MAYO CLINIC *"Form and Function"* A Radiologist's Perspective on Desktop and Mobile Image Viewing



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• None



"Form and Function"

The American architect Louis Sullivan stated

"It is the pervading law of all things organic and inorganic, of all things physical and metaphysical, of all things human and all things superhuman, of all true manifestations of the head, of the heart, of the soul, that the life is recognizable in its expression, **that form ever follows function.** *This is the law.*"

Information Knowledge Deliver

Sullivan, Louis H. (1896). <u>"The Tall Office Building Artistically</u> <u>Considered"</u>. *Lippincott's Magazine* (March 1896): 403–409



Outline

- 1. Mobile image viewing will compliment, not replace dedicated PACs workstations. PACS can inform thoughtful mobile utilization
- 2. Mobile offers significant opportunity to improve timely patient care
- 3. Ability to collaborate across desk top and mobile platforms will be valuable
- 4. Clinical patient care decisions **are** be made on mobile platforms prior to formal radiologic image interpretations and reporting.



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Four basic interpretation modes drive workstation form and function

- Planar images—PA and lateral chest
- Scrolling stacks- CT, MR, PET/CT
 - Images may be spatially linked to allow comparison using different contrast sequences or time points
- CINE loops-typically planar images across time observing arterial to venous flow or other physiology
- Volumetric image review—interactive advanced
 3D multiplanar or surface rendered review



Planar images







Scrolling stacks- CT, MR, PET/CT



CINE loops





Volumetric image review—interactive





Exam interpretation consists of four phases

- Lesion detection
- Lesion interpretation
 - Change assessment (fusion, subtraction)
 - Multi-spectral characterization
- Integration with non-imaging clinical data
- Report generation and communication
 - Report text blob—often with front-end speech
 - Report text with structured data elements (BIRADS)
 - Image annotation and key image montage, graphics
 - Asynchronous alerts—text, secure EHR message
 - Verbal alerts
 - Synchronous image review (in person or remote via mobile)



Lesion Detection—"Gestalt"

- "Gestalt" impression—nonselective pathway useful part of expert search process
- Expert radiologists are able to detect 70% of lesions on chest radiograph in 200 msec glimpse (Kundel HL, Nodine CF. Radiology 1975;116 (3):527-532)
- Consistent image orientation and size valuable
 - My mentors insisted on it!
 - Accuracy and speed of observer recognition of human face reduced by inverting image (Rousselet GA, Macé MJ, Fabre-Thorpe M. Journal of Vision 2003 (3), 440-445)



Lesion Detection—Selective Pathway

- "Gestalt" can inform subsequent selective image review (Drew et al. Radiographics 2013; 33:263-374)
- Search patterns are taught in Radiology residency programs
- Errors in lesion detection can be studies by eye tracking measurement of gaze dwell time:
 - Faulty scanning—eyes do not dwell on lesion
 - Faulty recognition—eyes dwell on lesion less than defined minimum time
 - Faulty decision making—eyes dwell time on lesion exceeds minimum, but lesion not called (Berbaum et al. Academic Radiology 1998; 5:9-19)



Lesion Detection Satisfaction of Search (SOS)

- Satisfaction of search is a false negative observer error (missed lesion) which occurs when multiple unrelated lesions are present (Tuddenham. Radiology 1962; 78:694-704)
- SOS can be secondary to global changes in visual Search behavior or faulty decision making (1. Berbaum and Franken. Radiology 2011; 261: 1000-1002, 2, Berbaum et al. Acad Radiol 1998; 5 (1):9-19)



Lesion Detection Computer Assisted Detection (CAD)

- CAD use most prevalent in mammography and chest radiographs and chest CT, more recently MRA for intracranial aneurysm
- Assumptions of lesion prevalence made by CAD systems can affect accuracy and false positive rate
- A significant tool to help manage large volume image data sets
- Andriole et al. Optimizing Analysis, Visualization, and Navagation of Large Image Data Sets: One 5000-Section CT Scan Can Ruin Your Whole Day. Radiology 2011; 259:346-362.
- Stepan-Buksakowska et al. Computer-Aided Diagnosis Improves Detection of Small Intracranial Aneurysms on MRA in a Clinical Setting. AJNR Am J Neuroradiol. 2014 Oct; 35(10):1897-902



Lesion detection: "Gestalt" and selective pathway search patterns vary by interpretation mode

- 1. Planar images
 - Consistent image presentation, orientation, field of view and distance to image important
 - Essentially all eye tracking studies done on planar imaging (Andriole et al. Radiology 2011; 259:346-362)
- 2. Scrolling stacks: Consistent GUI, spatial linking and hanging protocols, scroll speed and resolution
- 3. CINE loops: scroll speed, resolution critical
- 4. Volumetric: Consistent GUI, speed and resolution



Physiologic considerations

- Ergonomics
 - Adjustable chairs, tables
 - Multiple input devices
 - 3 mouse types (programable buttons and scroll wheels)

- Head sets, foot pedals, hand held mics
- Spatial and Contrast resolution
 - Ambient light levels, reflective surfaces controlled
 - Display luminance calibrated



Dedicated PACS reading room "darn nice!" Mobile will compliment, **Both** must respect human physiology and large data sets



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Clear articulation of Mobile Use Cases will help scope mobile imaging IT projects

- Radiologist Away from Desktop PACS Workstation
- Radiologist at Desktop PACS--synchronous interactions with clinician
- Proceduralist to proceduralist interactions
- Radiologist/Proceduralist Interactions with Patients



Radiologist Away from Desktop PACS Workstation

- On campus (within firewall)— in meeting, at lunch
- Off campus (outside firewall)
 at kids soccer game, in car, at home
- Engagement at varying levels of exam completion
 - Specific question from tech on exam in progress
 - Trainee question regarding specific finding of exam completed in PACS, w/o finalized report
 - Emergent opinion for entire cross-sectional exam data set
 - Preview images prior to emergent intervention, for example review CT, CTA, CTP prior to IA thrombectomy for stroke
 - Final interpretation of exam with access to prior exams, reports and clinical data



Radiologist at Desktop PACS Synchronous interactions with clinician

- Currently available desktop or mobile standalone systems that allow synchronous review and annotation
- Ideally future systems integrated to Radiologist's PACS
- Clinician may be inside or outside firewall



Proceduralist to proceduralist interactions

- Surgical trainee to orthopedic trauma consulting staff
 do we fix this comminuted hip fracture tonight?
- Neurologic Surgeon to Neurovascular Interventional Radiologist—should we clip or coil this internal carotid artery aneurysm this weekend?



Radiologist/Proceduralist Interactions with Patients



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Synchronous collaboration is a patient care "game changer!"

- Acute stroke care rapidly evolving
 - Telestroke programs allow extending acute intravenous TPA care to rural areas with rapid (often mobile) review of non contrast head CT
 - Four recent trials have show intra-arterial thrombectomy to improve patient outcomes for proximal anterior circulation occlusion (MR CLEAN, ESCAPE, EXTEND-IA, SWIFT PRIME)
 - Mobile stroke units launched by U of Texas at Huston and Cleveland Clinic. U Colorado will be third.
 - CT scanner on truck, IV TPA in field, bypass community hospital on way to stroke center for IA thrombectomy
 - IA image selection criteria more complex and evolving
- Synchronous collaboration between field and centrally located stroke experts key to improving care







Prehospital Acute Neurological Treatment and Optimization of Medical care in Stroke Study (PHANTOM-S; conducted in Berlin, Germany) *decreased time to treatment without an increase in adverse events.* JAMA. 2014 Apr 23-30;311(16):1622-31.



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Clinical patient care decisions *are* being made on mobile platforms prior to radiologic interpretations

- They probably were before any mobile device was certified by the FDA!
- Anecdotes plentiful ever since cell phones could take and forward images
- "Necessity is the mother of invention"
- Very little is know about lesion detection and lesion interpretation expert performance on mobile
- Medical community needs AAMP's assistance to "keep us safe!!"



Clinical patient care decisions on mobile platforms prior to radiologic interpretations

- Respect environment in which images are reviewed
 - significant variations in luminance levels even between mobile devices of the same model
 - approved Mobile MIM software contained QA step of identifying a low contrast target
 - Clean screen, no protective film
 - Appropriate viewing angle and distance
- Respect mobile form factors
 - Workflow should be optimized for device screen size and device input mechanisms



Clinical patient care decisions on mobile platforms prior to radiologic interpretations

- Respect data set size
 - Consistent review methodology
 - Advanced post processing can improve navigation of large volumetric data sets and reduce scrolling fatigue
- Collaboration with expert viewer on dedication desktop PACS whenever possible
- "Form ever follows function" Limit mobile use to scenarios where mobile form factor provides advantage



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Thank you for your attention! Questions?

