Findings-Seen-On', 'IFAs', 'PAGE: Referring', 'Any', 'CareTeam', 'Auto-LMR', 'QPID', 'EDIS', and 'Page...'. Below the menu bar, there is a toolbar with icons for 'Save', 'Close', 'Wet Read', 'Draft', 'Correct', 'Reject', 'Prelim', 'Sign', 'Normal', and 'Discard'. The main text area contains the following report content:

Fields (11) | Report - John Doe
Protocol
COMPARISON
Lines
Lungs
Pleura
Heart
Soft tissues
Abdomen
Bones
IMPRESSION
RECOMMENDATION

CT scan of the chest WITH intravenous contrast, using standard protocol.

COMPARISON: None

FINDINGS:
Lines/tubes: None.

IMPRESSION:
RECOMMENDATION

Lungs and Airways: The lungs and airways are normal with no focal abnormality demonstrated.

Pleura: THERE IS A LARGE RIGHT PNEUMOTHORAX.

Heart and mediastinum: The thyroid gland is normal. No significant mediastinal, hilar or axillary lymphadenopathy is seen. The heart and pericardium are within normal limits.

Soft tissues: Normal.

Abdomen: Limited contrast-enhanced views of the upper abdomen show no abnormality within the visualized liver, spleen, pancreas, or kidneys. The adrenal glands are normal.

Bones: The visualized bony thorax is within normal limits.

IMPRESSION:
LARGE RIGHT PNEUMOTHORAX

The critical findings in this report were reported to the responding clinician, Nino Mihatov, M.D., who responded indicating that the communication was understood. Contact was made at the time of interpretation on Wed, Nov 20 2013 at 7:02 PM, within 5 minutes of observation.

QUERY: WHY WAS STUDY ORDERED

EMR search:
Why was an **MRI** of
the **cervical spine**
ordered?

Search terms
highlighted in text in
EMR

Suspected
syringomyelia
quickly determined
as reason for scan

The screenshot shows the RadFusion EMR interface. The browser address bar displays `http://qpuid/portal/?app=`. The main content area is titled "QPID EMR" and includes a search bar for MRN/Name and a "Go" button. Below the search bar, there are two columns of search results. The left column lists dates, departments, and codes, while the right column lists search terms. The right column includes terms like "LMR Medications", "Allergy List", "PAML Medication", "LMR Problem List", "OnCall Medication", "MGH OE Meds", "EMPI Demograp", "LMR Health Maint", "BLOOD", "UNSCHEMULED", "MICRO SEND OL", and "BLD UR". A red box highlights the search results area. The main text area displays the "HISTORY OF PRESENT ILLNESS" for a patient. The text describes the patient's medical history, including scoliosis, a footdrop, and an MRI study of the head and cervical spine. A red circle highlights the phrase "I wonder if anything serious is wrong" in the text. The interface also includes a "General Qpid" sidebar with a "Why Study Ordered" section and a "Web Searches" section with various search engines.

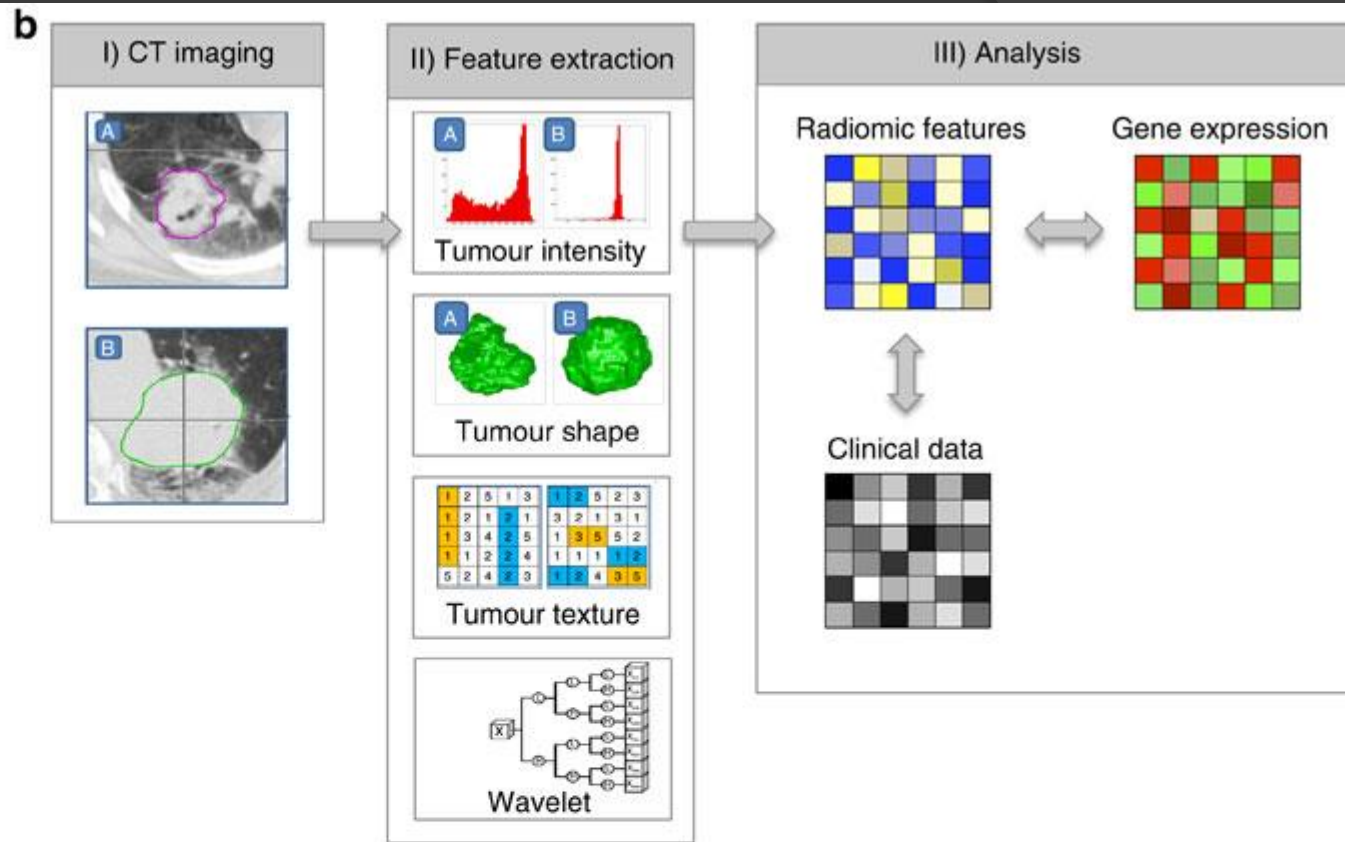
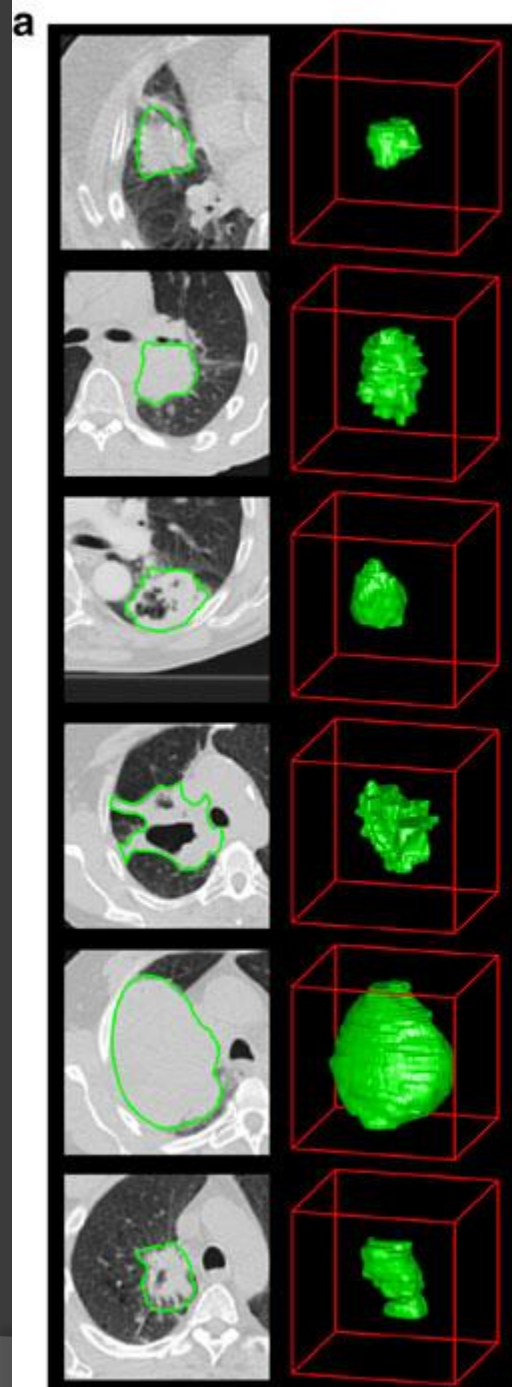
21st Century

Advanced Analytics

- ① Artificial Intelligence (AI) and Deep Learning (DL)
- ① Radiomics

Radiomics

- ⦿ Mathematical interrogation of image data versus visual inspection
- ⦿ Creation of mathematical “Phenotypes”
- ⦿ Value comes from linking Radiomic patterns (Phenotypes) to diagnoses and prognoses in large populations of patients



Aerts et al. Decoding tumor phenotype by non invasive imaging using a quantitative radiomics approach. Nature Communications 5, #4006, 3 June 2014]

- 440 features– intensity, shape, texture, intra-tumoral heterogeneity

> [Radiology](#). 2016 Feb;278(2):563-77. doi: 10.1148/radiol.2015151169. Epub 2015 Nov 18.

Radiomics: Images Are More than Pictures, They Are Data

[Robert J Gillies](#)¹, [Paul E Kinahan](#)¹, [Hedvig Hricak](#)¹

Review > [Nat Rev Clin Oncol](#). 2017 Dec;14(12):749-762. doi: 10.1038/nrclinonc.2017.141.

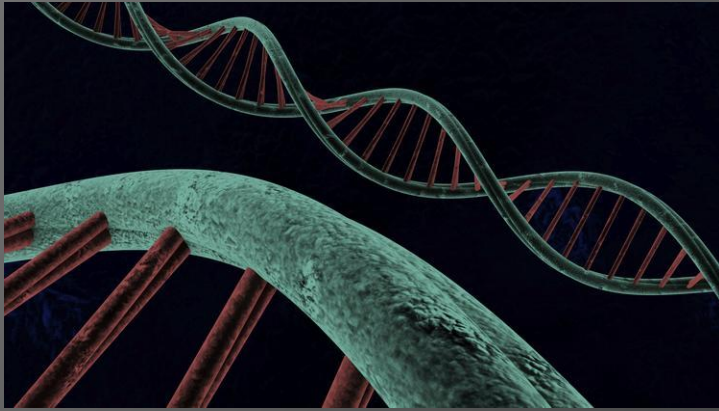
Epub 2017 Oct 4.

Radiomics: the bridge between medical imaging and personalized medicine

Review > [Technol Cancer Res Treat](#). 2018 Jan 1;17:1533033818782788.

doi: 10.1177/1533033818782788.

Radiomics for Response and Outcome Assessment for Non-Small Cell Lung Cancer



21st Century

Precision Medicine



Toward Precision Medicine: Building a Knowledge Network and A new Taxonomy of Disease

National Research Council of the National Academies, White Paper, 2011

“Classification of patients into subpopulations that differ in their susceptibility to a particular disease, in the biology and/or prognosis of those diseases, or in response to a specific treatment”

Subpopulations defined by **genotype** and **phenotype**

Imaging and Precision Medicine:

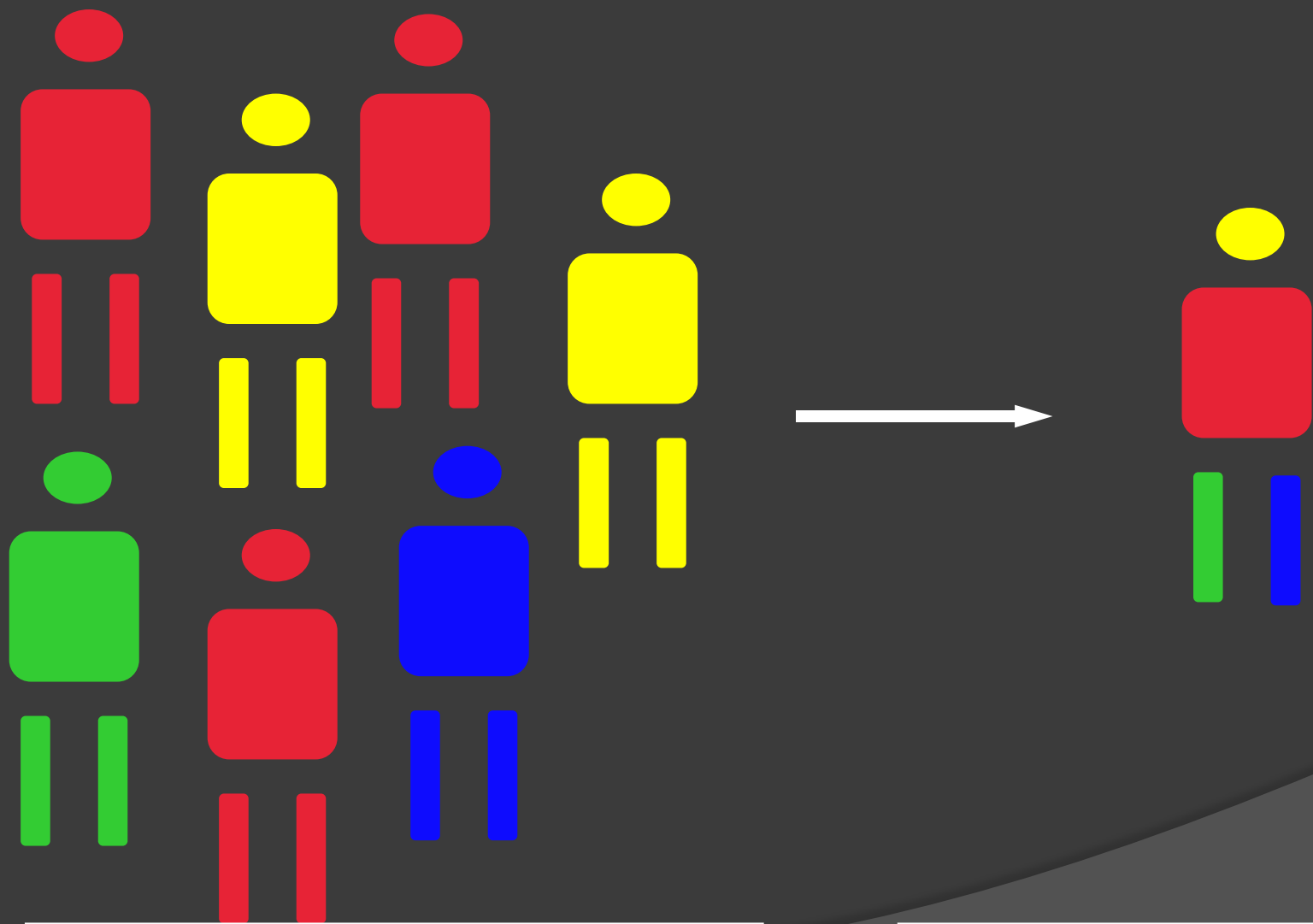
Phenotype: Observable manifestations of disease—clinical course, physical exam, labs, pathology, imaging

Imaging Phenotype: Sum total of the manifestations of a disease or condition demonstrable by imaging

ICD 10 and ICD 11: define ~ 99% of diseases based on phenotype even when genotype is known

Medical imaging and the practice of radiology are fundamentally exercises in determining disease phenotype

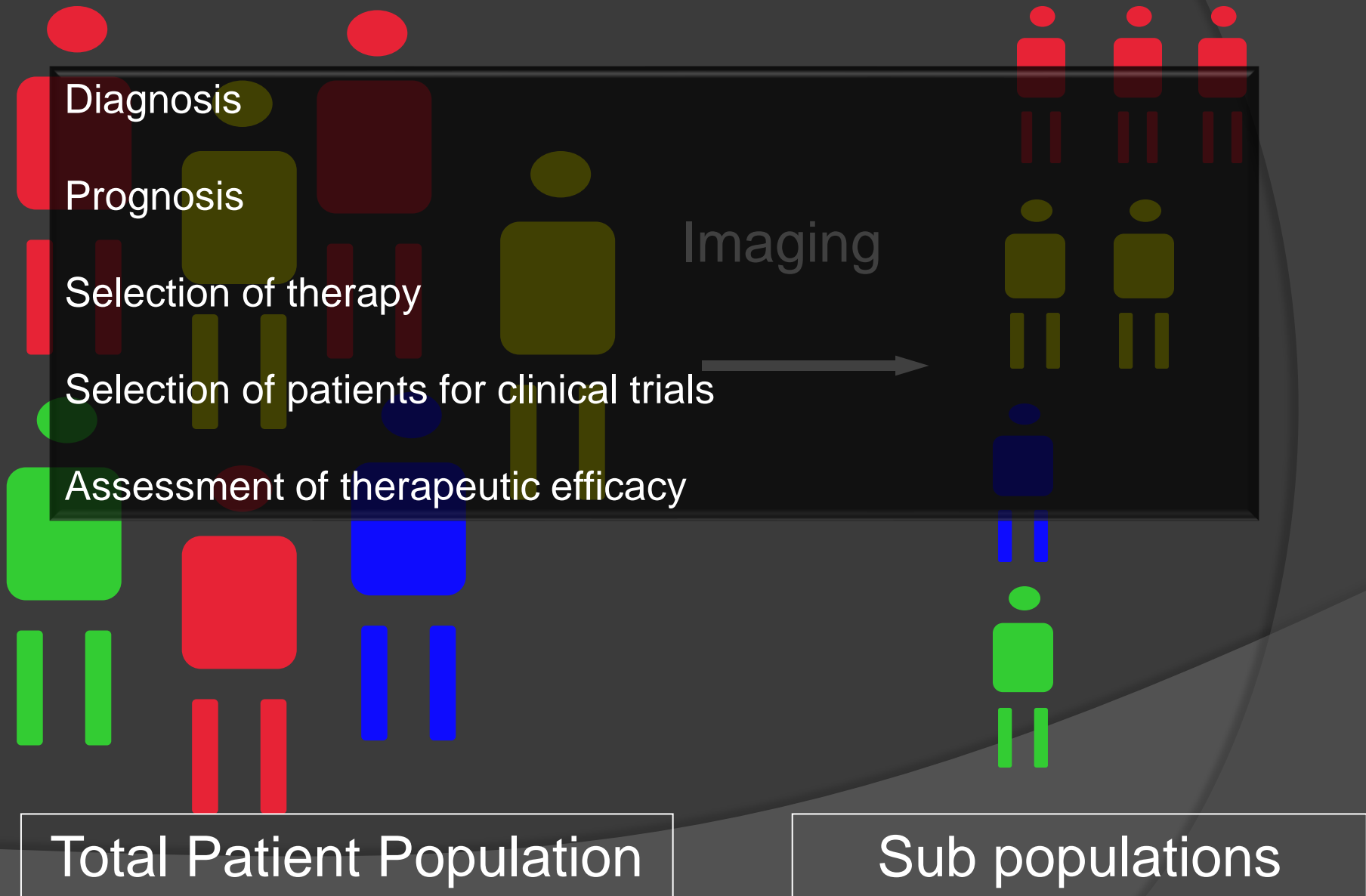
The Importance of adequate (sub) phenotype designation



Total Patient Population

“Average” Patient

The Importance of adequate (sub) phenotype designation



Neurofibromatosis 1

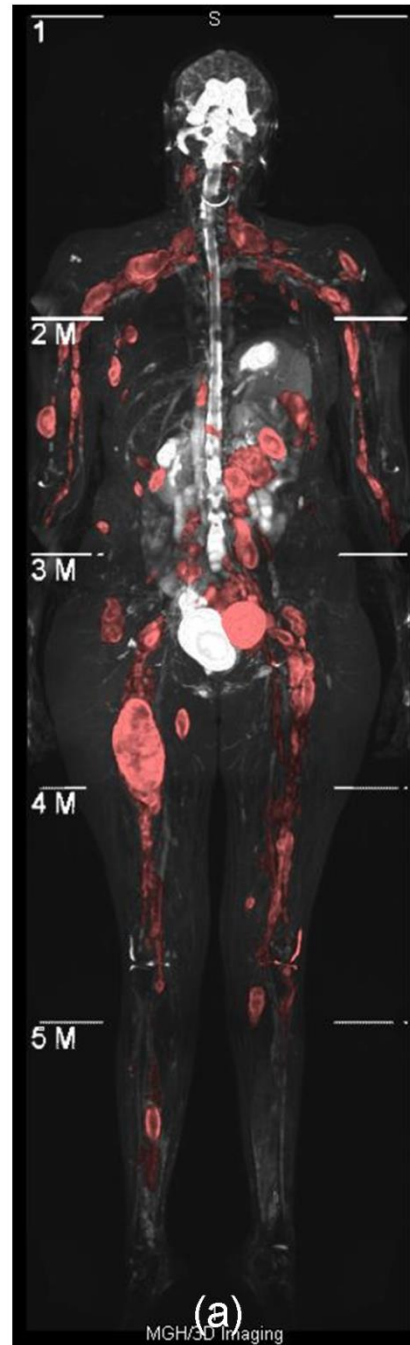
Genotype is known—
but what is the
expression of the
condition—i.e. the
phenotype?

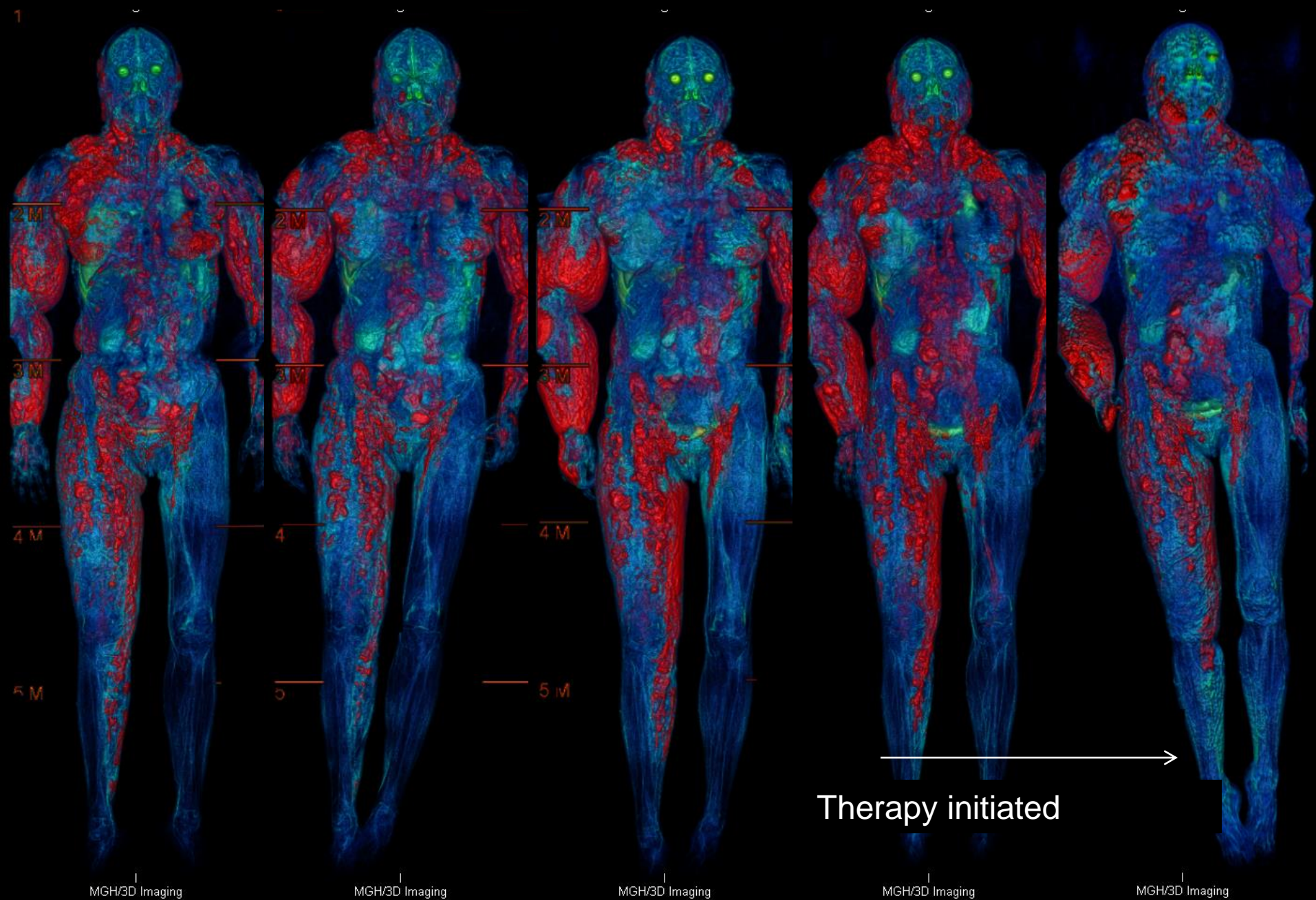
Imaging used for
surveillance of disease
manifestations:

- Presence
- Location
- Severity

Whole body MRI with image
segmentation

Courtesy of WL Cai, MGH





Therapy initiated

MGH/3D Imaging

MGH/3D Imaging

MGH/3D Imaging

MGH/3D Imaging

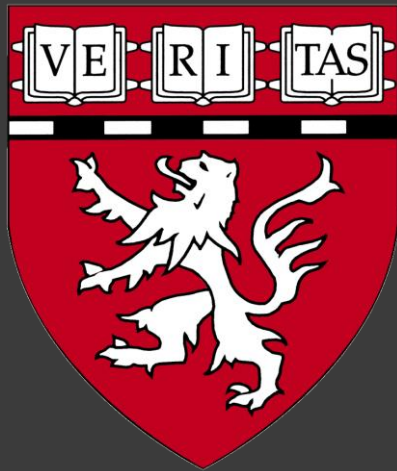
MGH/3D Imaging

Courtesy of WL Cai, MGH

The Future

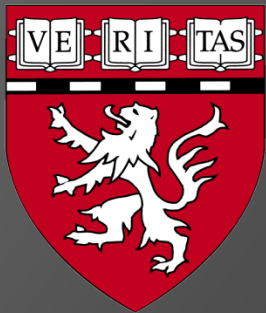
- ① Innovations in medical imaging will continue relentlessly in all aspects
- ① The pace of change is unlikely to slow down so enjoy the “slow” pace of change today

- ◎ But... our goals and commitments will not change:
 - Ever better more effective care and outcomes for our patients—live better longer
 - Better value for society
 - Higher career fulfillment and satisfaction for radiologists and other care givers



“REINVENTING RADIOLOGY IN THE TWENTY-FIRST CENTURY”

Michigan Radiological Society: Centennial Gala and
Education Event
October 23, 2021



James H Thrall MD
Chairman Emeritus
Department of Radiology
Massachusetts General Hospital
Distinguished Juan M Taveras Professor of Radiology
Harvard Medical School

