Image Display & Manipulation 8

Image Production Evaluation and Archiving

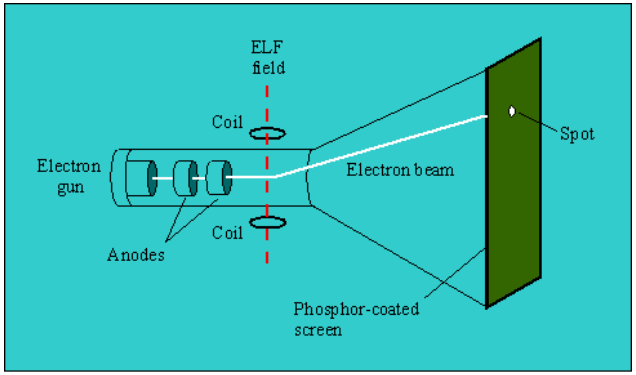
Cathode Ray Tube - CRT

- A cathode-ray tube (CRT) is a vacuum tube containing one or more electron guns
- The beams are manipulated to display images on a phosphorescent screen.
- The images may represent electrical waveforms (oscilloscope), pictures (television set, computer monitor), radar targets, or other phenomena.
- Flat Panel Screens NOT CRTs are now used in most devices

Advantages of Each Technology

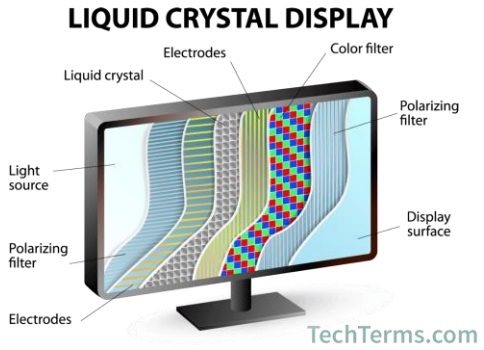
Flat Screen Panel - LCD

- Light Weight
- Low Power Use
- Much Larger Size

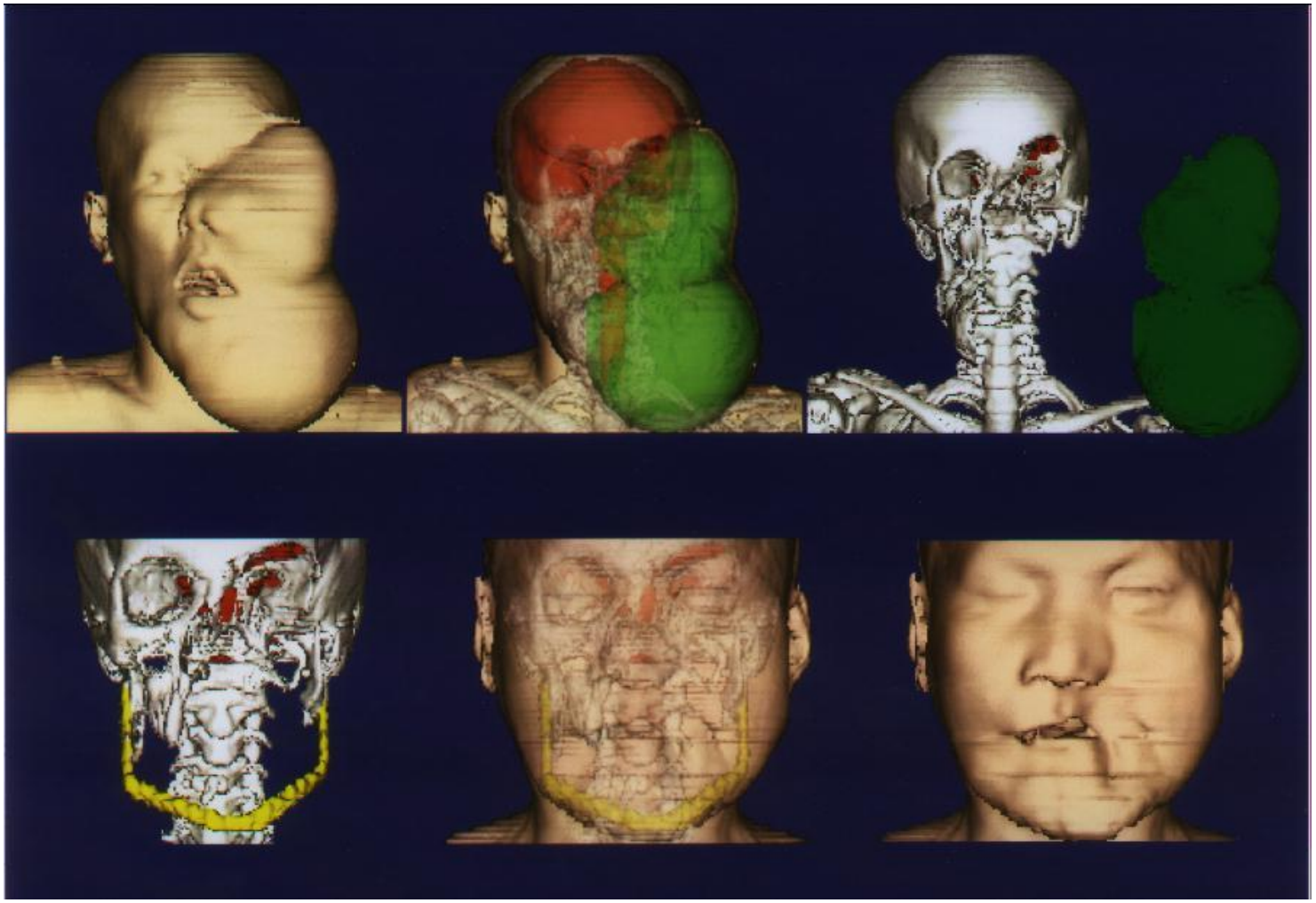


Cathode Ray Tube - CRT

- Look Good at Any Resolution
  - Do not have pixels
- Blur-Free Motion
- Incredible Black Levels



Post-Processing



Post-Processing (Manipulation)

Post Processing is the manipulation of both RAW data and IMAGE data after scanning.

- **Result in Retrospective Images**
- **Images planned prior to scanning are Prospective Images**

2 Types of Post Processing

- **Reconstruction**
  - **When raw data are manipulated to create pixels that are then used to create an image**
  - **Can only be done from operator console**

- **Reformation**
  - **When image data are assembled to produce images in different planes, or to produce 3D images**

Retrospective Reconstruction

- Many parameters can be changed in retrospective reconstruction, but the images that result are always in the same plane and the same orientation as were the original images

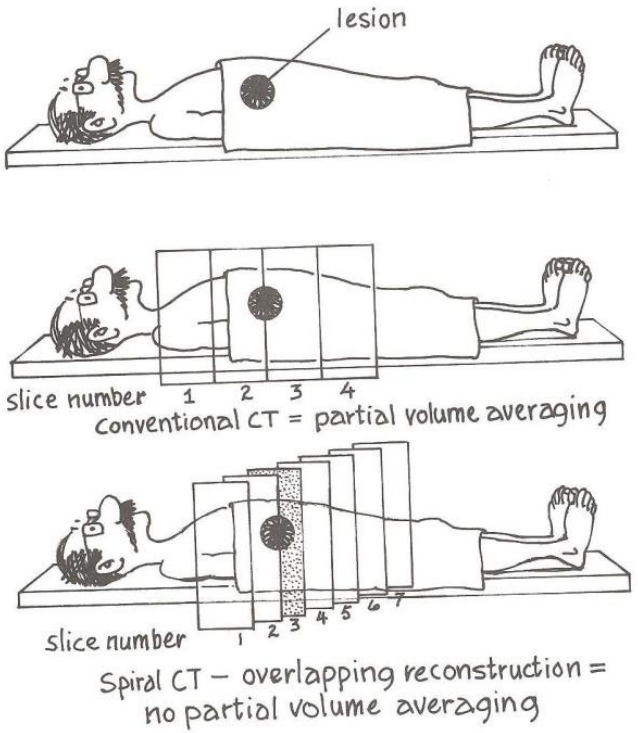
- Parameters that can be change retrospectively are
  - DFOV
  - Image center
  - Reconstruction Algorithm
  - Slice Incrementation (on helical data only)
  - Image thickness (on MDCT systems only)

Overlapping Reconstructions

- **Overlapping reconstructions (image incrementation) can be changed on helical data from either SDCT or MDCT systems.**

- **This is often done to produce overlapping images that are then used in MPR or 3D reformations**

- **The thicker the original slice the more beneficial will be overlapping reconstructions**



Retrospectively Changing Image Thickness

- On MDCT systems, data from the parallel rows of detectors can be combined in different ways to create thicker slices for viewing or storing

- The goal of using a thin slice for scanning and reconstructing thicker slices for viewing and storing is to:

  1) Maintain the advantage of high-resolution thin slice imaging
  2) Create image files that are manageable and more easily reviewed by radiologists

Filter Functions

- Filtering is used to minimize streaks on the image that result from back projection
- Filtering is done by a series of complicated mathematic steps, often referred to as a reconstruction algorithm
- Applying a filter function to an attenuation profile is called convolution
- **NOTE: this is not a physical filter as in the x-ray tube but a mathematical filter

Filter Functions (cont'd)

- Many different filters are available
  - They use different algorithms depending on which parts of the data must be enhanced or suppressed
    - Some will "smooth" the data, reducing the difference between adjacent pixels
    - Some reduces artifacts but also reduces spatial resolution

Filter Functions (cont'd)

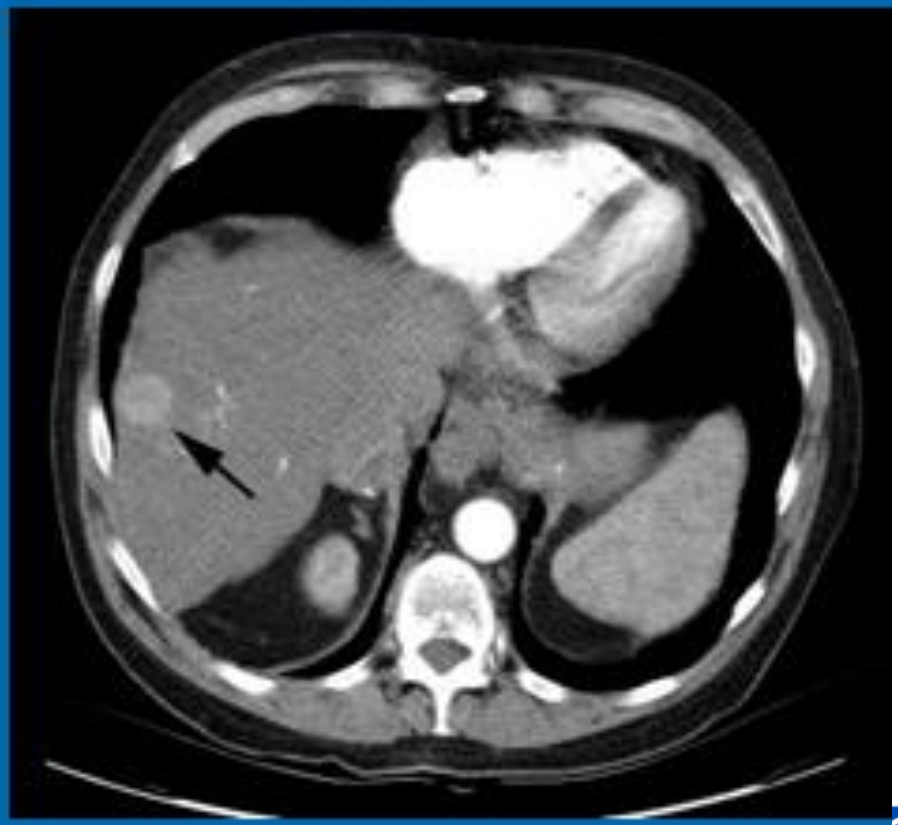
- Others enhance contrast by accentuating the difference between neighboring pixels
  - Improves spatial resolution, but at the cost of low-contrast resolution
- Filter functions may be referred to as algorithms, convolution filters, or kernels
- <u>Filter functions can only be applied to raw data</u>

HIGH AND LOW PASS

- High pass filters are used for imaging bone, inner ear, etc.
- High pass filters result in images with enhanced edges, short scale of contrast, and much more noise
- Low pass filters are used for imaging soft tissue such as brain and liver
- Low pass filters appear less noisy with a long scale of contrast

High Pass Filtering
Edge Enhancement

Low Pass Filtering
Smoothing



CONVOLUTION FILTERS

- **Low pass filters (smoothing):**
  - **suppress high spatial frequencies, causing the image to have a smooth appearance and possible improvement in contrast resolution**

- **High pass filters (edge enhancement):**
  - **suppress low spatial frequencies, resulting in edge enhancement and possible improvement in spatial resolution**

ALGORITHMS

- **A set of rules or directions for getting a specific output from a specific input**

- **Reconstruction algorithms are a set of well-defined software steps designed to produce an image from a given input**

- **Each algorithm uses a different mathematical formula for processing data, which will enhance certain features of the CT image.**

Example:

Bone algorithm-enhances the edges of anatomic structures and higher contrast image is produced
Soft tissues algorithms –reduced contrast and smoothes

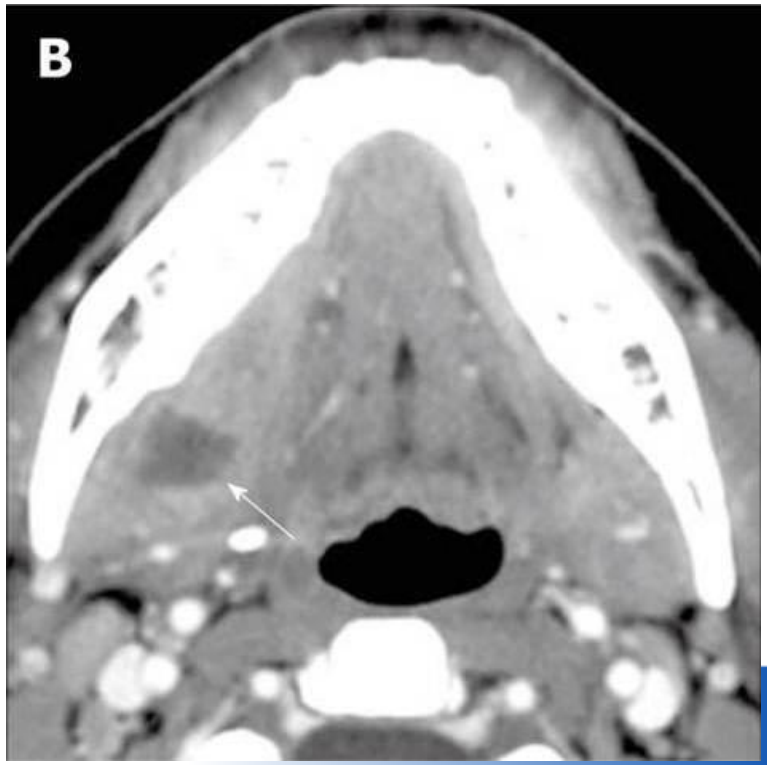


Image Reformation

- Also called image rendering
  - Think of the loaf of bread
  - and different ways of slicing it.

- To reformat a CT study all the source images must have identical
  - DFOV
  - Image center
  - Gantry tilt
  - And have no gaps (all slices contiguous)

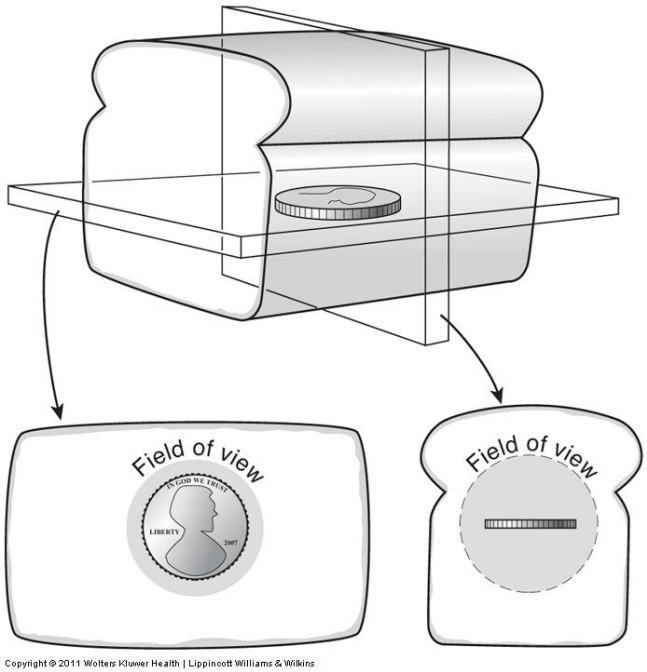


Image Reformation

- Only image data are used to generate images in a different plane or orientation
- Used to better display anatomic relationships
- May be either two- or three-dimensional

- In general, the thinner the original slice, the better the reformatted image

Multiplanar Reformation

- Process of using image data to create a view in a different body plane

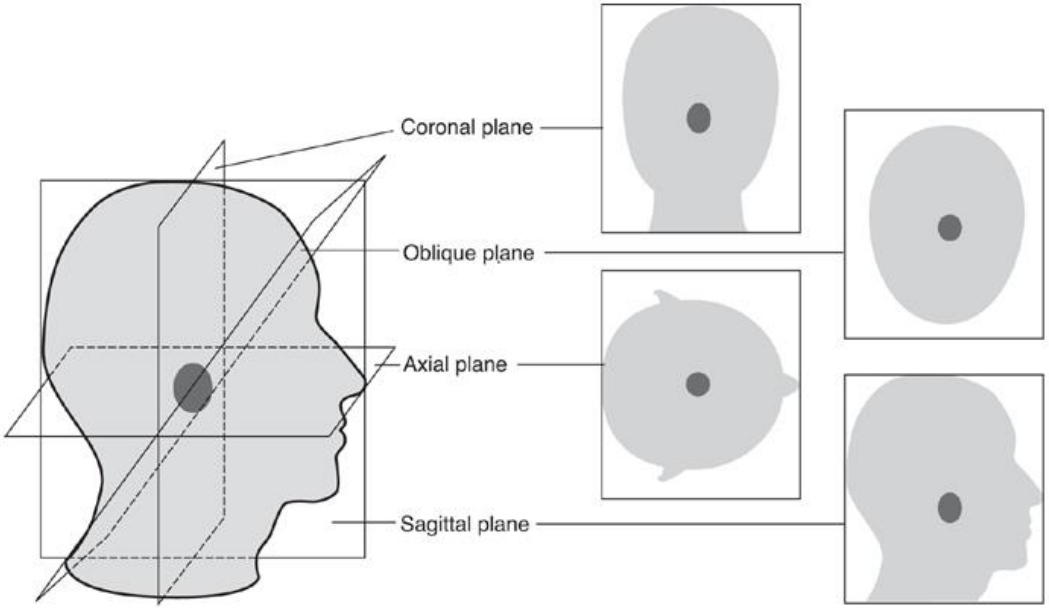
- When the voxels of the image are isotropic (same in the x,y, and z plane) there is almost no loss of image quality in the new plane

- The quality of the reformations depend on the quality of the axial images

  - The slice thickness affects image detail –thick slices result in blurring and loss of structural detail

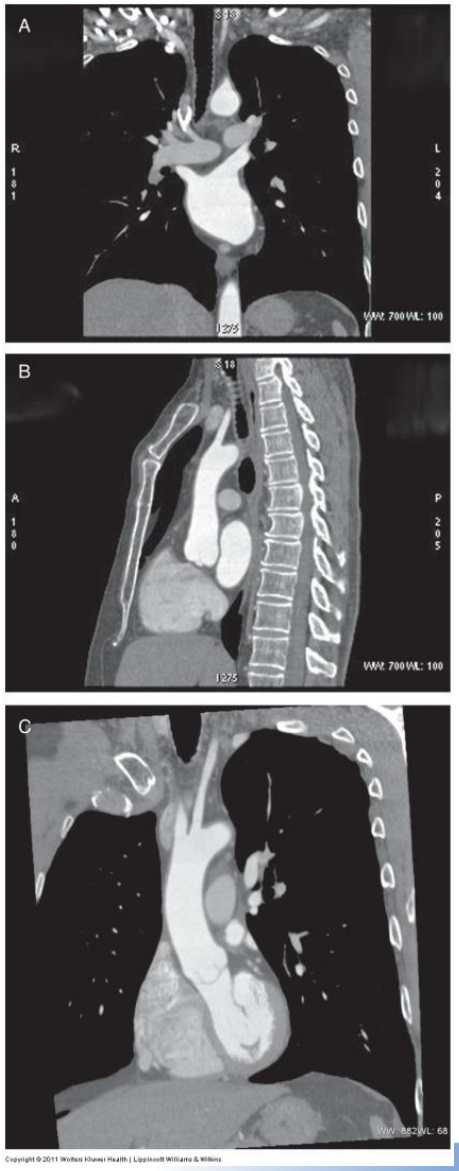
Multiplanar Reformation (MPR)

- **Multiplanar reformations are two-dimensional in nature**
- **2D image displays always represent the original CT attenuation values**



Multiplanar Reformation

- Coronal
- Sagittal
- Oblique



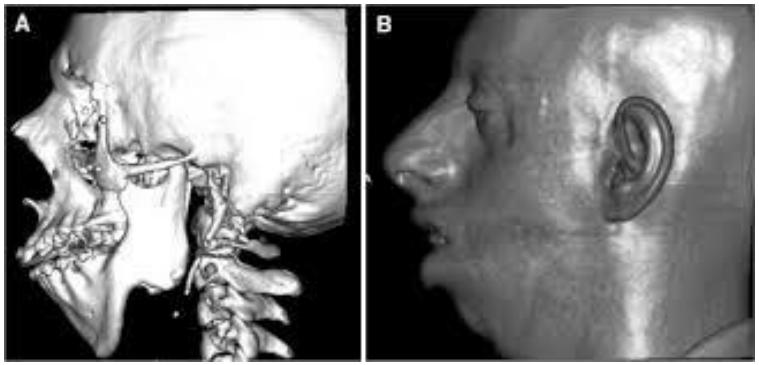
3D Reformation

- 3D Reformations seek to represent the entire scan volume in only one image
- 3D techniques manipulate or combine CT values to display an image
  - the original CT value information is not included
- Two Types of 3D Reformation or Rendering
  - Surface rendering (SR) or Shaded Surface Display (SSD)
  - Volume Rendering (VR)

Surface Rendering

Also called Shaded Surface Display - SSD

- **The computer creates representation of surfaces that will be visible in the displayed image and then lights according to a standard protocol and displays the image.**



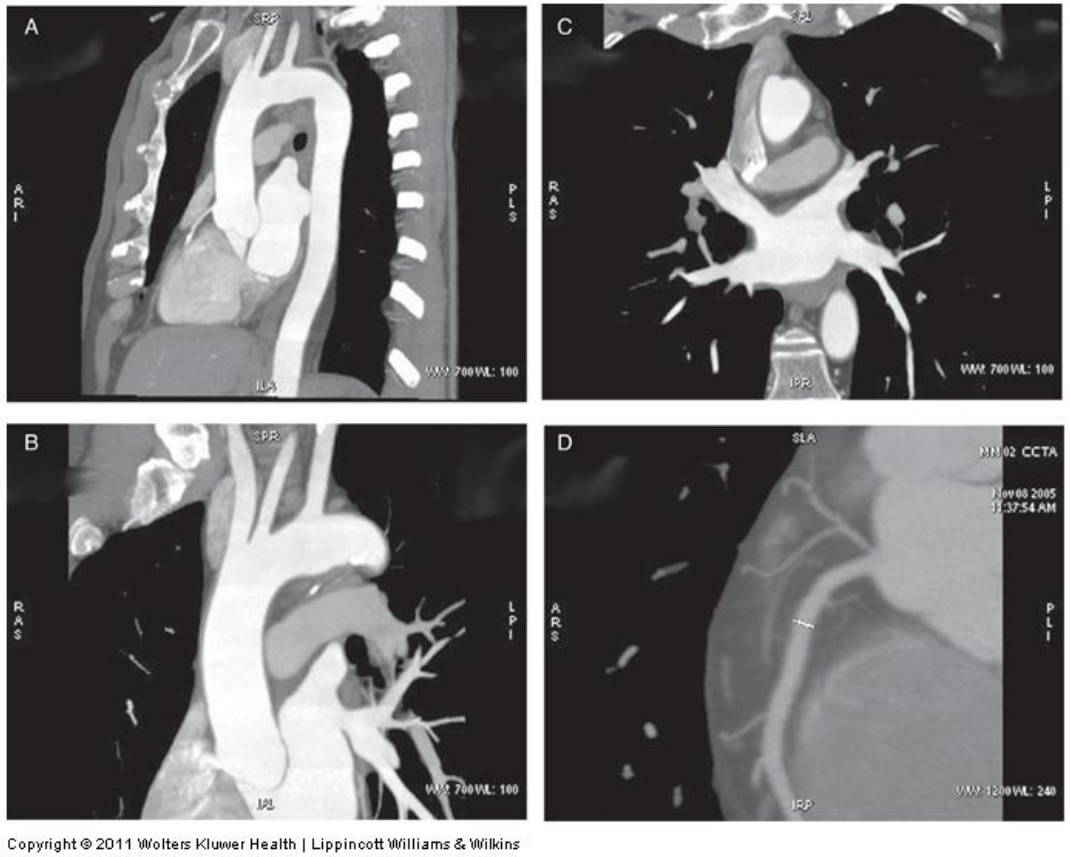
- **Looks much like a photograph**

- **The computer uses a threshold value to determine which voxel values to use to make the image**
  - **Those voxel s with a value above or below the threshold will not be included in the image**

- **Surface rendering uses only a small portion of the voxels to make the image**

MIP Projection Display

- **Maximum-intensity projection (MIP)**
  - **Selects voxels with the highest value to display**
  - **Best for displaying bone and contrast filled structures**



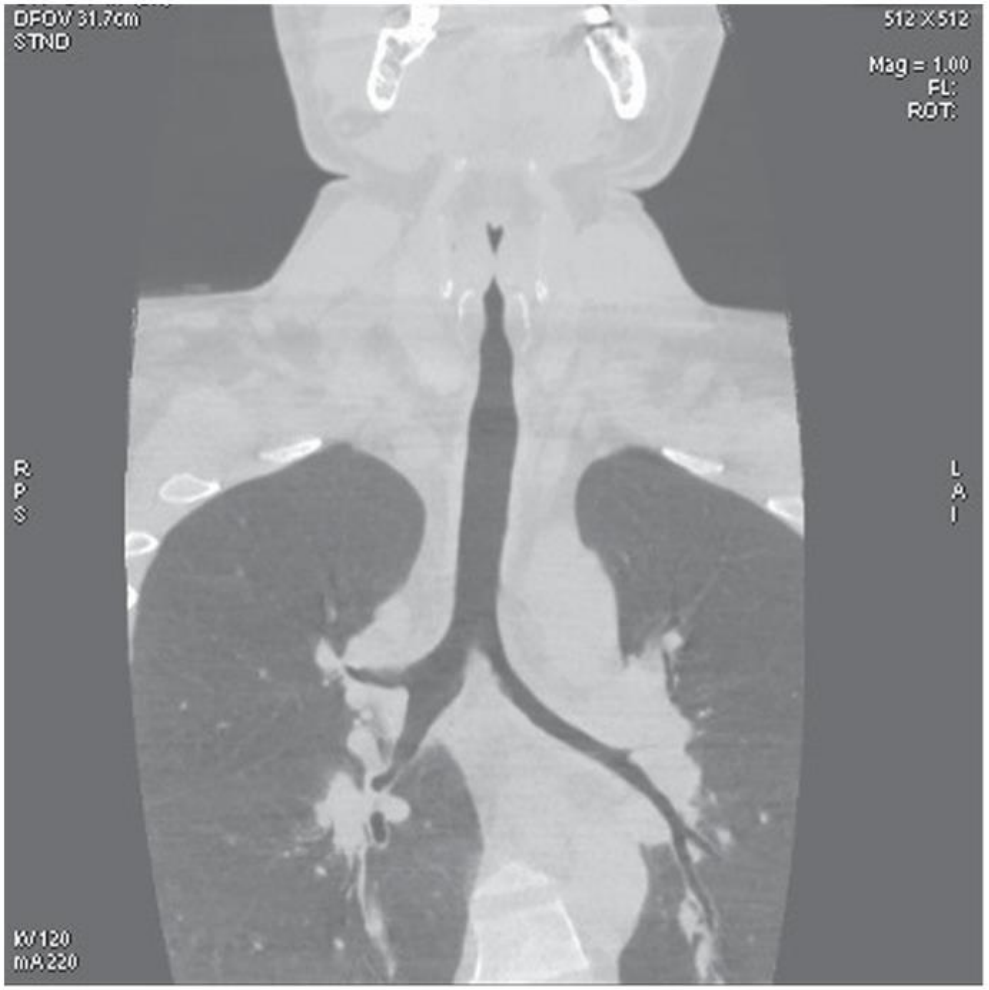
MIP Limitations

- A basic problem with MIP is that unless depth cues are provided, images are 3D ambiguous

- Generates a ‘string of beads’ or “string of pearls” artifact

MinIP Projection Display

- **Minimum intensity projection (MinIP)**
  - **Selects voxels with the lowest value to display**
  - **Useful for displaying the bronchial tree**



Volume Rendering (VR)

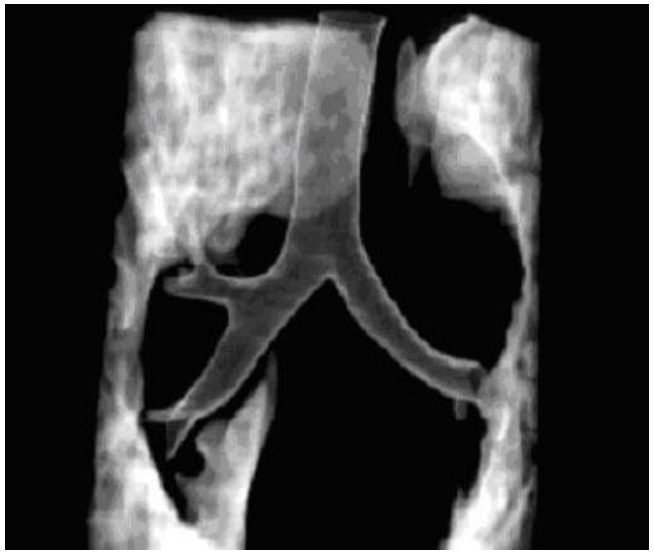
- 3D semitransparent representation of the imaged structure
- It has become the favored 3D image technique
- An advantage is that all voxels contribute to the image
- Allows the image to display multiple tissues and their relationship to one another

Volume Rendering

- Lets viewer see thru for both internal and surface structures
- Better quality 3D images with more information
- Uses the entire data set from 3D space
- Requires more computing power

Endoluminal Imaging (Virtual Reality Imaging)

- A form of VR
- Also called perspective volume rendering or virtual endoscopy
- Designed to look inside the lumen of a structure



Applications of Virtual Endoscopy

- Evaluate the colon (virtual colonoscopy or colonography)
  - Colon is filled with air or CO2
  - Imaged in both supine and prone positions
- Evaluate the airways (virtual bronchoscope)
- Evaluate the pancreatic and common bile ducts (virtual cholangiopancreatoscopy)
- Evaluate the inner ear (virtual labyrinthoscopy)

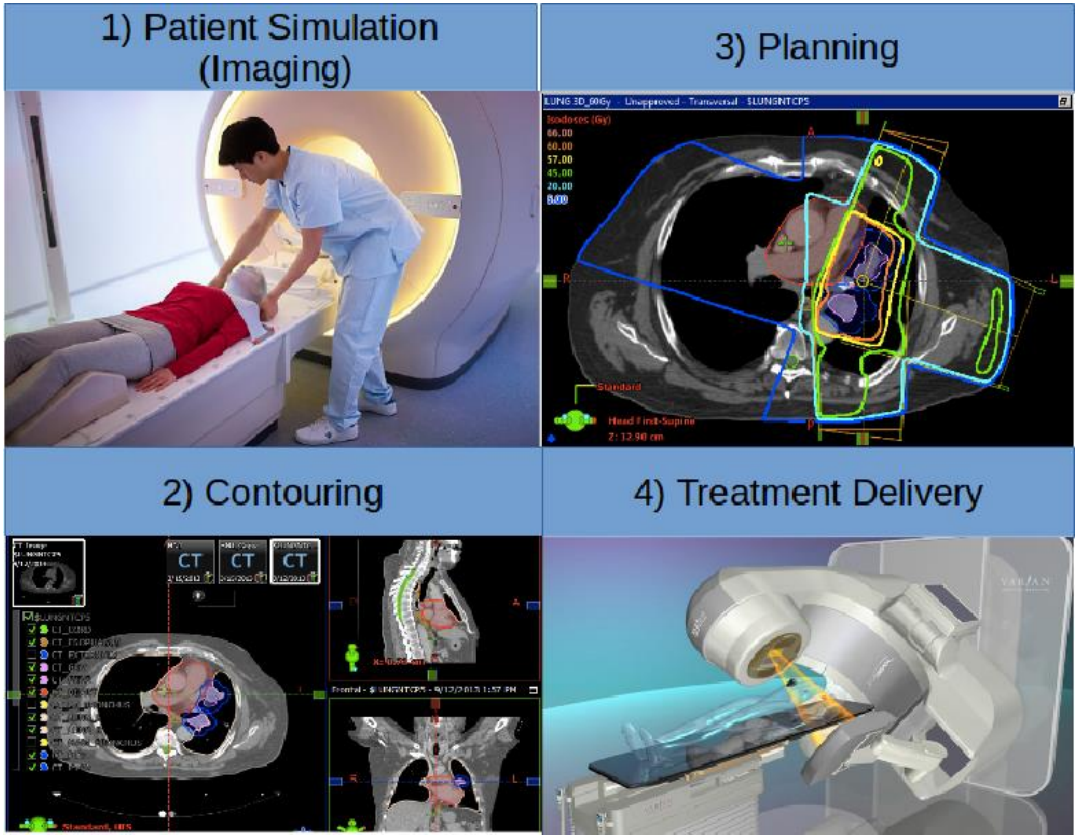
Video of Vitrual Colonoscopy

Factors That Degrade Reformatted Images

- Segmentation errors
  - Areas that are edited out accidentally
- Image noise
  - Incorrect factors used to obtain images
- Artifact
  - Motion
  - Metal
  - Stair-step
    - Caused by thick slices or change of DFOV

Radiation Therapy

- Radiographs have always been used in Radiation Therapy planning
- 3D CT images became more useful because of volume planning and tissue densities
- 3 step process
  - Patient scanning
  - Treatment planning and CT simulation
  - Treatment setup



CT Simulation Process

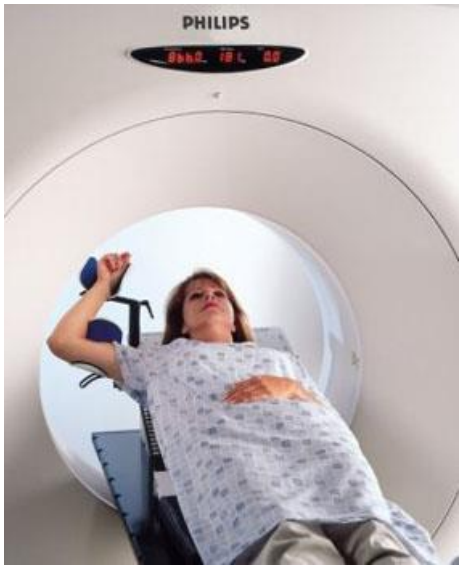
- 3 steps
  - Patient Scanning
    - Pt. scanned in the exact position as treatment
    - Electron densities from the image data are used to compute dose distributions
  - Treatment Planning and CT simulation
    - Beam placement and treatment design are executed using the virtual simulation software
  - Treatment Setup
    - CT simulation software used to set up the patient in the treatment machine

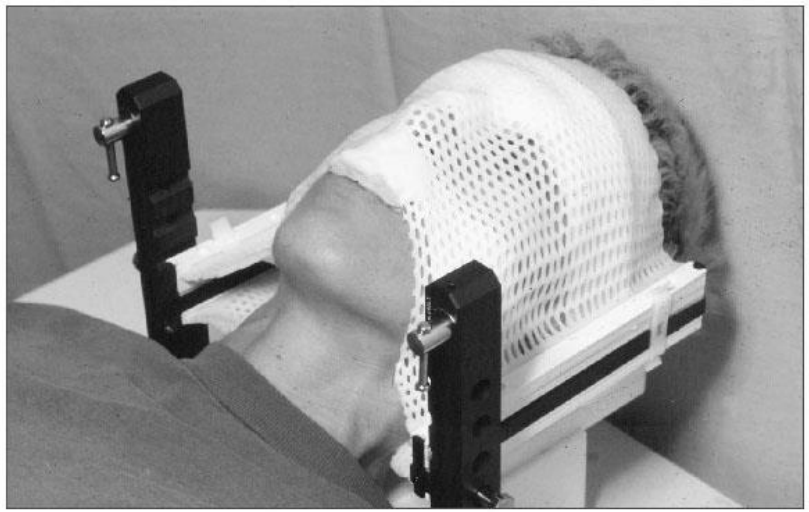
CT Scanning for Radiation Therapy

- CT Scanners for Therapy Planning
  - Have flat table tops with immobilization devices
  - Larger gantry for specific positions for therapy planning
  - Registration devices to insure that the immobilization devices can be used in the exact manner on the treatment table as the CT scanning table
  - Laser system for exact positioning with the axis of the CT scanner

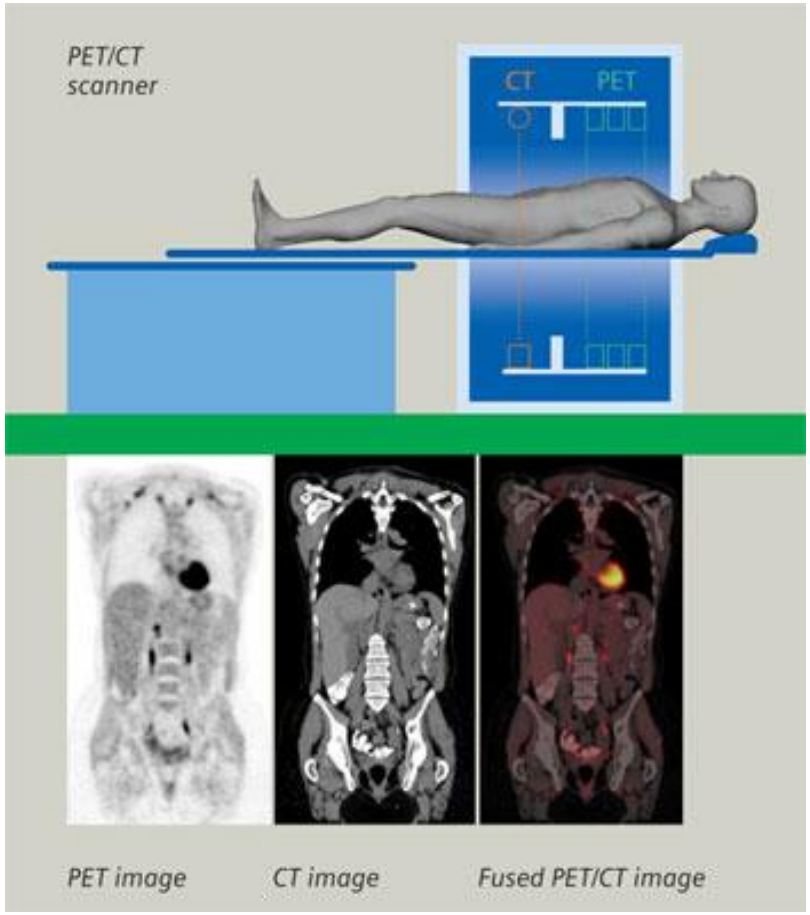
CT Therapy Planning

- Flat Table Top
- Larger Gantry
- Immobilization devices



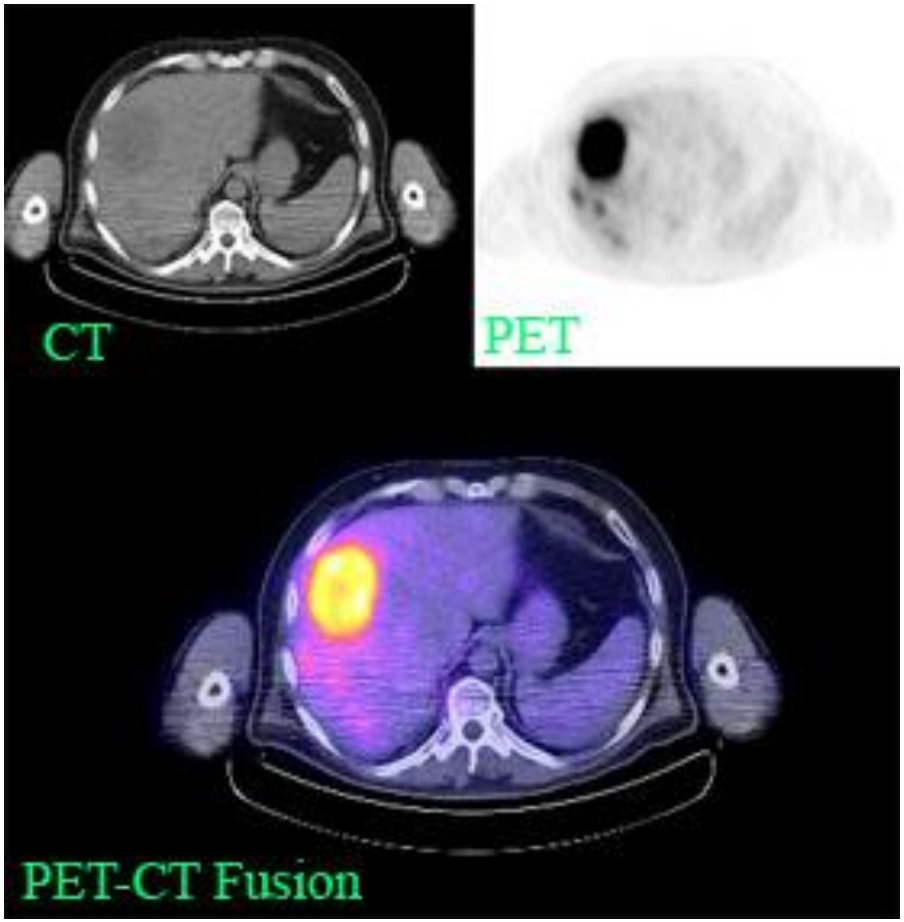


PET/CT Fusion Imaging



What is PET/CT

- CT is Computed Tomography
- PET is Positron Emission Tomography
- When Fused together you get the best of both
  - The anatomic detail of CT
  - The metabolic detail of PET



Introduction

- Anatomic imaging provided by CT
  - CT has a high sensitivity for the detection of structural abnormalities
  - CT not as useful in characterizing these abnormalities as malignant or benign

- Molecular imaging is a methodology that investigates events at the molecular and cellular level
  - The nuclear medicine study known as positron emission tomography (PET) is a molecular imaging method that provides metabolic detail

- Whereas CT provides structural information about the body, PET provides functional information regarding how the cells of the body operate

CT Fusion

- CT or PET can be used individually or combined for diagnosis
- A combination of the modalities provides the most complete diagnosis
- “Fusing” the images provides information on both cancer location and metabolism
- Past attempts were made to fuse CT and PET studies that were performed at different times, in different places, and on different equipment
- Aligning the images was problematic

- **PET/CT scanners are composed of a multi-detector CT scanner in conjunction with, but separate from, a PET scanner**

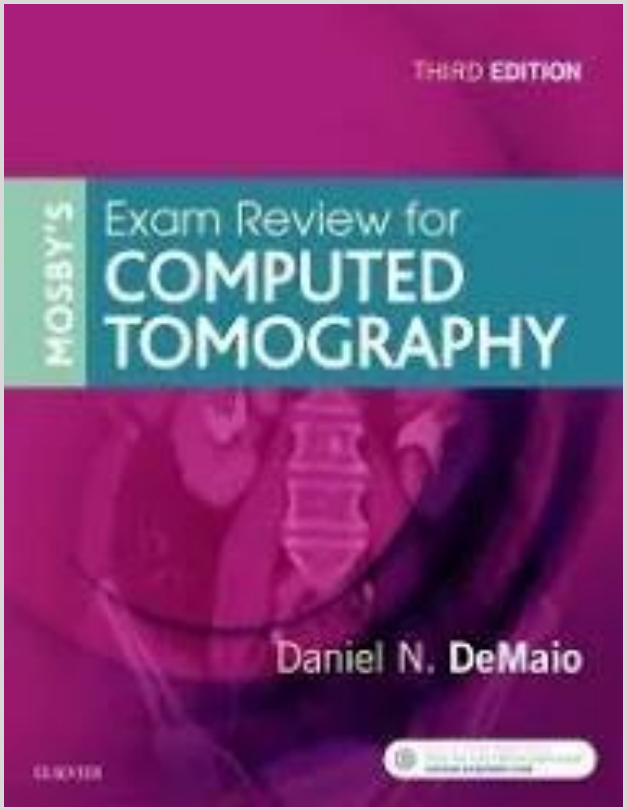
- **During the study the patient passes first through the CT scanner and then into the imaging field of the PET scanner**

- **In PET/CT the strengths of the two modalities complement each other**

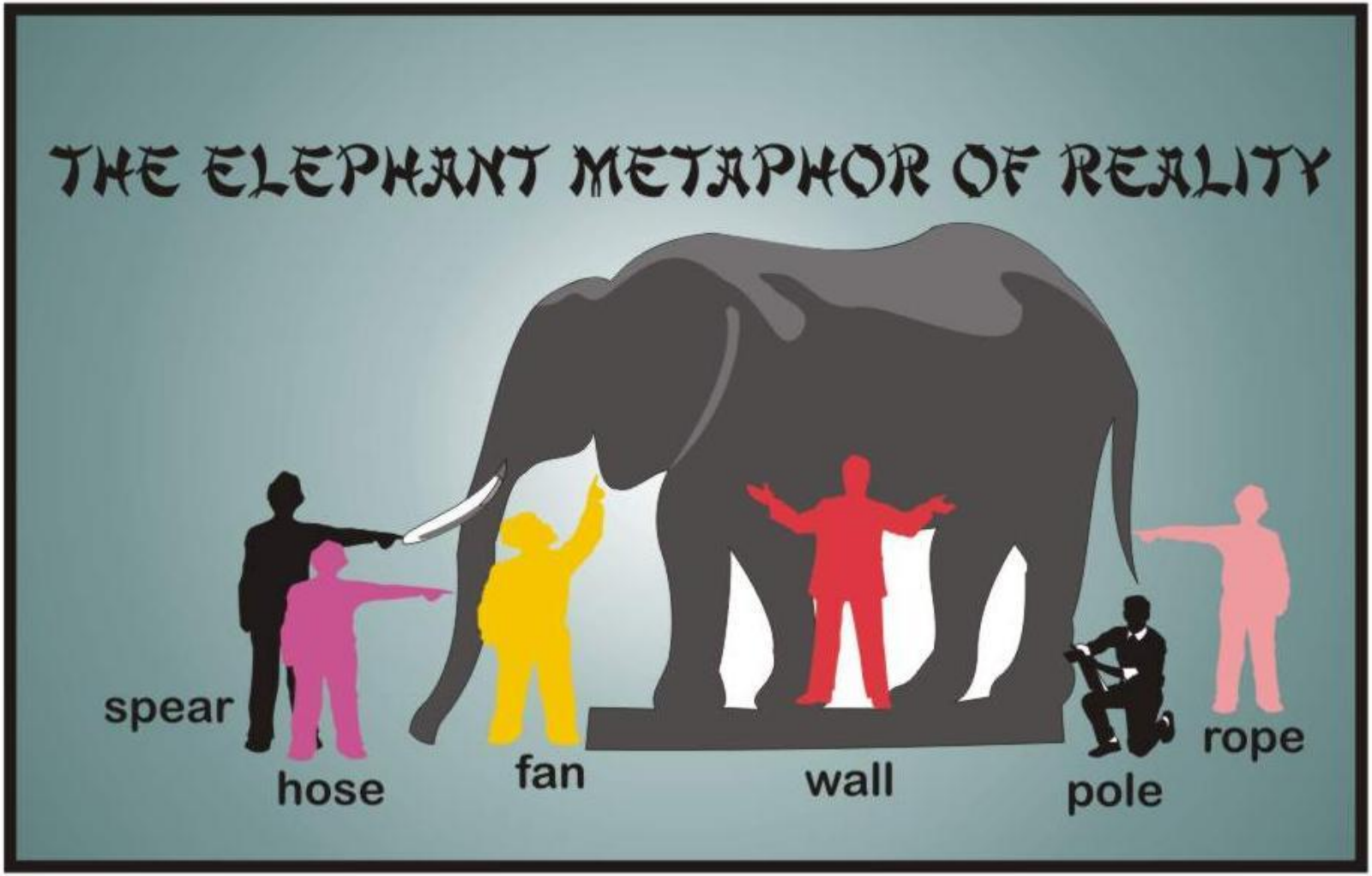
Who Can "DO PET/CT

- CT is a radiographic study
- PET is a nuclear medicine study
- Most technologist are not trained and certified in both fields
- Holding certification with ARRT (R or NM) or NMTCB allows one to sit for the CT Registry.
- Most facilities require certification in NM to perform PET/CT studies
- May require certification in CT also

Review Book



- **Highly Recommended**
- **Online Version has hundreds of questions for practice with explanations**
- **Mock Registry and Mock Registry of individual sections.**


THE ELEPHANT METAPHOR OF REALITY
spear
hose
fan
wall
pole
rope