Radiologist's Digital Workspot

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Radiology Workspot Requirements

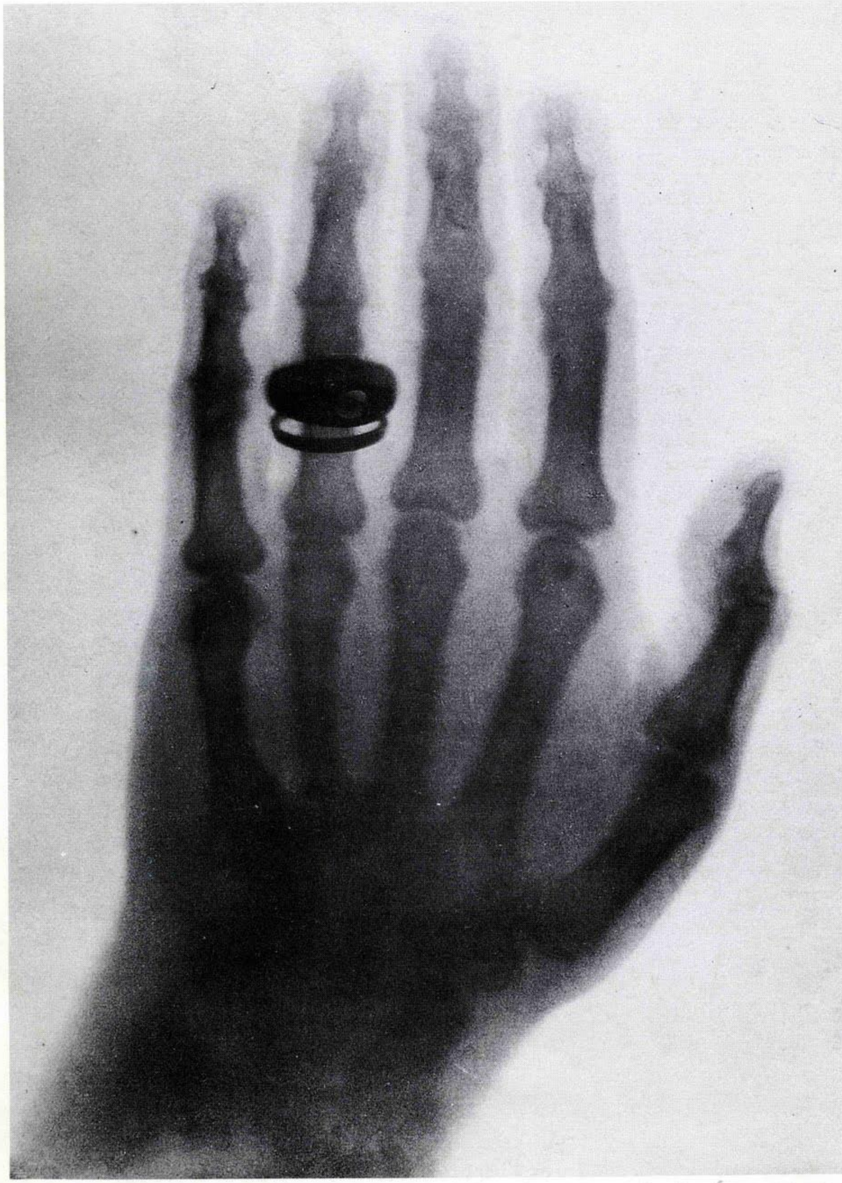
- Visualization
- Information
- Decision Support

Radiology Workspot Requirements

- Visualization
- Information
- Decision Support

Medical Imaging Objectives

- Extract info from within living organisms
- Provide spatially discrete mapping
- Image as a surrogate record of morphology & physiology
- Guidance for Procedures



#23,958 (© 1993)

X Rays

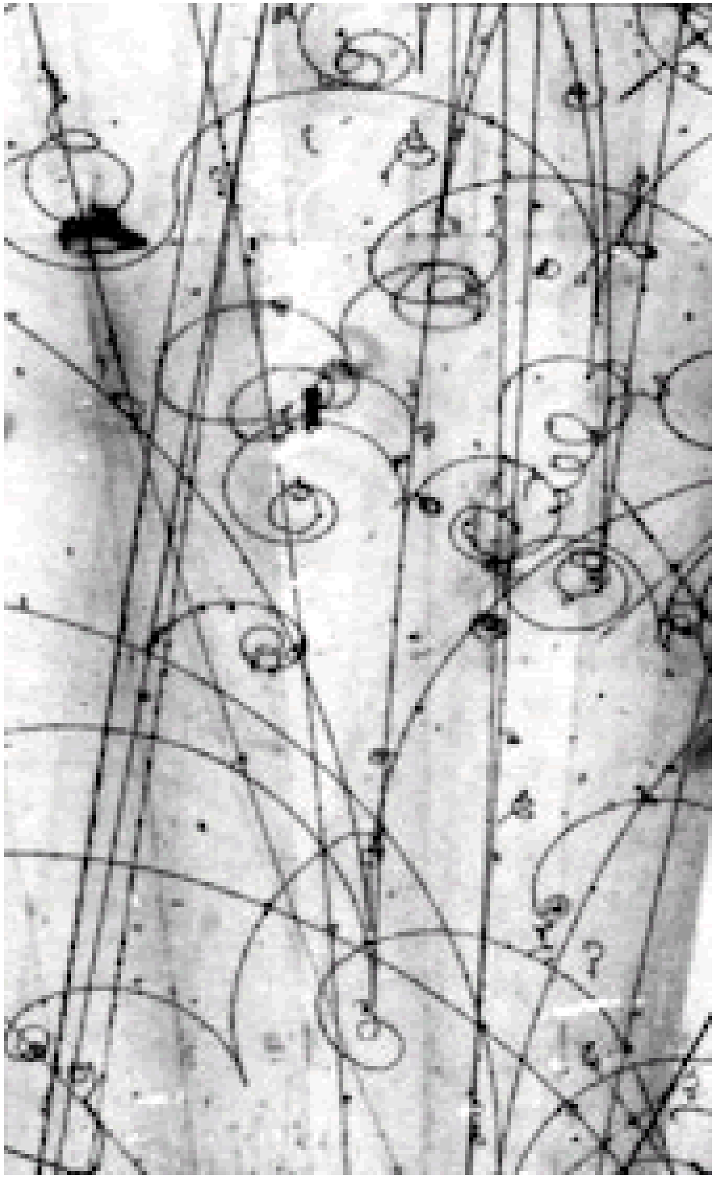
“Radiology is the only medical specialty created by technology”

Bob Moliter
SCAR News, April 1995

Physics Asks…

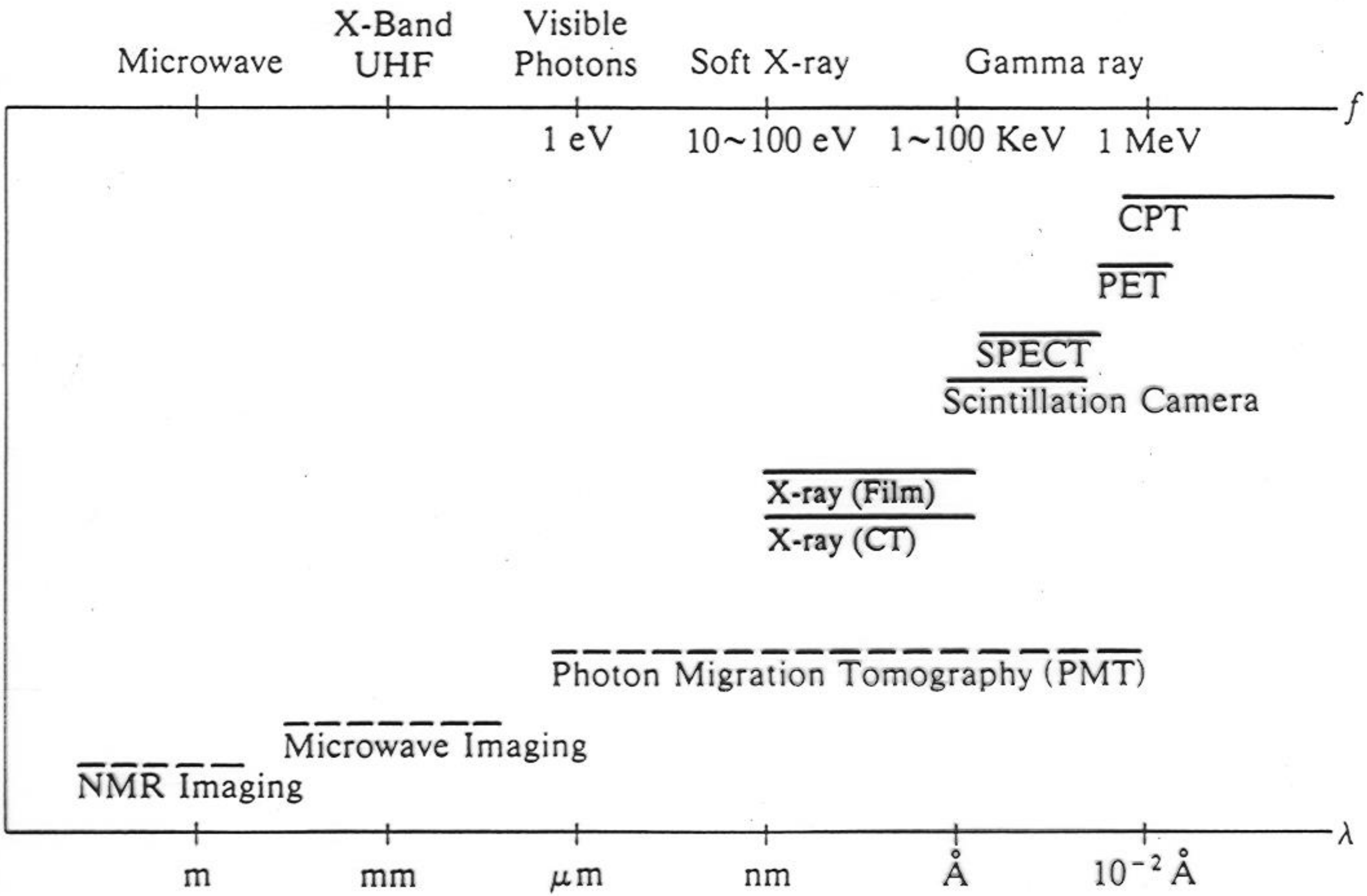
How do matter and energy interact

- Do nothing at all
- Scatter, reflect, refract
- Absorb
- Excite (e.g., glow or spin)
- Impart molecular change



Courtesy of
Jeff Siewerdsen, PhD

Electromagnetic Spectrum



Radiology

	Contrast resolution	Spatial resolution	Temporal resolution	Physiologic/ Functional
Radiography	+	+++	+	+
Fluoroscopy	+	++	+++	++
CT	++	++	++	+
MRI	+++	+	++	+++
US	++	+++	+++	++
NM	++	+	+	+++

The Nobel Prize in Physics 1901 was awarded to Wilhelm Conrad Röntgen *"in recognition of the extraordinary services he has rendered by the discovery of the remarkable rays subsequently named after him"*.

http://www.nobelprize.org/nobel_prizes/physics/laureates/1901/

The Nobel Prize in Physiology or Medicine 1979 was awarded jointly to Allan M. Cormack and Godfrey N. Hounsfield "for the development of computer assisted tomography"

The Nobel Prize in Physics 1952

"for their development of new methods for nuclear magnetic precision measurements and discoveries in connection therewith"

Felix Bloch

1/2 of the prize

USA

Stanford University
Stanford, CA, USA

Edward Mills Purcell

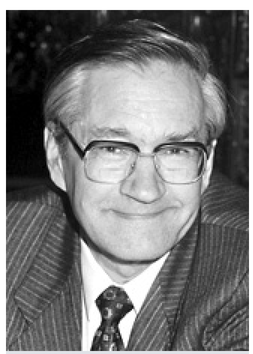
1/2 of the prize

USA

Harvard University
Cambridge, MA, USA

The Nobel Prize in Chemistry 1991

"for his contributions to the development of the methodology high resolution nuclear magnetic resonance (NMR) spectroscopy"



Richard R. Ernst

Switzerland

Eidgenössische
Technische Hochschule

The Nobel Prize in Physiology or Medicine 2003

"for their discoveries concerning magnetic resonance imagin

Paul C. Lauterbur

1/2 of the prize

USA

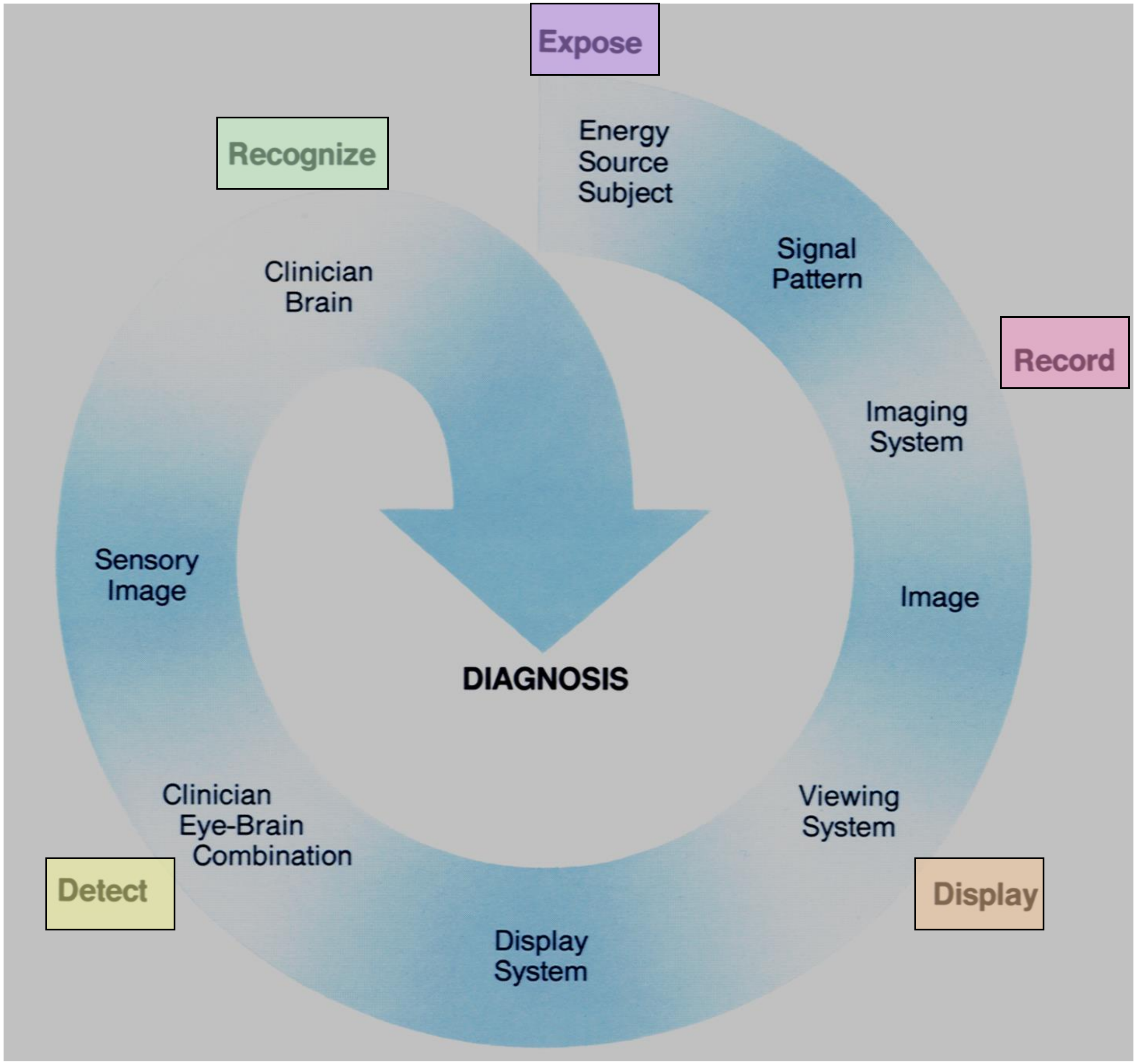
University of Illinois
Urbana, IL, USA

Sir Peter Mansfield

1/2 of the prize

United Kingdom

University of Nottingham,
School of Physics and
Astronomy
Nottingham, United
Kingdom



JAFFE C. MEDICAL IMAGING, VISION AND VISUAL PSYCHOPHYSICS: KODAK MONOGRAPH (VOL. 60, #1)

The reason a radiologist is required to assume that the overwhelming number of ambiguous things are normal, in other words, is that the overwhelming number of ambiguous things really are normal. Radiologists are, in this sense, a lot like baggage screeners at airports. The chances are that the dark mass in the middle of the suitcase isn't a bomb because you've seen a thousand dark masses like it in suitcases before, and none of those were bombs—and if you flag every suitcase with something ambiguous in it, no one would ever make his flight. But that, of course, doesn't mean that it isn't a bomb. All you have to go on is what it looks like on the X-ray screen—and the screen seldom gives you quite enough information.

Malcom Gladwell, 2004, The New Yorker

Satisfaction of Search (SOS)

- Important source of error in the detection of subtle abnormalities
- Obvious abnormalities capture visual attention and decrease vigilance
- History appears to direct perceptual resources to the prompted abnormalities, thereby alleviating satisfaction of search

Courtesy of
Jeff Siewerdsen, PhD

Imaging and Therapy

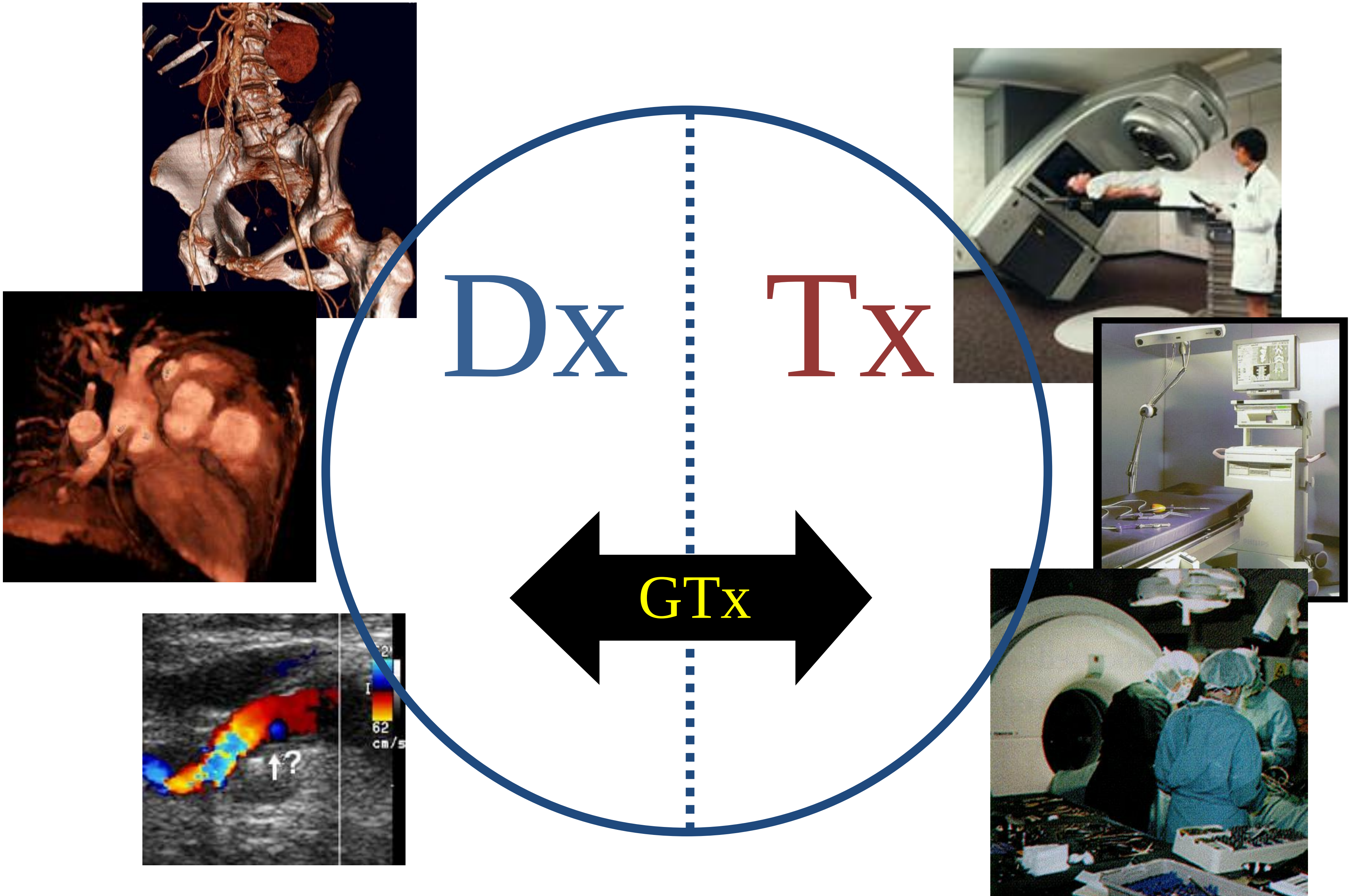


Figure 1a <p>Evolution of radiologic imaging display paradigms. (a) Analog light box or alternator. (b) Analog view of digital modality (CT) using tile mode with one set window and level. (c) Simple picture archiving and communication system (PACS) workstation using digital display but largely static film paradigm. (d) Dynamic digital display paradigm with simultaneous stack or cine mode of images from multiple orthogonal MR sequences. (e) Advanced postprocessed 3D volume-rendered CT images with color and multiplanar reformations. (f) PET, CT, and fused PET/CT, from top row to bottom row, respectively.</p>

Published in: "Optimizing Analysis, Visualization, and Navigation of Large Image Data Sets: One 5000-Section CT Scan Can Ruin Your Whole Day"
Andriole et al.
Radiology Vol. 259, No. 2: 346-362

ERGOQUEST
ZERO GRAVITY WORKSTATIONS


P
R

Radiology Workspot Requirements

- Visualization
- Information
- Decision Support

Premise

- Relevant clinical information enables the radiologist to interpret imaging findings in the appropriate context, leading to . . .
  - More relevant diff dx
  - More useful report for clinicians
  - Better outcome for the patient

SIIM 2014:

U Chicago: Obara, Sevenster, Quan, Travis, Chang

- Evaluated the quality of clinical hx accompanying radiology orders
- Did they include known chronic conditions pertinent to the radiological interpretation?
  - e.g., lupus, Crohn’s disease, cancer, HIV

SIIM 2014:

U Chicago: Obara, Sevenster, Quan, Travis, Chang

40% Relevant chronic conditions not in Hx/Indication from referring providers

35% Radiologist effort, added the information to report (EHR, prior rad report, or from MD)

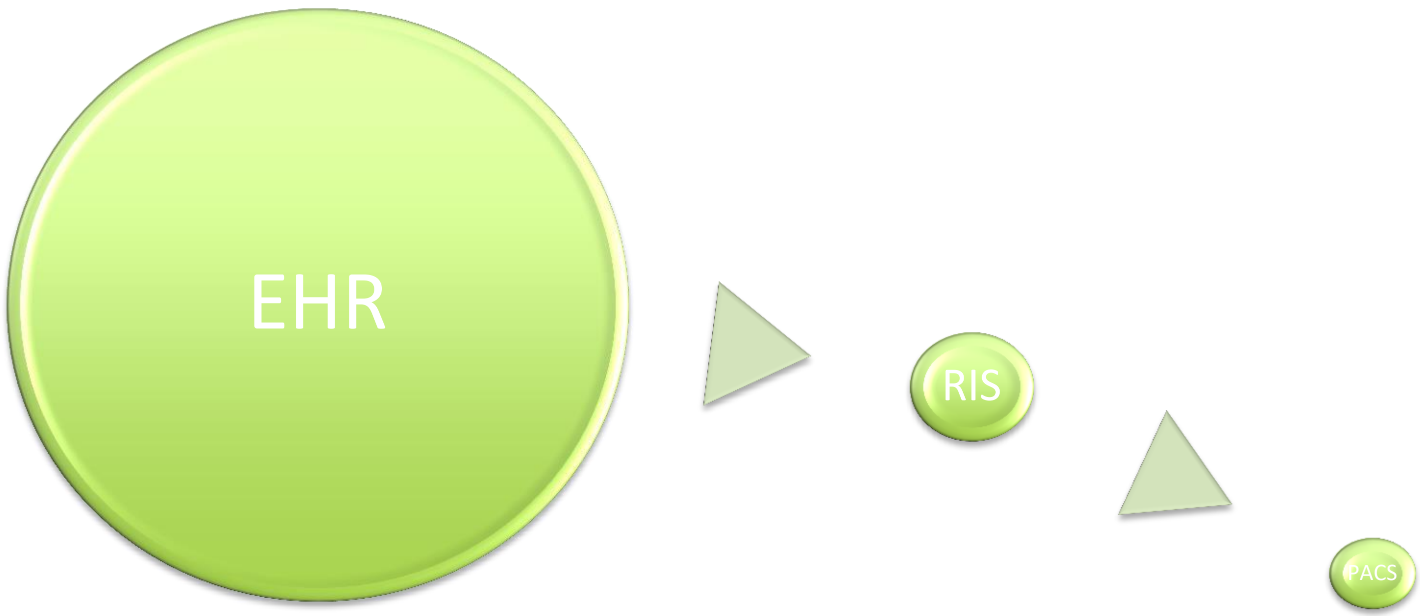
25% No evidence radiologist was aware of relevant condition

Why not make better use of the EHR?

- Does “in the dark” = the best read?
- Clinicians have pt data
- Shouldn’t Radiology?

Courtesy of Dr. Cree M. Gaskin, UVA

Clinical Data



Patient and Order Data

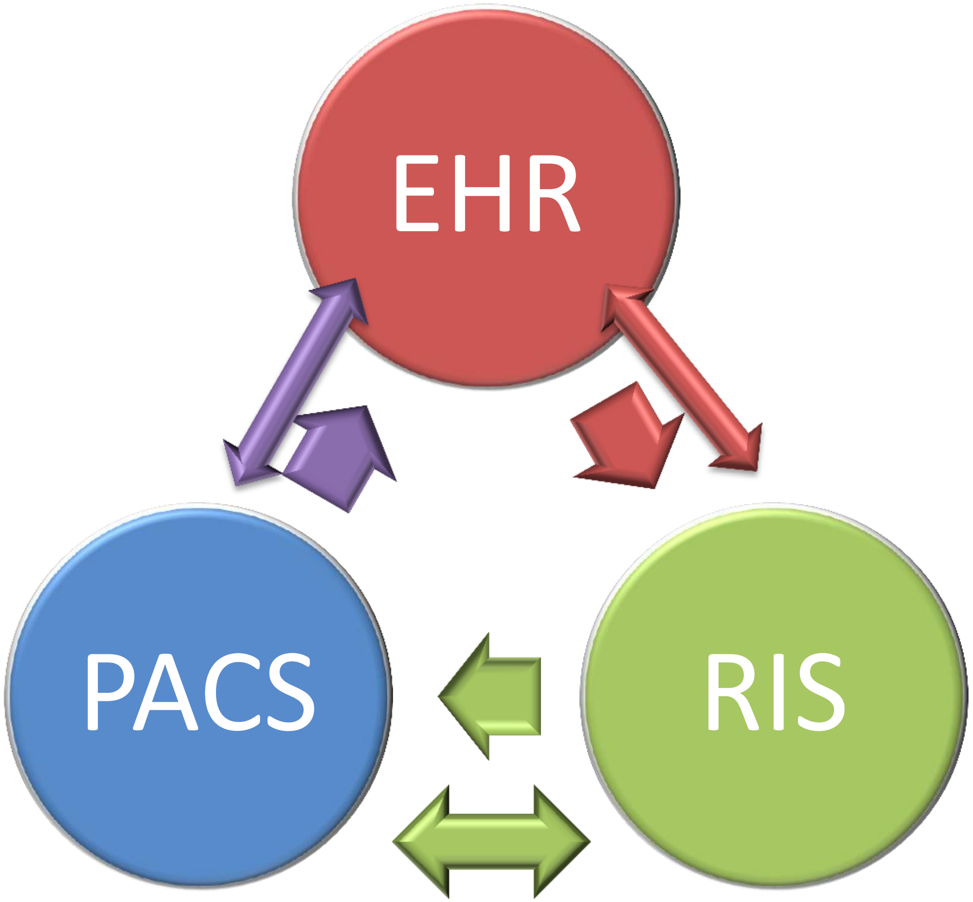
Order and exam data

Some order and exam data

EHR Data while reading on PACS
How to get it

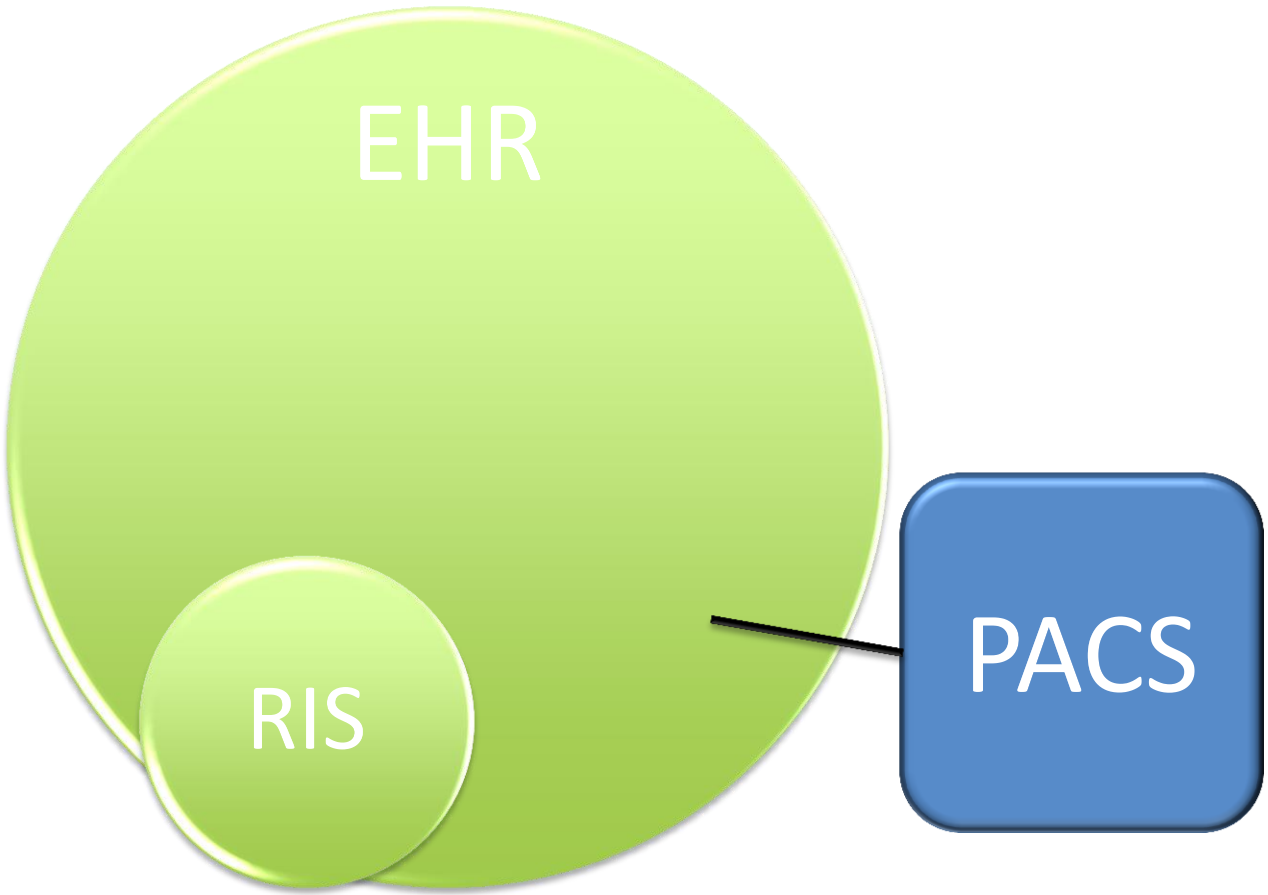
- EHR-driven workflow
- Enslave EHR, keep context with PACS
- Third-party to pull EHR data and share information

Courtesy of Dr. Cree M. Gaskin, UVA



Courtesy of Dr. Cree M. Gaskin, UVA

EHR-Driven: Single vendor RIS/EHR

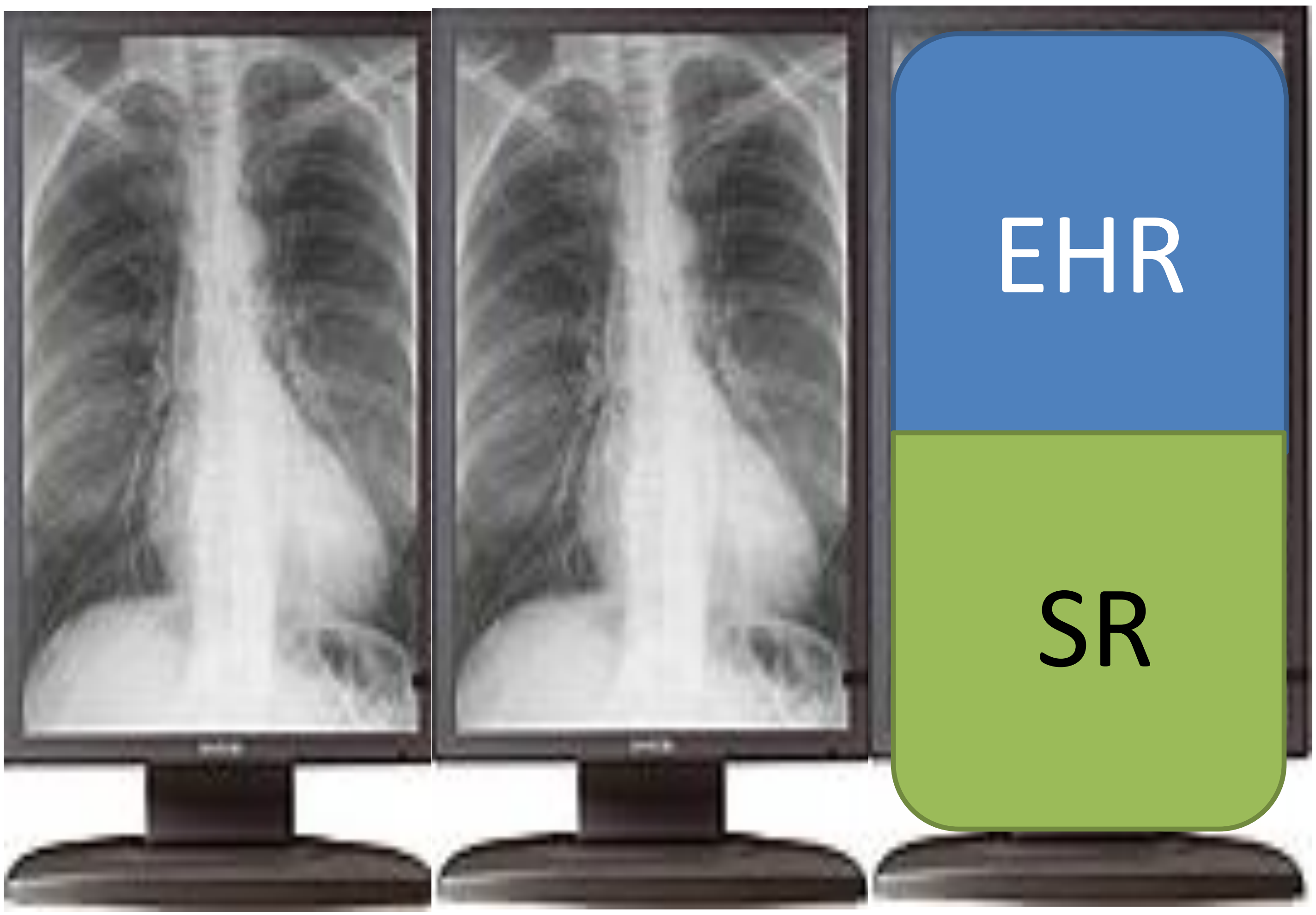


EHR-Driven = Centralized Activities

- **Protocoling**
- **Reading studies**
- Chart review/search
- “Meaningful use”
- Teaching file
- Tech work lists
- Manage referrals
- Report creation and signing
- MD performance metrics
- Administrative reports
- Peer review (prior while reading)
- Charting – orders, notes
- “Watch” patients; result tracking
- **Communication with providers**

Courtesy of Dr. Cree M. Gaskin, UVA

EHR-driven: UVA



Protocoling: Relevant Data

- Demographics
- Reason for exam
- Associated diagnosis
- Allergies
- Patient and provider contact information
- Order and scheduling questions/answers
- Prior matching exam

Allergies:	Betadine, Sulfa Drugs
Exam Ordered:	**MRI MUSCULOSKELETAL PELVIS WO CONTRAST**
Display Name:	MRI MUSCULOSKELETAL PELVIS WO CONTRAST
Diagnosis:	Femoroacetabular impingement of left hip
Reason for Exam:	left hip pain
Order Comments	
Last Exam Same Modality	MRI L SPINE WO CONTRAST (03/08/2010)

Protocoling: Available Data

- Relevant labs
- Previous protocols (2014) – copy forward
- Full chart access

Relevant Lab Information MRI MUSCULOSKELETAL PE

Lab Component	Date	Value	Reference Low	Referenc
CALC GFR (mL/min/1.73m2) (no units)	3/30/2008	>60		
Test performed at UVA Lab unless otherwise noted above.				
hCG Quant (U/L)	2/2/2008	778 (H)		
Test performed at UVA Lab unless otherwise noted above.				
Creatinine (MG/DL)	3/30/2008	0.8	0.6	1.1
Test performed at UVA Lab unless otherwise noted above.				
BUN (MG/DL)	3/30/2008	9	7.0	18.7
Test performed at UVA Lab unless otherwise noted above.				

Last CR: 0.8 MG/DL on 3/30/2008   Location:

Pregnant? No

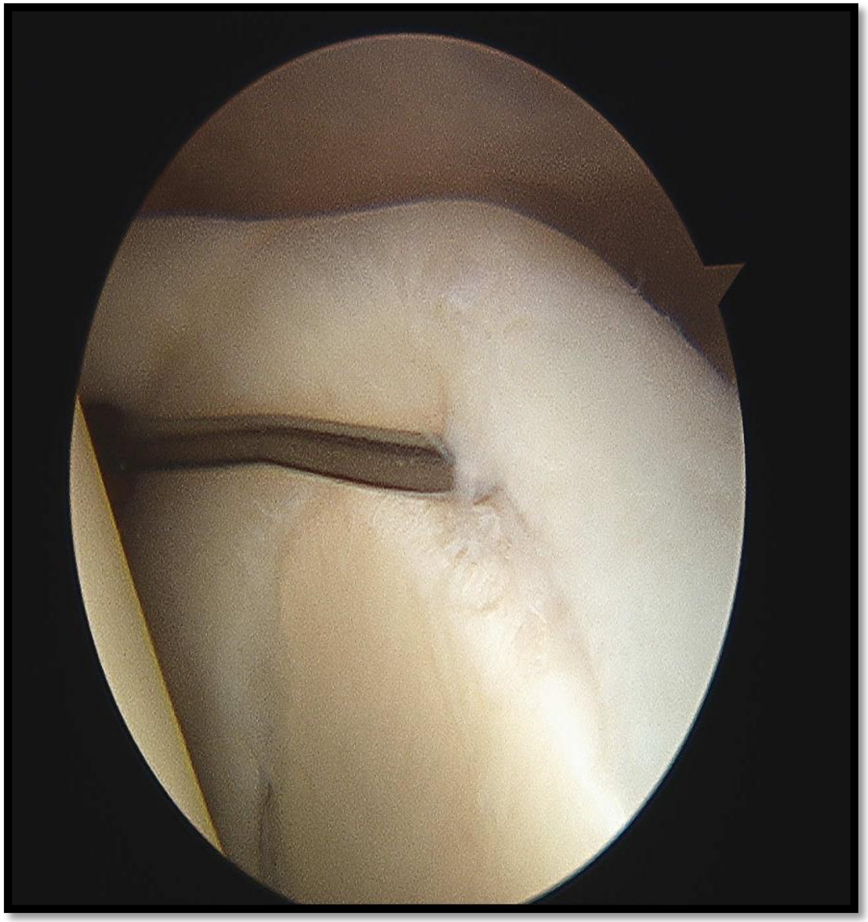
GFR Calculator

EHR-Driven = Data

- Full patient chart
  - All patient information
  - All ordering information
  - All exam information
  - Pre-selected, filtered, boiled down

Patient images

Patient images

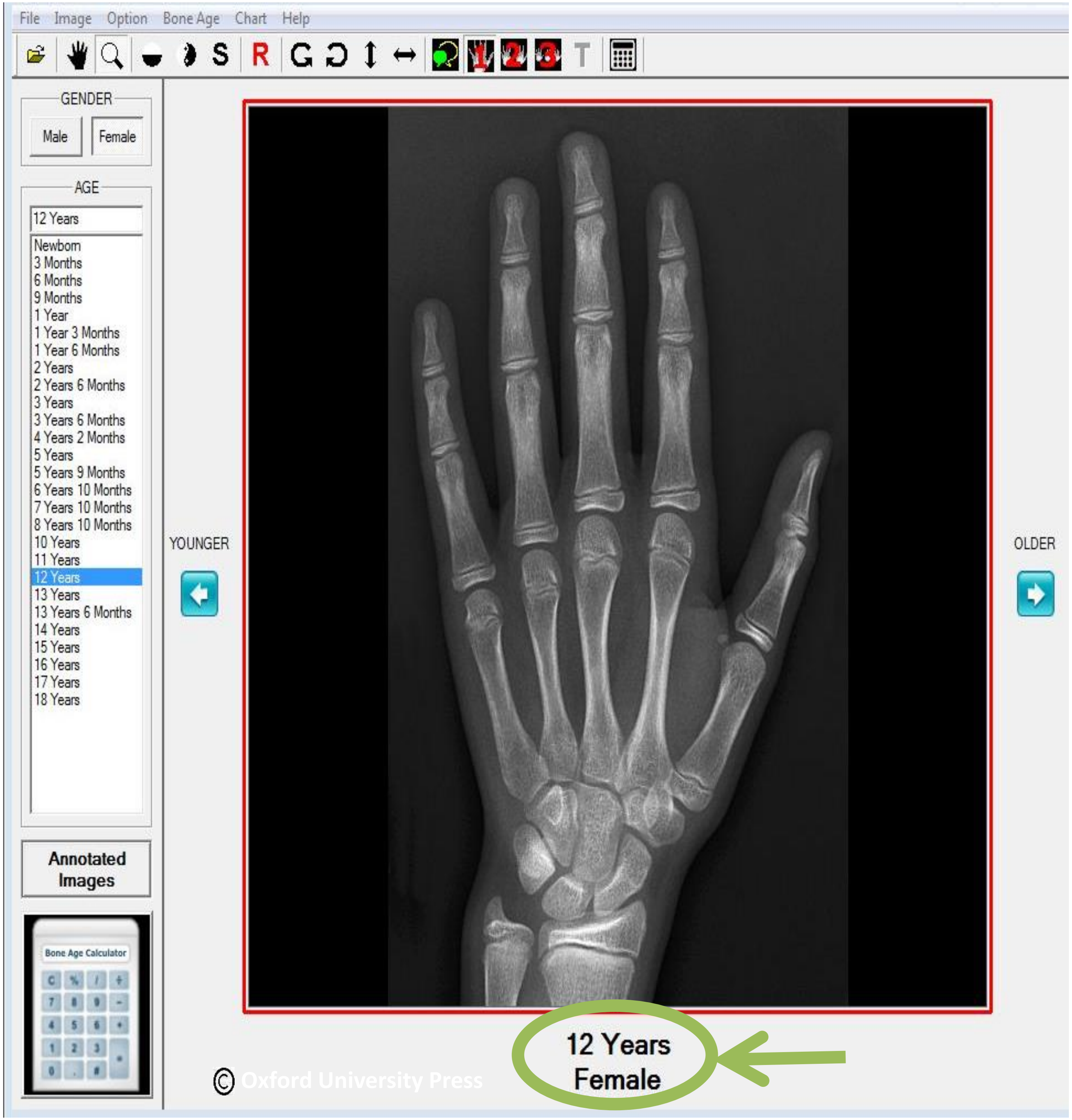


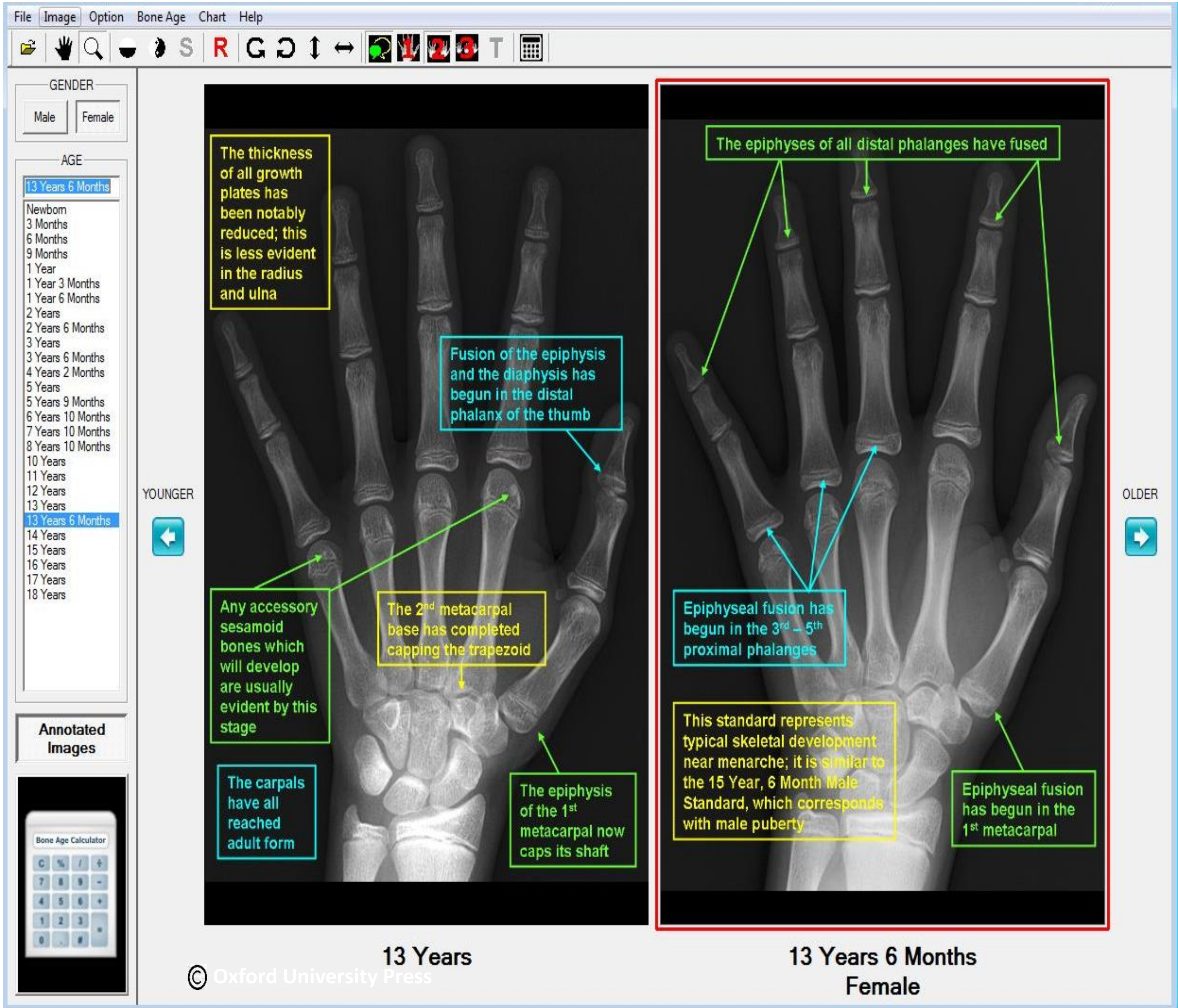
EHR-driven workflow

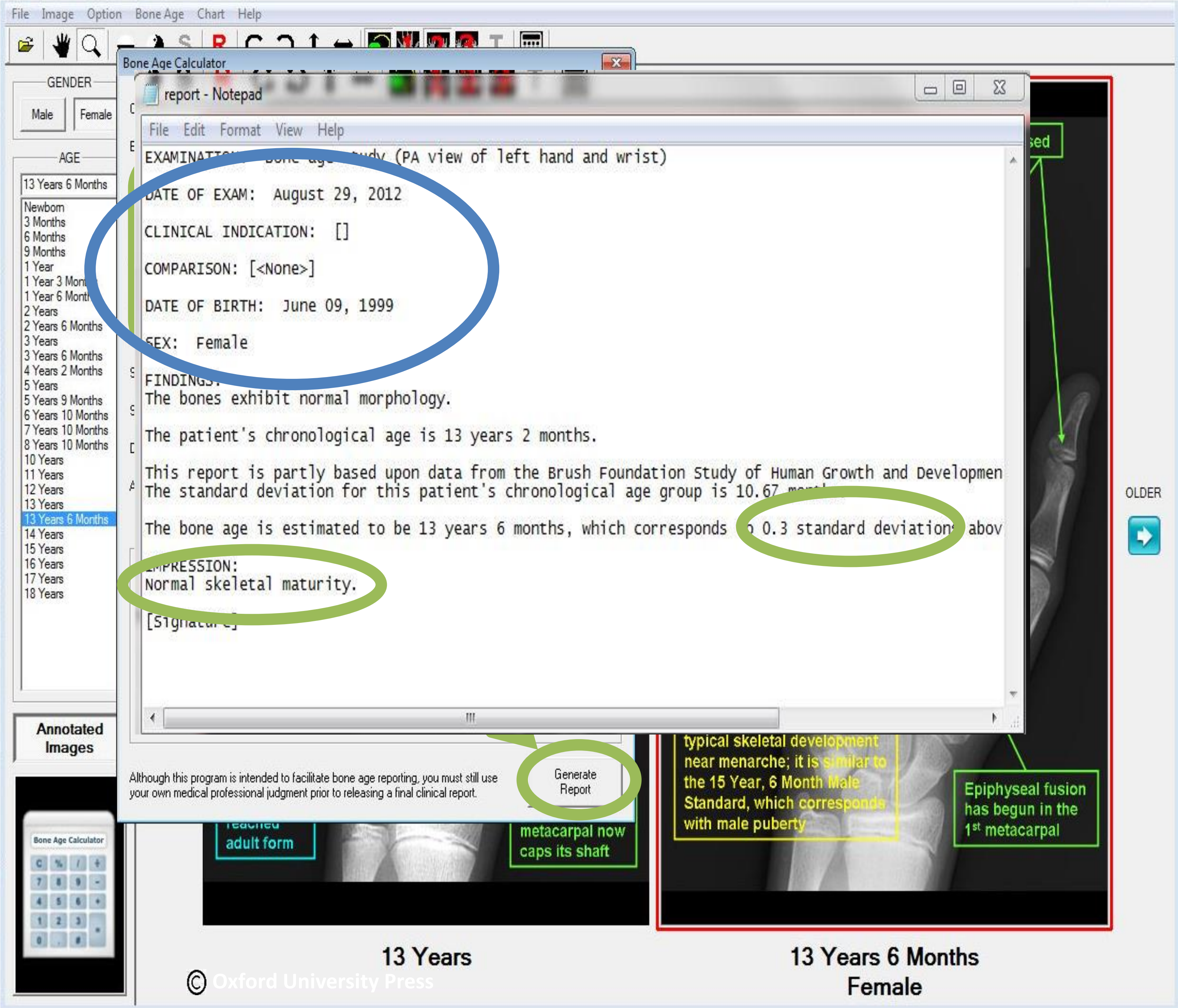
- Centralizes tasks
- Efficient delivery of more data
- Better care? More informed “reads”
- Improved provider communication
- Improved stratified report turnaround times
- Meaningful use incentives – yes

Interpretation

- You see what you look for
- You look for what you know
- You need to know what you don't know


File Image Option Bone Age Chart Help
GENDER
Male
Female
AGE
12 Years
Newborn
3 Months
6 Months
9 Months
1 Year
1 Year 3 Months
1 Year 6 Months
2 Years
2 Years 6 Months
3 Years
3 Years 6 Months
4 Years 2 Months
5 Years
5 Years 9 Months
6 Years 10 Months
7 Years 10 Months
8 Years 10 Months
10 Years
11 Years
12 Years
13 Years
13 Years 6 Months
14 Years
15 Years
16 Years
17 Years
18 Years
Annotated Images
Bone Age Calculator
YOUNGER
OLDER
© Oxford University Press
12 Years
Female


File Image Option Bone Age Chart Help
GENDER
Male
Female
AGE
13 Years 6 Months
Newborn
3 Months
6 Months
9 Months
1 Year
1 Year 3 Months
1 Year 6 Months
2 Years
2 Years 6 Months
3 Years
3 Years 6 Months
4 Years 2 Months
5 Years
5 Years 9 Months
6 Years 10 Months
7 Years 10 Months
8 Years 10 Months
10 Years
11 Years
12 Years
13 Years
13 Years 6 Months
14 Years
15 Years
16 Years
17 Years
18 Years
Annotated Images
Bone Age Calculator
YOUNGER
OLDER
The thickness of all growth plates has been notably reduced; this is less evident in the radius and ulna
Fusion of the epiphysis and the diaphysis has begun in the distal phalanx of the thumb
Any accessory sesamoid bones which will develop are usually evident by this stage
The 2nd metacarpal base has completed capping the trapezoid
The carpals have all reached adult form
The epiphysis of the 1st metacarpal now caps its shaft
13 Years
The epiphyses of all distal phalanges have fused
Epiphyseal fusion has begun in the 3rd – 5th proximal phalanges
This standard represents typical skeletal development near menarche; it is similar to the 15 Year, 6 Month Male Standard, which corresponds with male puberty
Epiphyseal fusion has begun in the 1st metacarpal
13 Years 6 Months
Female


File Image Option Bone Age Chart Help
Bone Age Calculator
report - Notepad
File Edit Format View Help
(PA view of left hand and wrist)
DATE OF EXAM: August 29, 2012
CLINICAL INDICATION: []
COMPARISON: [<None>]
DATE OF BIRTH: June 09, 1999
SEX: Female
The bones exhibit normal morphology.
The patient's chronological age is 13 years 2 months.
This report is partly based upon data from the Brush Foundation Study of Human Growth and Developmen
The standard deviation for this patient's chronological age group is 10.67
The bone age is estimated to be 13 years 6 months, which corresponds
0.3 standard deviation
abov
Normal skeletal maturity.
GENDER
Male
Female
AGE
13 Years 6 Months
Newborn
3 Months
6 Months
9 Months
1 Year
2 Years
2 Years 6 Months
3 Years
3 Years 6 Months
4 Years 2 Months
5 Years
5 Years 9 Months
6 Years 10 Months
7 Years 10 Months
8 Years 10 Months
10 Years
11 Years
12 Years
13 Years
13 Years 6 Months
14 Years
15 Years
16 Years
17 Years
18 Years
Annotated Images
Bone Age Calculator
Although this program is intended to facilitate bone age reporting, you must still use your own medical professional judgment prior to releasing a final clinical report.
Generate Report
adult form
metacarpal now caps its shaft
typical skeletal development near menarche; it is similar to the 15 Year, 6 Month Male Standard, which corresponds with male puberty
Epiphyseal fusion has begun in the 1st metacarpal
OLDER
13 Years
13 Years 6 Months
Female
© Oxford University Press

Courtesy of Dr. Cree M. Gaskin, UVA

Bone age reporting by faculty*

Manual

- Time: 90 sec
- Report errors: 23%
- Preference: No

Integrated software

- Time: 45 sec
- Report errors: 0%
- Preference: Yes, 9/9

*abstract submitted to a spring 2015 meeting

What is an Ontology?

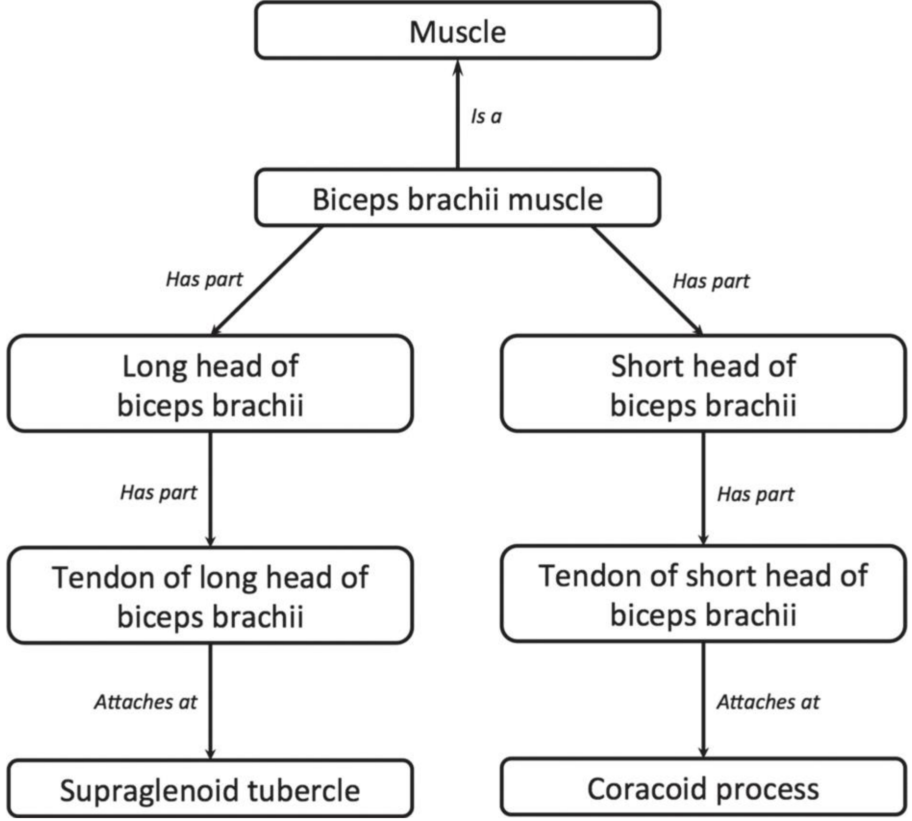
- Description of essential reality
- **what actually is,** as opposed to what one can see **(observation),** or what one can know **(epistemiology)**
  - [Smith B. Mereotopology: A Theory of Parts and Boundaries. Data and Knowledge Engineering. 1996;20:287-303.]
- Metaphysical commitments or presuppositions embodied in the different natural sciences
  - [Quine WVO. Ontological relative, and other essays. New York: Columbia University Press. 1969]

Ontology

- Structured organization of knowledge
- In medical informatics, ontology has come to mean a structured list of concepts, typically prepared by an expert or panel of experts

Figure 1a <p>Ontologic modeling of the biceps brachii muscle. (a) Drawing illustrates the biceps brachii muscle. (Reprinted, with permission, from reference 36.) (b) Chart illustrates a related ontology fragment, with relationships indicated by arrows and accompanying text (italics). Conceptual relationships may be interpreted as "subject-verb-object" sentences in which the subject is the concept at the origin of the arrow, the relationship itself constitutes the verb, and the object is the concept at the arrow's destination. Different relationships are used to indicate parts (eg, biceps brachii muscle "has-part" long head of biceps brachii), types (eg, biceps brachii "is-a" muscle), and attachments (eg, tendon of long head of biceps brachii "attaches-at" supraglenoid tubercle). Note that ontologies also often encode reverse relationships (eg, long head of biceps brachii is "part-of" biceps brachii muscle) (not shown).</p>

Published in: "Ontology-based Image Navigation: Exploring 3.0-T MR Neurography of the Brachial Plexus Using AIM and RadLex"
Wang et al.
RadioGraphics Vol. 35, No. 1: 142-151



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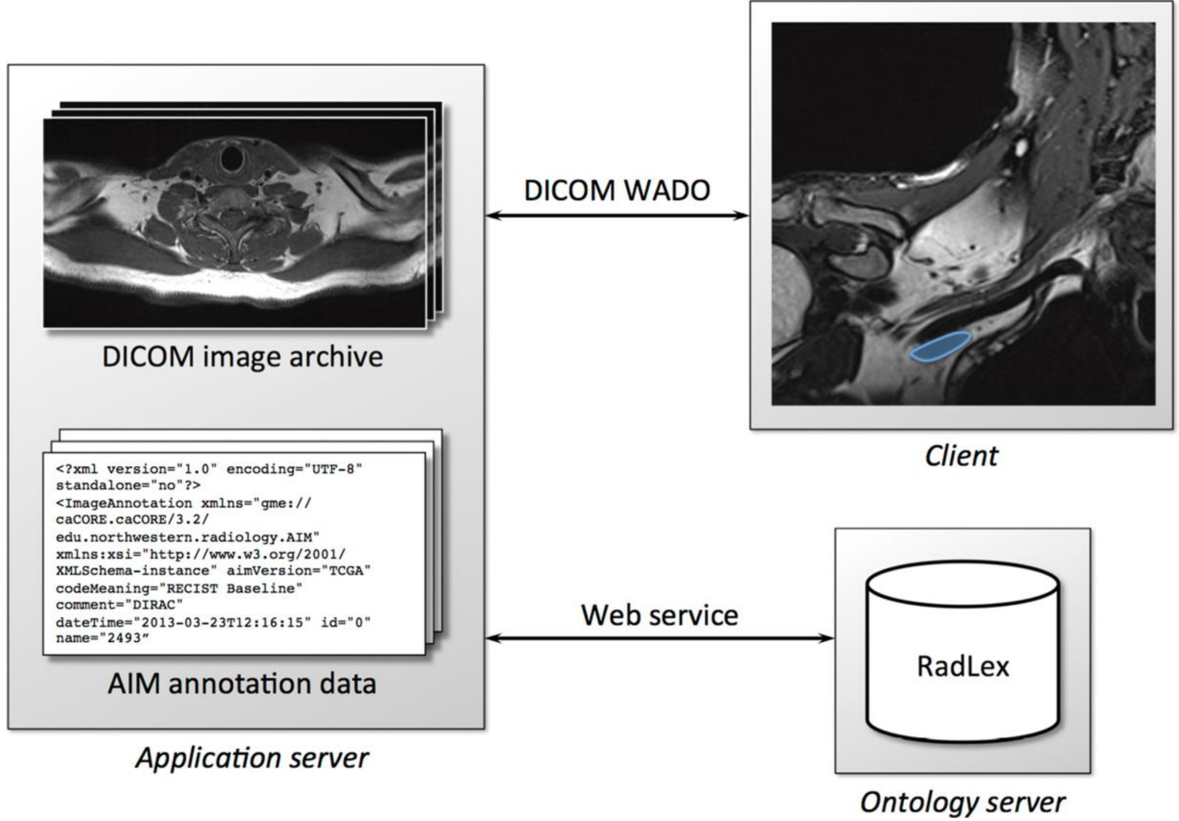

Figure 2 <p>Web-based application architecture for an ontology-driven imaging atlas. The application server manages images in a DICOMDigital Imaging and Communications in Medicine archive and maintains a set of image annotations encoded with the AIMAnnotation and Image Markup standard. The application server responds to client requests for images using the DICOMDigital Imaging and Communications in Medicine Web Access to DICOMDigital Imaging and Communications in Medicine Persistent Objects (WADOWeb Access to DICOM Persistent Objects) protocol. RadLex data are dynamically retrieved from a separate ontology server through a Web services interface. In this example, the client has used DICOMDigital Imaging and Communications in Medicine WADOWeb Access to DICOM Persistent Objects to display a coronal T2-weighted SPACEsampling perfection with application optimized contrasts by using different flip angle evolutions MR image in the region of the brachial plexus (blue = axillary vein).</p>

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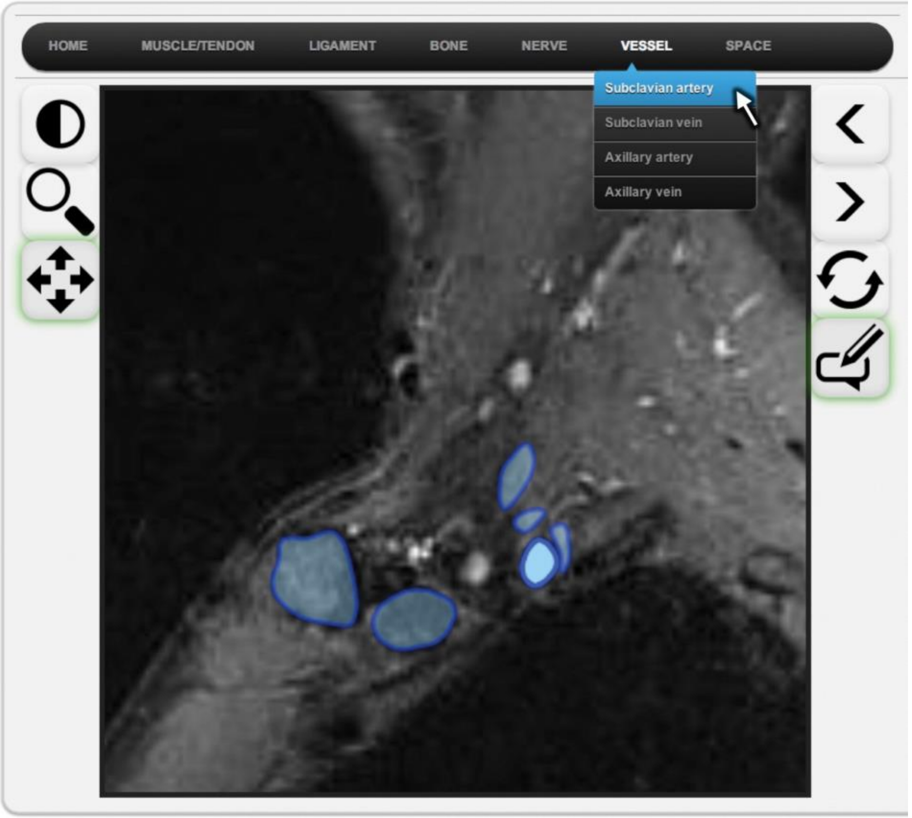

Figure 3a <p>Browser-based interface to ontology-driven imaging atlas. (a) Drop-down menus (top) provide a mechanism for selecting structures by category and name (the subclavian artery has been selected in this example). Image annotations are shown in the atlas in blue, with the currently selected structure highlighted in brighter opaque blue and other available annotations shown in darker transparent blue. (b) Any available annotation may be selected by moving the cursor over the structure of interest (the coracoclavicular ligament has been selected in this example). Annotations may be toggled on and off to more fully reveal the underlying imaging appearance. Additional information about a structure of interest may be obtained by means of a pop-up menu, which is invoked with the right mouse button. (c) Pop-up menu for the supraspinatus muscle with attachment information derived from RadLex.</p>

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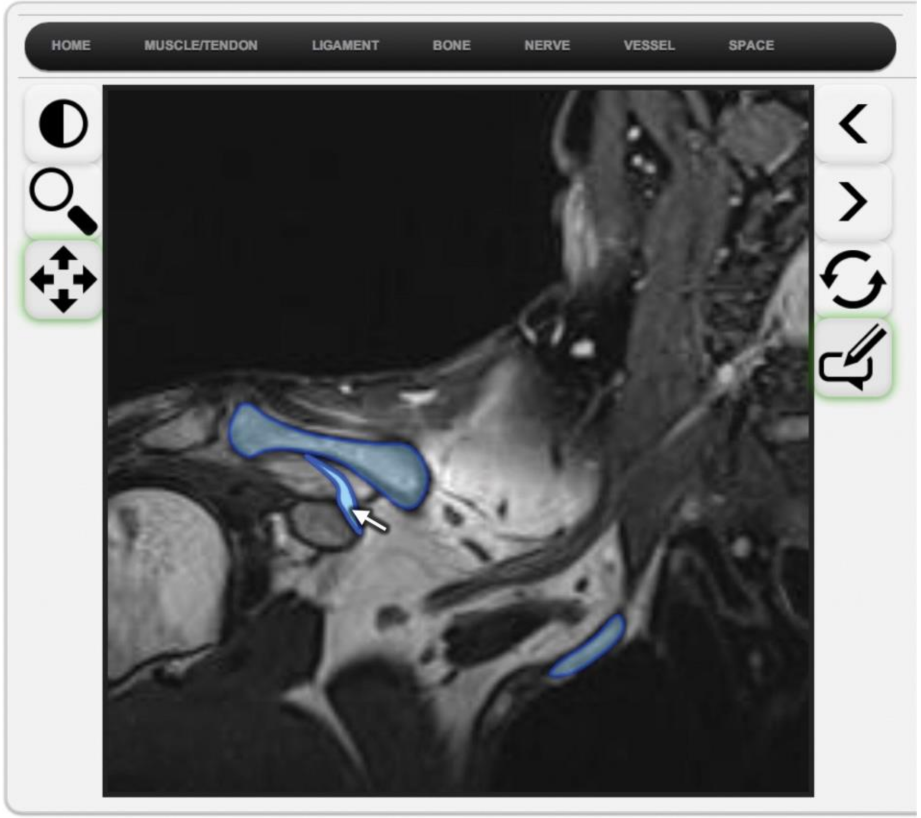

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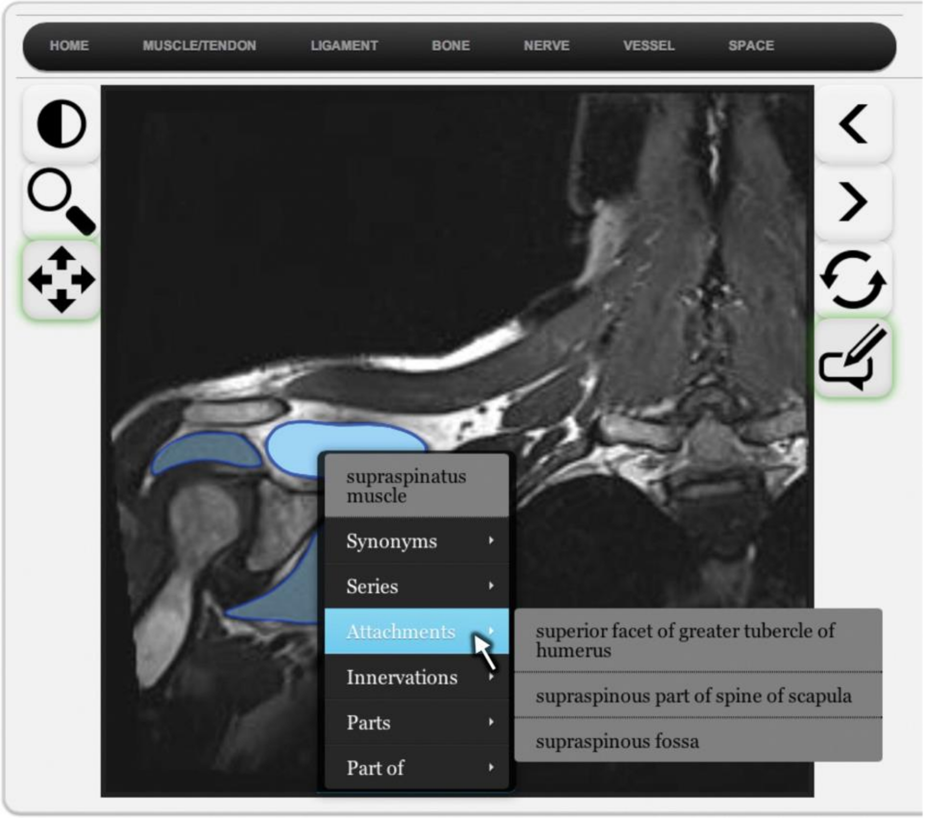

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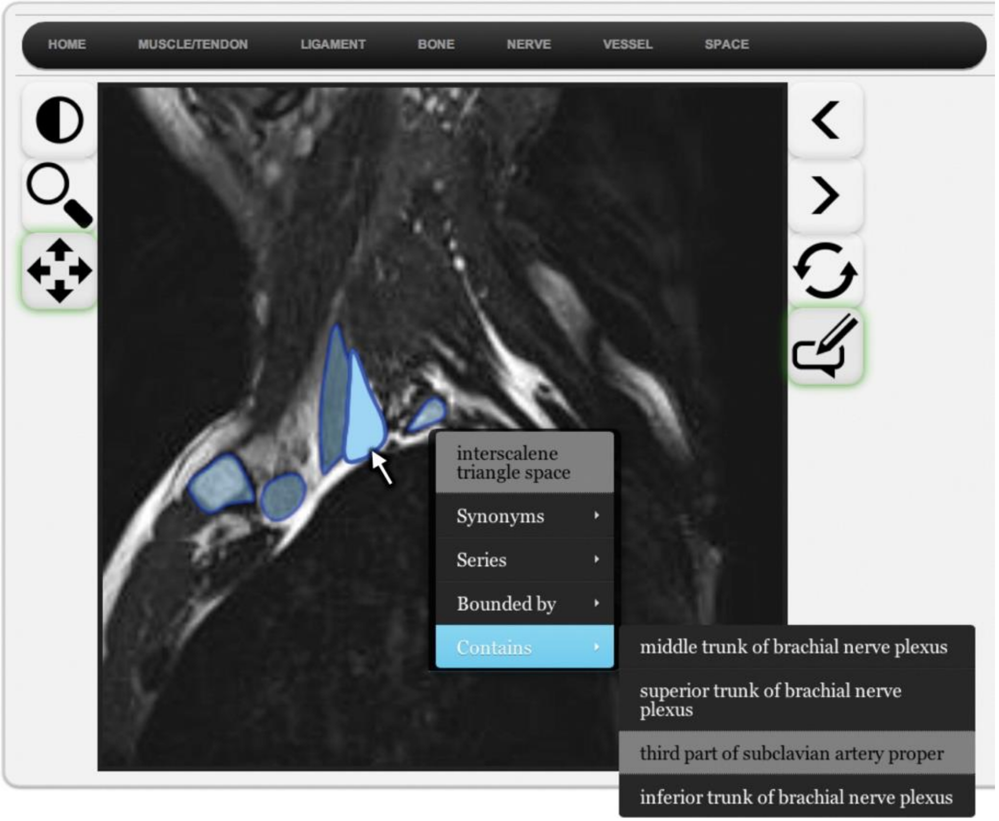

Figure 4a <p>Ontology-assisted image navigation. (a) Pop-up menu reveals that the superior, middle, and inferior trunks of the brachial plexus, as well as a portion of the subclavian artery, course through the interscalene triangle. (b) Entries in the pop-up menu system are themselves selectable, and choosing the middle trunk of the brachial plexus links to a representative image and annotation. (c) Graphical annotation browsing may then be used to demonstrate that the middle trunk of the brachial plexus lies superior to the subclavian artery. In this way, the application facilitates exploration of the ontologic and spatial relationships between structures.</p>

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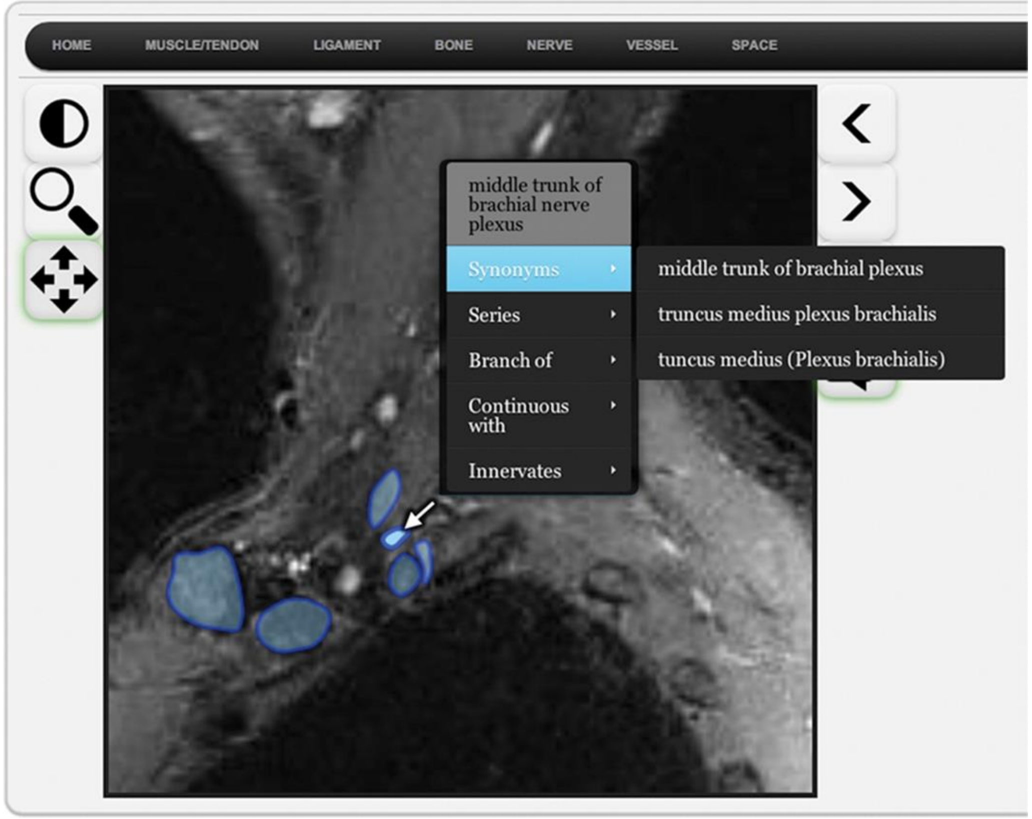

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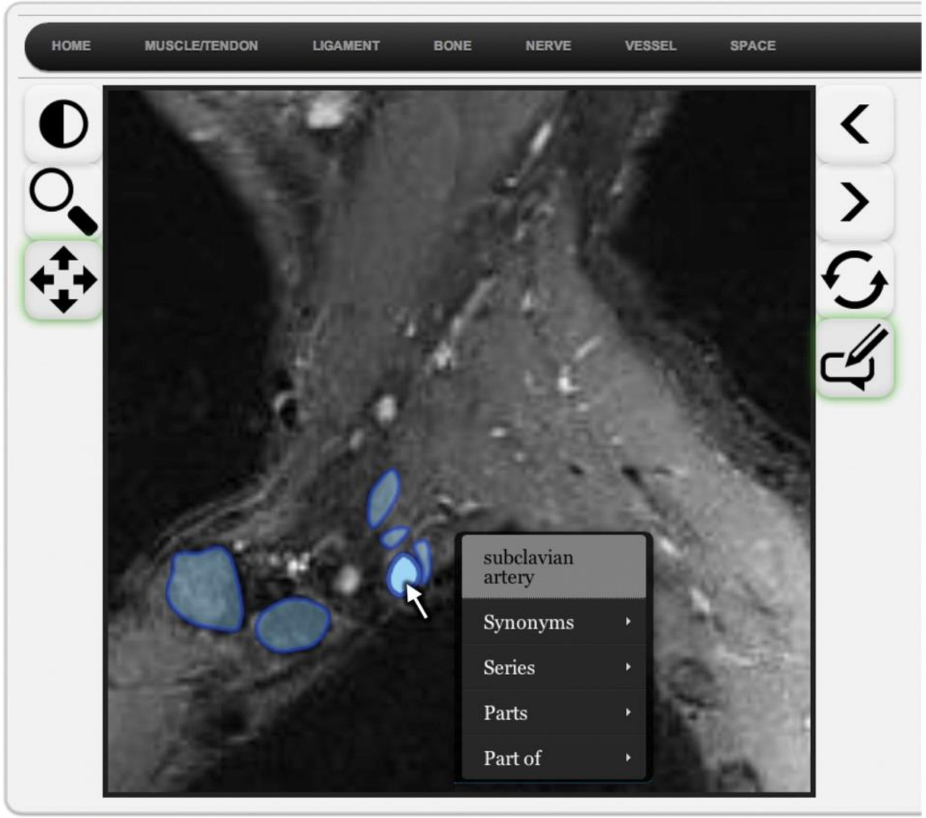

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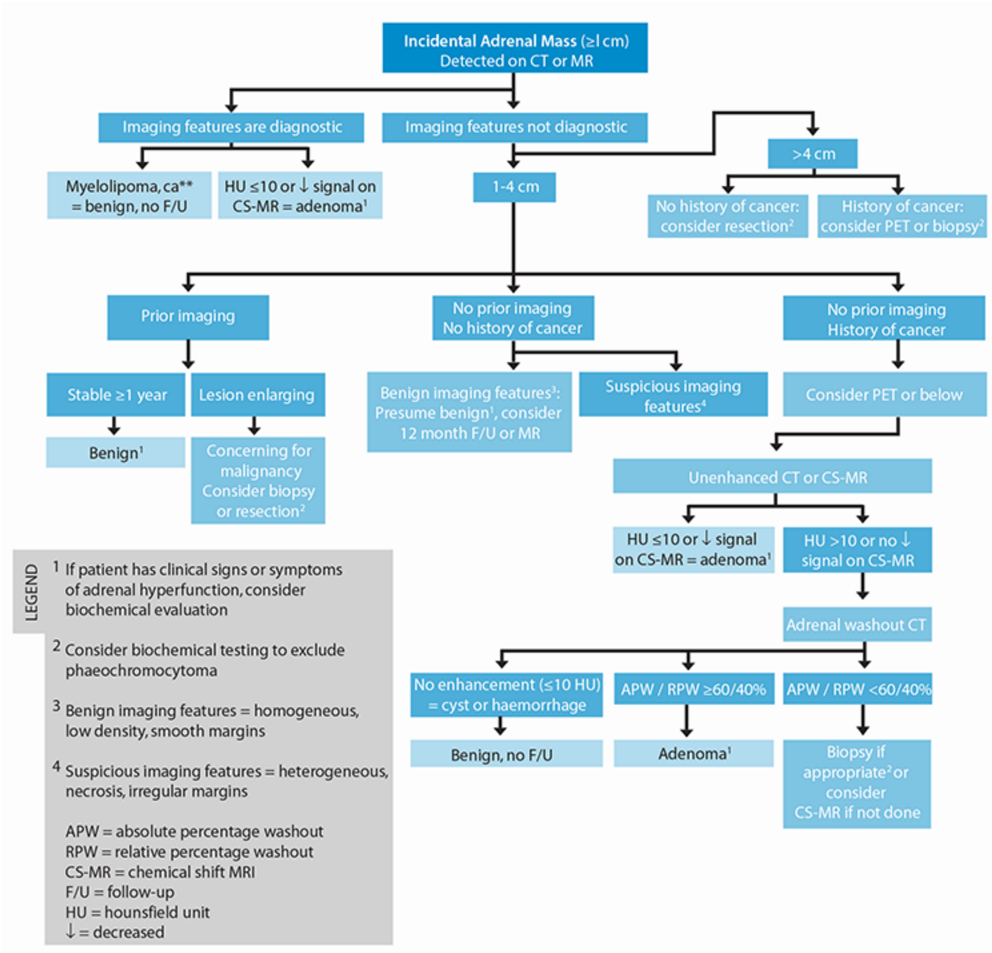
Published in: "Ontology-based Image Navigation: Exploring 3.0-T MR Neurography of the Brachial Plexus Using AIM and RadLex"
Wang et al.
RadioGraphics Vol. 35, No. 1: 142-151

Radiology

- Anatomy
- Physiology
- Pathology
- Interpretation
- Nosology
- Communication

JACR | Journal of the American College of Radiology
Health Services Research & Policy ■ Clinical Practice Management ■ Training and Education ■ Leadership

RADIOLOGY BUSINESS



DIKW Hierarchy

- Data
- Information
- Knowledge
- Wisdom

SEMIOLOGY

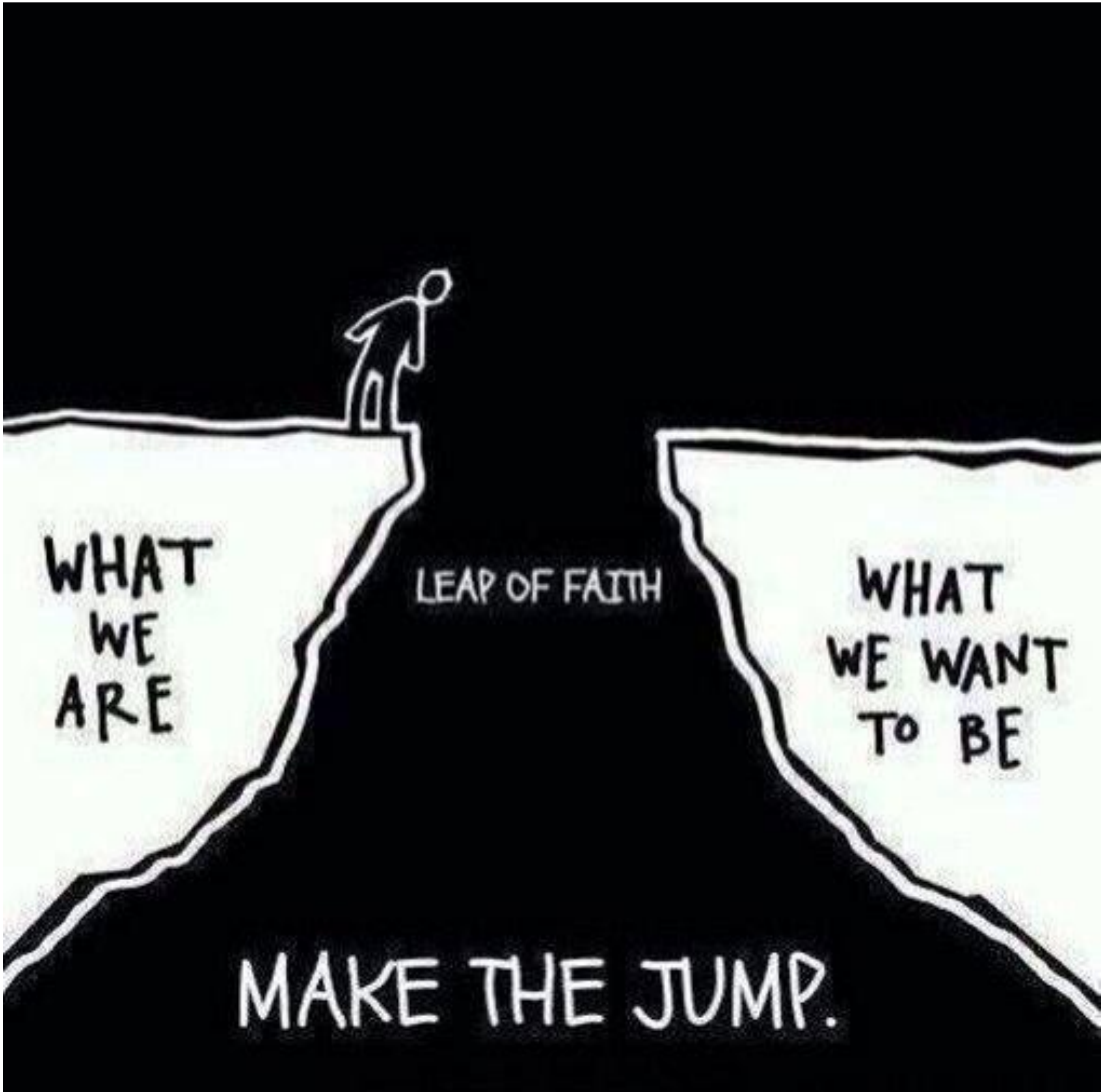
- The importance of radiologic semiology can be seen from the large number of articles, books, and Web pages dealing with radiologic signs
- Recognition of these signs forms an important part of the training process for radiologists

Apple Core Sign

PACS SUBSYSTEMS

- ACQUISITION
- DISPLAY/OUTPUT
- NETWORK/COMMUNICATIONS
- ARCHIVE/STORAGE
- DATABASE

H.K. Huang "Elements of Digital Radiology"


WHAT WE ARE
LEAP OF FAITH
WHAT WE WANT TO BE
MAKE THE JUMP.


HOSPITAL FOR SPECIAL SURGERY