Introduction to Digital Radiography [CR/DR], Computed Tomography [CT], and Magnetic Resonance Imaging [MRI]

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What Is Digital Radiography?

- Making radiographic images as versatile as pictures from your digital camera
- Making radiographic images visible and storable on a personal computer or a hospital-wide system
- ELIMINATING (or at least minimizing) HARD COPIES???

Food For Thought

Image Viewing Software

Digital Images

- Composed of a matrix of pixels e.g. 512 x 512 pixels, 1024 x 1280, etc
- Pixels = “picture elements”
- Each pixel is assigned a value (number)
- In imaging, the value of each pixel determines the grayness of the pixel [current standard is 256 shades of grey]
Digital Images – Take Home Points

- More bits per pixel will yield more shades of grey (a longer scale) in a displayed image
- The larger the image matrix (for a given area imaged), the greater the spatial resolution (clarity)
- Therefore, increasing the number of pixels (while keeping image area same) will result in smaller pixel size.

Connectivity – the importance of DICOM

- Digital Imaging and Communication in Medicine
- DICOM standard is critical for information exchange between modalities (CR/DR, CT, U/S...), image viewing software, storage devices, and printers
- Provides image and image information standards for ALL modern imaging modalities

DICOM

- Think of DICOM like a JPEG or TIFF file with consistent labeling fields (.dcm)
- DICOM defines the protocols for storing, querying, retrieving, sending, and printing digital images
- DICOM images also contain critical image “header” information
  – Patient ID, name, study date, positioning, etc.
What Is A PACS?
(Picture Archive & Communication System)

- Simplest: a hospital system for digital image distribution and storage
  - Access any patient’s images from any computer
  - Access any patient’s images from home
  - Could include any appropriately formatted digital image (endoscopic or dermatologic pictures)
- Mid-range: a hospital system for the distribution/storage of images and the associated interpretations
  - A Radiology Information System (RIS)
- High-end: fully integrated imaging (RIS), medical record, and hospital information system (HIS)

Components of a PACS

- Imaging modality: CR, DR, MRI, CT, US, NM, etc.
- Hospital intranet [LAN]/internet connections
- Viewing computers/workstations
- Central computer (server)
- Storage components – hard drives, DVD
- Potential interface to the hospital information system (HIS)

Example PACS Configuration

- Hospital
- Film Scanners / Digitizers
- Storage System / PACS Server
- Workstations
- Printer
- Web-based Viewing Stations
- CD/DVD-Burner

University of Minnesota College of Veterinary Medicine PACS

Why Might A Digital System Be Relevant To Private Practice?

- Easy access to current and previous patient imaging data
  - May require transition period [both old films and digital images]
  - May require “incremental digitization” of old films
- Better utilization of tech and doctor time
  - May be offset by the need for computer expertise
  - Less time filing, tracking and retrieving
- No Darkroom
  - No film inventory
  - No hazardous chemicals (disposal and OSHA issues)
  - No automatic processor or hand developing tanks
  - No service contracts
  - Free up space for production or storage

What Would “Going Digital” Enable Me to Do? (that I’m not doing now)

- Improve quality of “marginal” exposures
  - NOT a solution to bad radiographic technique
  - NOT an alternative to quality control
  - Net effect is fewer “retakes”
- Retrieve images from any “enabled” computer
  - From home
  - At a meeting (wireless)
What Would “Going Digital” Enable Me to Do? (that I’m not doing now)

- Easily send images for second opinion
  - Direct internet transfer (ISPs upload speed)
  - NOT an alternative to quality control
    - e.g. send bad images and hope for information
- Easily send images for referral
  - Burn a CD/DVD
  - Direct internet transfer (ISPs upload speed)

Image Viewing (software/workstation)

- Provides tools for image manipulation
  - Magnification
  - Window/leveling
  - Hanging Display
  - Comparative viewing with previous images
  - Image labeling

Computed Tomography [window width]


Computed Tomography [window level]


What Are The Types Of Digital Radiographic Systems?

- CR (computed radiography)
  - Cassette-equivalent (europium-doped barium-fluorohalide crystallized matrix plate)
  - Laser spot scanning → photostimulation luminescence (PSL) → photomultiplier detection
  - X-ray → latent image in plate phosphor → light (PSL) → light detected → analog to digital conversion (ADC) → pixels
- CCD (charge-coupled device)
  - Scintillation phosphor → light → minification via optical coupling lens → CCD device
What Are The Types Of Digital Radiographic Systems?

- Flat Panel Detector
  - DR (direct digital radiography)
    - Amorphous selenium photoconductive layer yields electrons
    - Charges stored in matrix array or storage capacitors
  - DR (indirect digital radiography)
    - CsI (light from X-ray) \( \rightarrow \) photodiode (amorphous silicon) \( \rightarrow \) thin-film transistor storage

Diagram of CR

- Plates have embedded photostimulable phosphors
- Similar to the intensify screen phosphors used in traditional film cassettes
- Used just like film-based cassettes

CR Image Formation

- X-ray production \( \rightarrow \) x-rays thru patient
  \( \rightarrow \) strike plate
- Latent image formation on the phosphor plate
  - Low energy electrons in the phosphors are elevated and trapped in a metastable energy state

CR Image Formation

- Plate is placed in film reader “processor”
- Plate is scanned with a red laser light
- Laser light inputs energy into the plate, knocking the electron out of the trap.
- The electron returns to lower energy level by giving of excess energy as visible light

CR Image Formation

- Visible light energy is detected by a collection of PhotoMultiplier Tubes
- PMT’s amplify the light energy signal
- The analog energy signal is converted to a digital image via an analog to digital converter
- Image is ready for final processing

CR Image Formation

- The image is then computer processed with the appropriate algorithm
  - For example, a thorax image is processed to show bone, soft tissue, fat, and air opacities with appropriate relation contrast
  - A different algorithm would be applied to an abdominal image because of fat/soft tissue mixtures contributing to the image.
What about image resolution in these systems?

- **Spatial:** (line pairs/mm)
  - typical film-screen = +/- 10 lp/mm
  - CR = 2.5 – 5.0 lp/mm
  - DR = 2.5 – 5.0 lp/mm
- **Contrast:**
  - CR better than typical film-screen
  - DR better than typical film-screen

What Are the Costs Of Private Practice-relevant Digital Radiography?

- **CR**
  - Basic $40-75K
- **DR**
  - Basic $75-120K
- **CCD**
  - Basic $35-60K (with new X-ray table)
What Type Of Digital Radiography Is Best For Private Practice?

• CR (computed radiography/cassettes)
  – Moderate Volume (3-6 cases/day)
  – Need for flexibility (horizontal-beam, intra-op)
• DR (flat panel detectors)
  – High volume (> 10 cases/day)
  – Fixed to one machine unless use “portable” system
• CCD (digital camera equivalent under table)
  – Moderate to high volume
  – Fixed to one machine

Advantages of Tele-imaging

➤ Brings a radiologist “into” the clinic
➤ Improves diagnostic yield and accuracy
➤ Improves patient care
➤ Continual CE for the clinic

References
