Digital Imaging in Pathology

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A Complete Digital Imaging System?

† Pathology is largely “IMAGE-BASED”
† A pathologist is perfectly situated to control the imaging process in order to process useful visual and nonvisual data and communicate it to the patient’s health care Team.
† Pathologists’ time is valuable
† A systematic approach maximizes education and training which are essential in maximizing user efficiency
† Equipment support and reliability is more efficient
Image capture

Display
PATHOLOGY AND IMAGES

• Pathology is visually-oriented and the practice is based largely on image recognition, interpretation and presentation.

• Costs of Imaging Solutions have diminished over the past few years.

• Available software and hardware tools necessary have become widely available and more affordable.
Objectives

- Overview of *Digital Imaging*
- Acquiring Images
  - Current technical offerings and gadgetry
  - Ergonomic and workflow issues
- Processing Images
  - Properties of digital images
  - Image manipulation software
  - Storage
Digital Imaging

- A technique used to capture continuous phenomena.
- Digitization is performed by sampling at discrete intervals and results in discontinuous data or events.
- If the sampling is fine enough, the human sensory organs cannot discern the gaps between each measured element.
- Computers are digital machines because at their most basic level they can distinguish between just two values, 0 and 1, or off and on. All data that a computer processes must be encoded digitally, as a series of zeroes and ones.
- Digital representations are approximations of analog events.
Advantages of Digital Conversion

- Long-term cost savings
- Manageability
- Re-purposing of form and function
- “Instant” (no developing)
- Archiving, distribution and sharing
- Accessibility
- Broad applications
Moving the Real World to a Digital Grid

- Capture Elements -

- CCD (Charge Coupled Device)
- CMOS (Complementary Metal Oxide Semiconductor)

Hardware items containing capture elements:
- Digital cameras
- “Video” cameras
- Flatbed Scanners
- Film scanners
- Glass-slide scanners
CCD Basics

- Grid of minute photosensitive cells (*Resolution*)
- Each cell outputs analog voltage proportional to its incident light level (*Brightness*)
- Analog to Digital Converter (ADC) and Digital Signal Processor (DSP) produce digital output (*Bit depth*) for each cell
- Inherently monochromatic
Bit Depth

- $2^1$ (2 bits): 2 levels
- $2^2$ (4 bits): 4 levels
- $2^3$ (8 bits): 8 levels
- $2^4$ (16 bits): 16 levels
- $2^8$ (256 bits): 256 levels
Re-Creating ‘True’ Color

One CCD

One CCD

Three CCDs
Important Camera Features

- Body design
- Threading / SLR type mounting
- Lens type and quality
- Video out and frames per second
- File transfer connection types
- CCD size, resolution, grade, dynamic range
- Mechanism of obtaining color (e.g. 1 CCD, 3CCDs)
- White balance capabilities
- Supported file types
- Remote capture software / Other
CCD Resolution

- Pixel
- “Mega-pixel”
- 3-megapixel CCD
  - 2,048-by-1,536 image
  - ~1MB for JPEGs/10MB uncompressed TIFFs
- 5 megapixel
  - 2560 x 1920 image
  - ~2.5MB for JPEGs/15MB uncompressed TIFFs
Workflow Issues

- Image capturing should be integrated directly into the workflow process in order to be performed routinely
- Desk space limitations and congestion
- Physical access to imaging system(s)
- *Training* on imaging system(s)
- System reliability and up-time
PICSPPlus gives the CoPathPlus user the tools to acquire and insert an image directly into a currently active patient record.

- Images can be drawings, diagrams, or text images that have been scanned into an image format.
- Pathology department images are typically acquired in the grossing room, at the microscope, or in an autopsy room.
- Other image capture areas can be from a crime scene, surgery, examining rooms, etc.
- Images can be imported into a report from any place that an image can reside and be accessed.
ONCE YOU HAVE ACQUIRED GOOD QUALITY IMAGES...

How do you improve them:
VARIATIONS IN DIGITAL IMAGES

**Good Image**

- Resolution
- Color
- Contrast
- Brightness

Accurate Reproduction

**Bad Image**

- Resolution
- Color
- Contrast
- Brightness

Poor Reproduction
Image Processing

For our purposes: use of computer software to manipulate the contents of a digital image file

Examples:
- Changing size
- Altering brightness and contrast
- Altering color
- “Cleaning” the image
- Enhancing the image (e.g. sharpening)
- Erasing/Adding content
- Compressing the image file
- Changing file formats
Features to Look for in Software

- Supported file types
- Methods of importing images
- Advanced control over manipulation functions
  - Resizing algorithms
  - Palettes
  - Tonal controls
  - Sharpening controls, other filters
  - Brightness and Contrast
- Layers
- Annotations
Image Size - Resizing

- Size follows function
- Easiest to think first in terms of absolute pixel count per dimension
- Interpolation
Brightness and Contrast

Preservation of detail is paramount
Enhancing Images

- Sharpening
- Blurring
- Recoloring
Cleaning Images

- Removing scratches and speckles
- Removing bloody/dirty backgrounds
- Removing distractions to focus on region of interest
- Removing floaters
- Potential ethical issues arise
File Formats

- Specifies the exact structure of stored digital bits within the computer image file
- Compatibility issues
  - Application
  - Platform
- Supported bit depths
- +/- Inclusion of/Support for compression
- Special features (e.g. layers etc.)
- May include additional information along with raw image data
Compress or UnCompressed Images

- **Uncompressed**
  - Largest file size
  - Exact copy of original data
  - TIFF

- **Lossless**
  - An exact copy of the original data is obtained after decompression
  - Image will not be degraded.
  - No information is lost
  - Structured data can be compressed up to 40-60 percent of original size
  - GIF, PNG, BMP, JP2

- **Lossy**
  - Original information content is lost
  - Any data can be compressed. Sometimes by 90% or more
  - JPG, JP2, MPG
Archiving the Images

- Once you are able to capture and create digital images.
- The images exist as digital files.
- The images are accurate reproductions of the slide or picture.
- Files are saved in the best file format with optimal sizes.
- Many files start to collect…….
Archiving and Utilizing the Digital Images

Utilizing Digital Images
- Current common uses
- Current uncommon uses
- Future uses
IMAGE MANAGEMENT AND UTILIZATION

- Capturing a digital image
- Adjusting the image
- Amassing images
- Indexing, Cataloging
- Storing and Maintaining images
- Display and Output
• Image management is a process of managing the workflow of digital images over internal and external networks.

• Images are then collected and stored to temporary or permanent archives, by means of a structured database or an image filing system.
Spectrum of Images per Case

- Single image files
- Grouped and/or tiled image files
- Full slide scan files
Naming / Labels

Each file will need a unique identifier
- For example, labeling image files with case number and auto-incrementing tag

   SYS-11213-1a-1.JPG

Manual / Automated labelling
- Barcoding, Cross-talk with LIS

Protected Health Information
- De-identifying with databases
- Anonymization
Professional image management and control. Instantly access your images

ACD Systems
http://www.acdsystems.com/English/index.htm
Tracking With Off-the-Shelf Applications

ACD Systems
http://www.acdsystems.com/English/index.htm
Potential Fields:

- Case number
- Patient demographics
- Image type
- Microscopic objective power
- Organ/Site
- Diagnosis(es)
- Rare flag
- Teaching material flag
- Altered flag

Customized database backend designed for broad or narrow purposes.
Some modern LIS applications are able to directly incorporate images.

Some modern HIS systems can handle images.

Alternatives include building a standalone imaging system with an *interface* to the LIS for associated data.

Copathplus ---> PICSPLUS
Spectrum of Imaging Tracking Applications

- File system free-for-all
- Single user local app.
- Multi-user networked app.
- Networked, distributed, LIS-integrated app.
- Images within LIS/HIS/PACS
Requisite Skillsets
Potential Uses for Digital Images

- Teaching
- CPC conferences
- QA/QC
- Publications
- Image-enhanced reporting
- Consultation
- Telepathology
- Retrospective case review assisting diagnosis
- Primary diagnosis
- Advanced image analysis
32 years old man with history of surgical removal of lower extremity tumor several months ago. He has multiple skin lesions. What underlying disease does he have? Guess what his lower extremity tumor might have been.

Presented by:

Syed Z. Ali, MD, Associate Professor, Pathology

Sheila Sheth, MD, Associate Professor, Radiology

Amit V. Parwani, MD, Ph D, Pathology Fellow
Diagnosis:

Metastatic Malignant Peripheral Nerve Sheath Tumor (MPNST)

Discussion:

Malignant peripheral nerve sheath tumor represents approximately 10% of all soft tissue sarcomas. It's found in approximately 4% of patients with neurofibromatosis I, where its development is thought to be a multi-step, multi-gene process. Approximately 10% of these cases are associated with irradiation. MPNST is usually found in the lower extremities, but can also occur in the head and neck region, usually associated with the large cranial nerves. Intraosseous occurrences have also been reported. The degree of anaplasia varies considerably in these tumors. Spindle cell morphology is most common, but epithelioid and even clear cell tumors also occur.
Case Annotation

Not true surgical margin (Margin in Specimen 2)
Publications
Here at the Department of Pathology, University of Pittsburgh School of Medicine we have begun highlighting different cases each month that are of greater than normal clinical interest, have unusual symptoms and/or diagnostic findings, or involve rare diseases or conditions. Below are links to the current Anatomic and Clinical Pathology Case of the Month.

- **Anatomic Pathology Case of the Month**
- **Clinical Pathology Case of the Month**

http://path.upmc.edu/casemonth.html
ATIENT HISTORY:

3-month-old male infant with pain over the left scrotum for two days. The mother noticed bluish discoloration of the left scrotum and took the patient to the hospital. Ultrasound of the scrotum revealed no flow to the left testis and flow to the right testis. Physical examination revealed hard and enlarged left testis, 2 cm, tender to palpation. The right testis and the penis were normal in appearance. Lab test showed normal AFP level.

ROSS DESCRIPTION:

The specimen consists of a 2.3 x 1.5 x 1.5 cm testicle with epididymis, appendix testis and spermatic cord. The entire specimen weighs 5.0 g. Cut surface of the testis shows a bulging, white-light tan tumor surrounded by a thin rim of tan-pink testicular tissue and tunica (Fig. 1). The tumor measures 1.7 x 1.4 x 1.4 cm. It is circumscribed, white, homogeneous soft mass with a centrally located, 0.2 cm in greatest dimension, cavity that contained straw yellow, clear fluid. The testicular tissue surrounding the tumor measures between 0.5 cm and 0.1 cm in thickness, and the mass appears to involve the rete testis. The epididymis does not appear to be grossly involved.

MICROSCOPIC DESCRIPTION:
Pathology Images in Pathology Reports

- Business driven versus clinical function
- More useful for certain report types
- More useful for certain service types
  - Consultations
  - Autopsy
  - Dermatopathology
  - Hematology/Heme-oncology
  - GYN/Breast & GU/Prostate
  - GI
- Printing versus ‘online’ viewing
- May Lead to Legal issues.
Integration of Images in Pathology Reports

Dear Doctor Ruby,

Thank you for sharing the photomicrograph in the text. The histological features observed in the specimen suggest a diagnosis of a specific type of neoplasm. The neoplastic cells are arranged in a pattern consistent with a malignant tumor.

Diagnosis:
1. Poorly differentiated carcinoma in situ with evidence of invasion in submucosa.
2. Poorly differentiated adenocarcinoma with invasion of the submucosa.

Thank you for considering this diagnosis.

Sincerely,

Helen F. Rabin, M.D.
Assistant Professor of Pathology
Yale University Hospital
HBSAEC
Pathology Images in the Electronic Medical Record

Without careful considerations, pathology images will likely be underutilized.

Important features might be:
- Rich clinical context
- Annotation
- Timeliness
- Number and type of images
- Customized by clinical service type

Other Areas of Digital Imaging

*Static* telepathology for expert/subspecialist consultation

*Hybrid* telepathology without robotics for consultation

*Dynamic* telepathology with robotics for full pathology services

*Whole-Slide Scanning* for:
- Distance education
- Telepathology
- QA/QC, CME, proficiency testing, Primary Diagnosis
Diagnostic Imaging-System Considerations

- Physical size, resolution, characteristics of monitor
- Image Resolution
- Color (Bit) depth
- Color correctness
- Frames per second of live display
- Refresh speed (responsiveness to remote movement)
- Telepresence to remote site
The Future of Pathology Imaging

- Live interaction
- Large, ultra-sharp displays
- Full control of remote ‘microscope’ with instantaneous response times
- “Glass quality” images
- Real time image analysis