

Image Display & Manipulation 8

Image Production Evaluation and Archiving

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Cathode Ray Tube - CRT

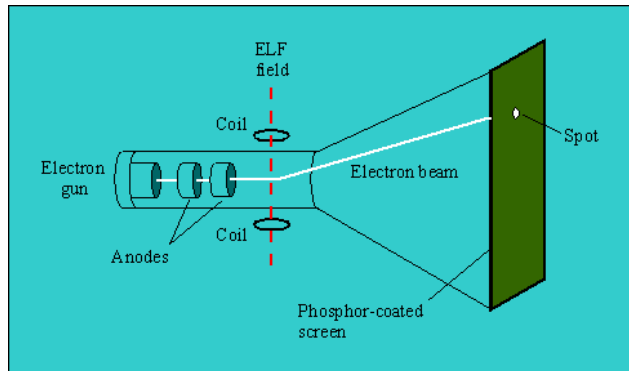
- **A cathode-ray tube (CRT) is a vacuum tube containing one or more electron guns**
- **The beams are manipulated to display images on a phosphorescent screen.**
- **The images may represent electrical waveforms (oscilloscope), pictures (television set, computer monitor), radar targets, or other phenomena.**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



Advantages of Each Technology

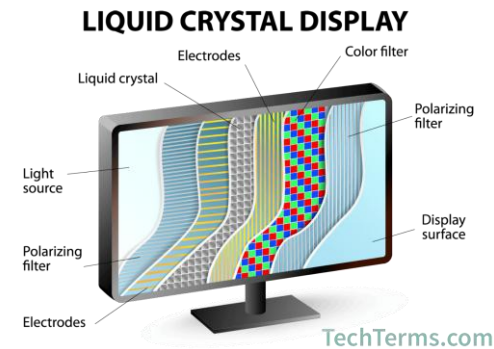
Flat Screen Panel - LCD

- **Light Weight**
- **Low Power Use**
- **Much Larger Size**

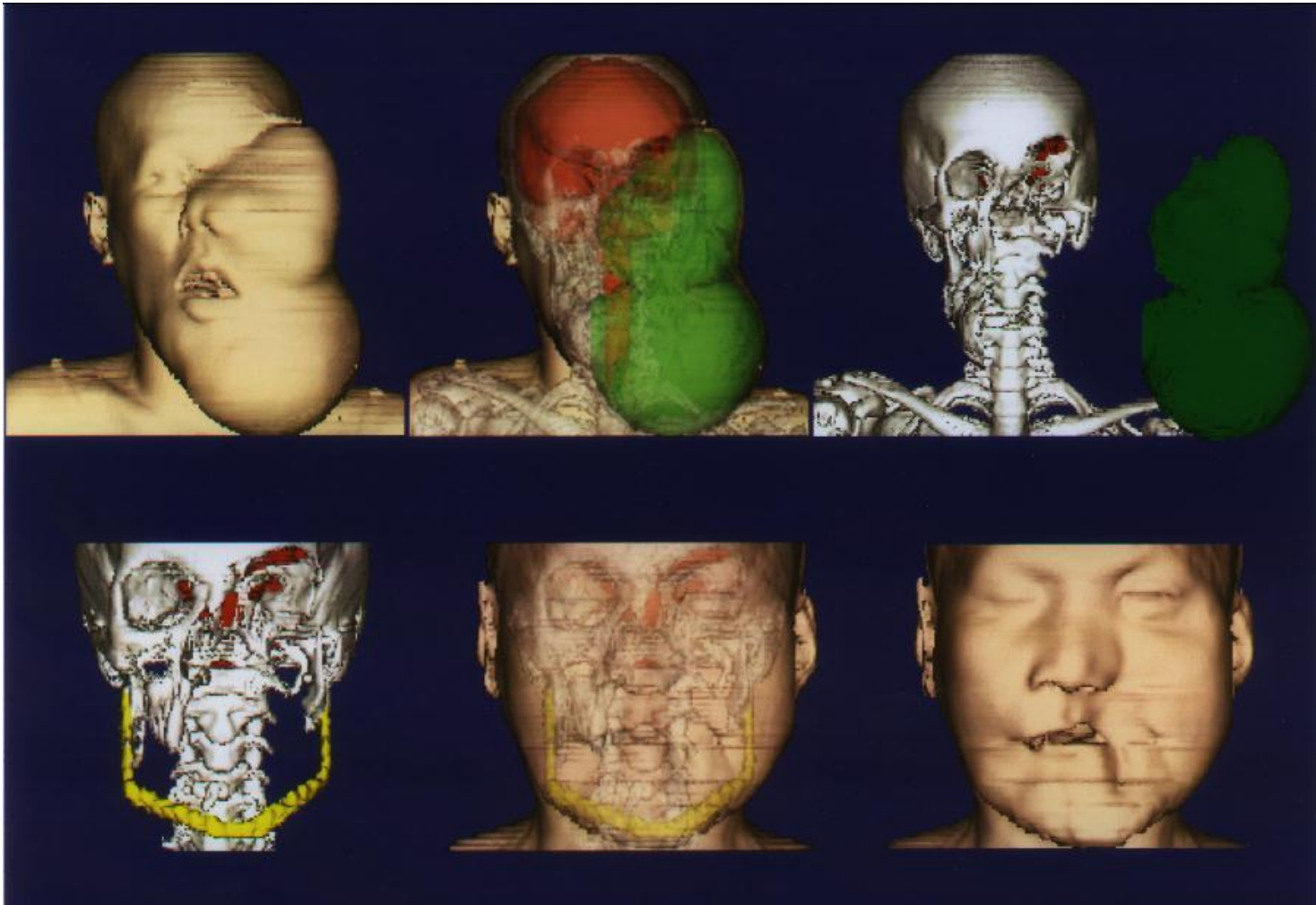


Cathode Ray Tube - CRT

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



Post-Processing



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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



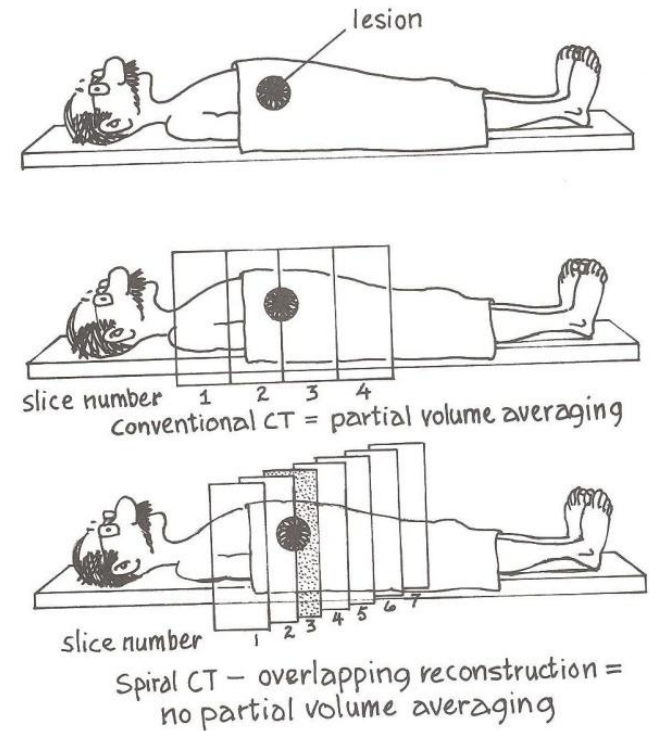
Retrospective Reconstruction

- 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
- Filter functions can only be applied to raw data

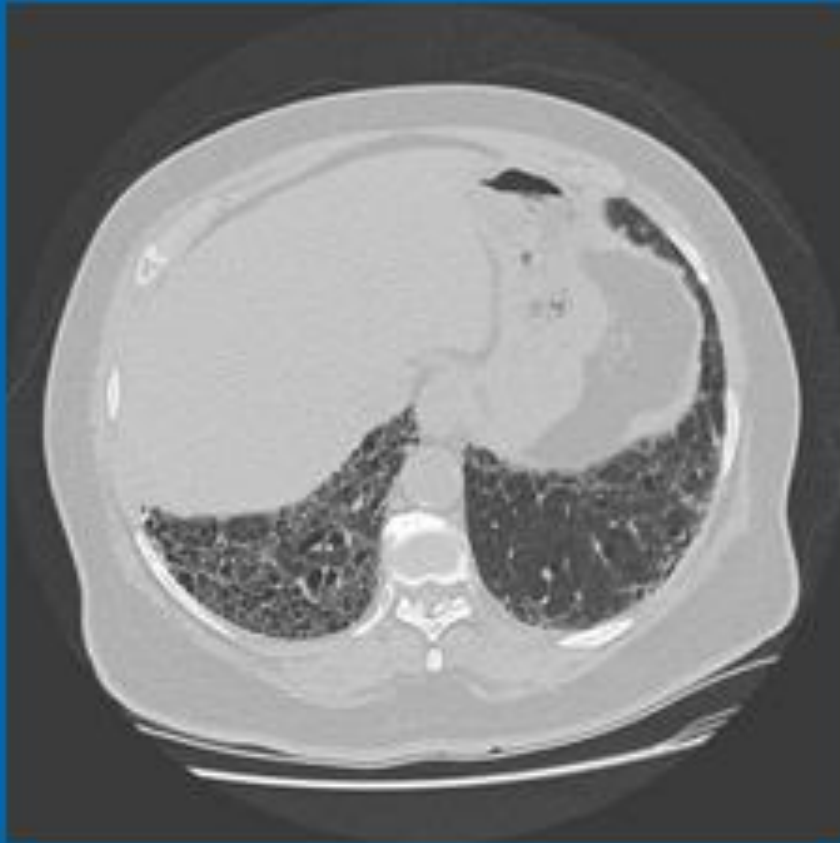


HIGH AND LOW PASS

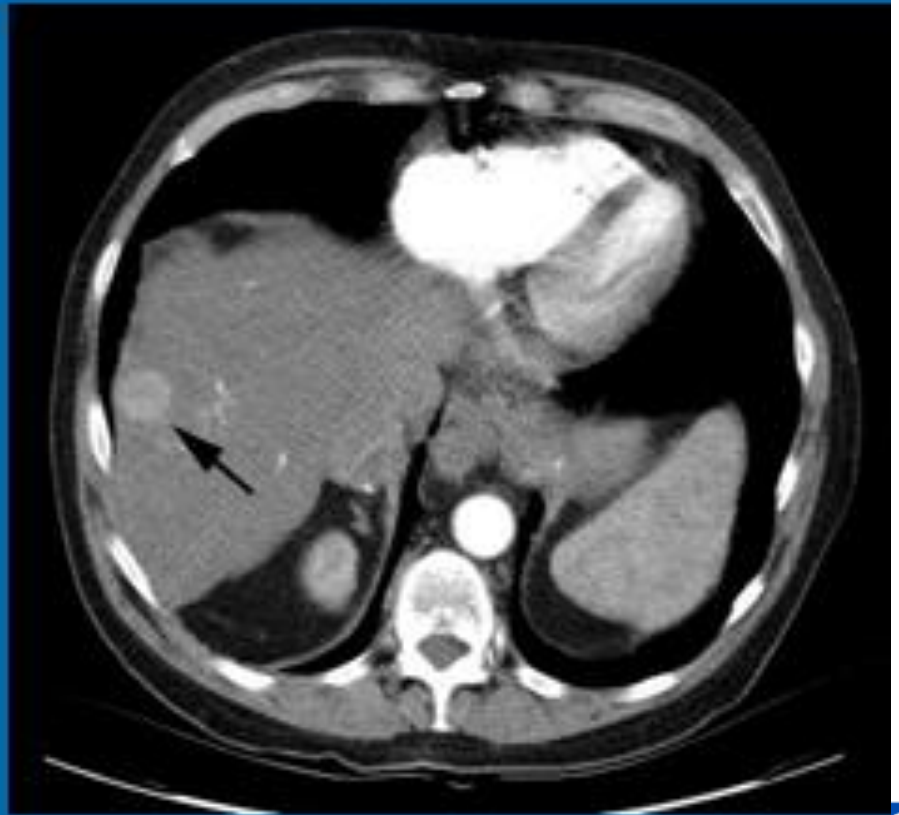
- **High pass filters are used for imaging bone, inner ear, etc.**
- **High pass filters result in images with enhanced edges, short scale of contrast, and much more noise**
- **Low pass filters are used for imaging soft tissue such as brain and liver**
- **Low pass filters appear less noisy with a long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

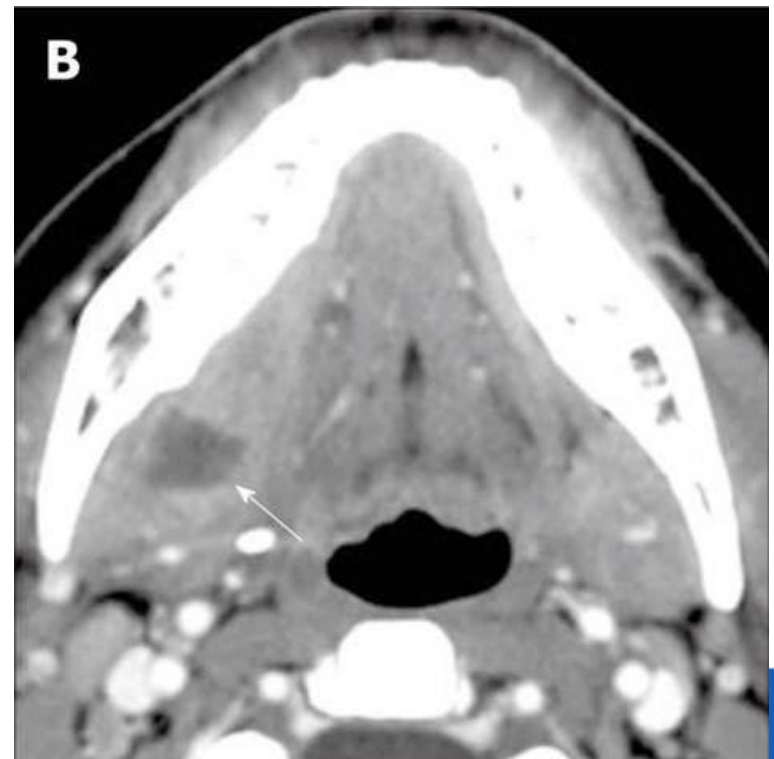
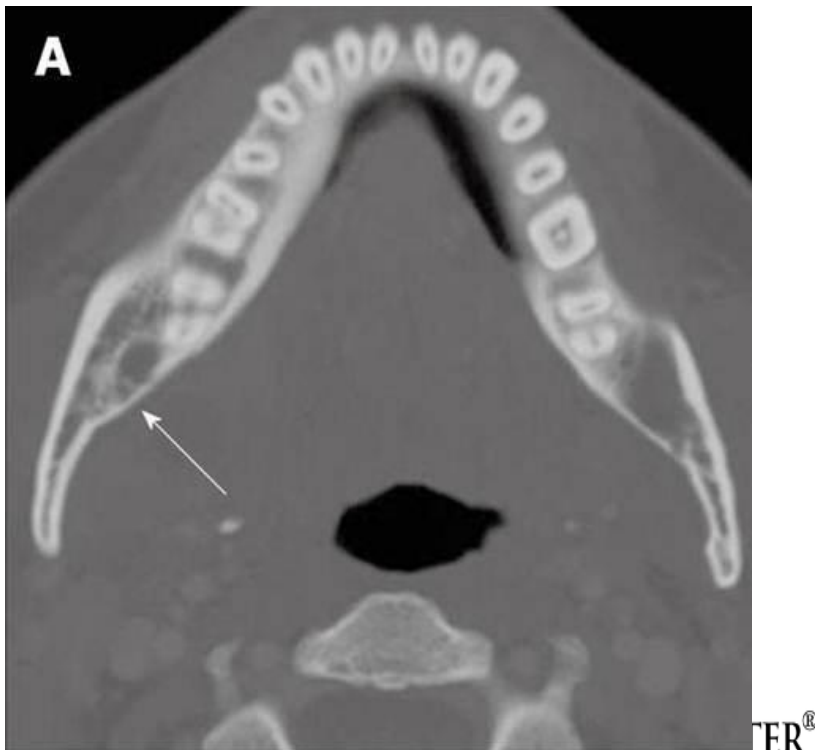
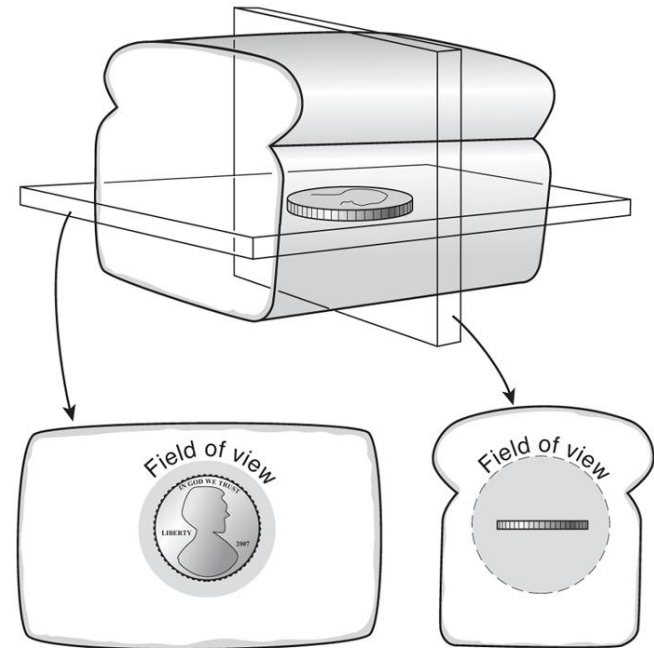


Image Reformation

- **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)**



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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



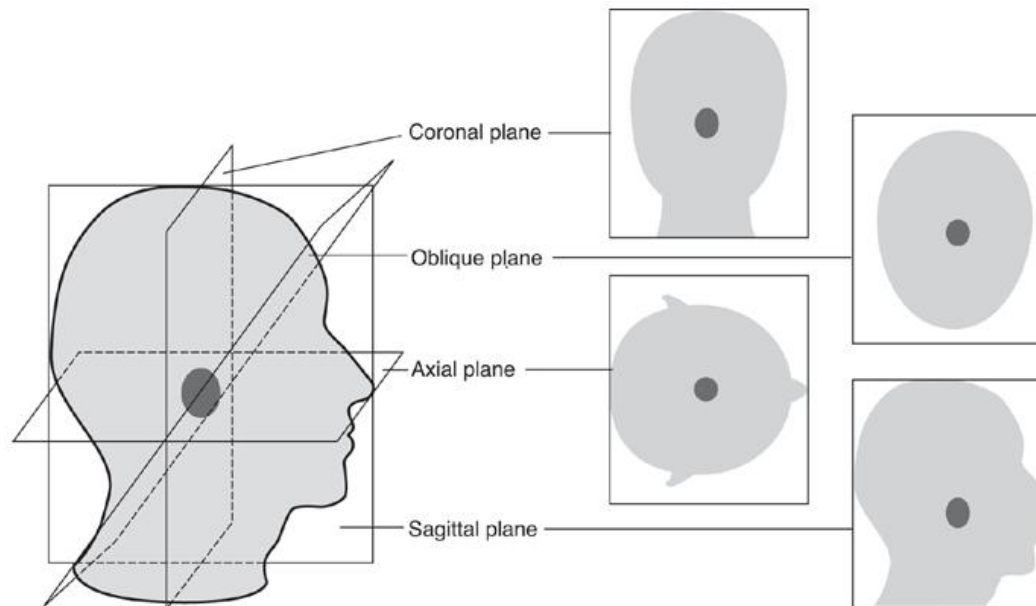
Multiplanar Reformation

- **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**



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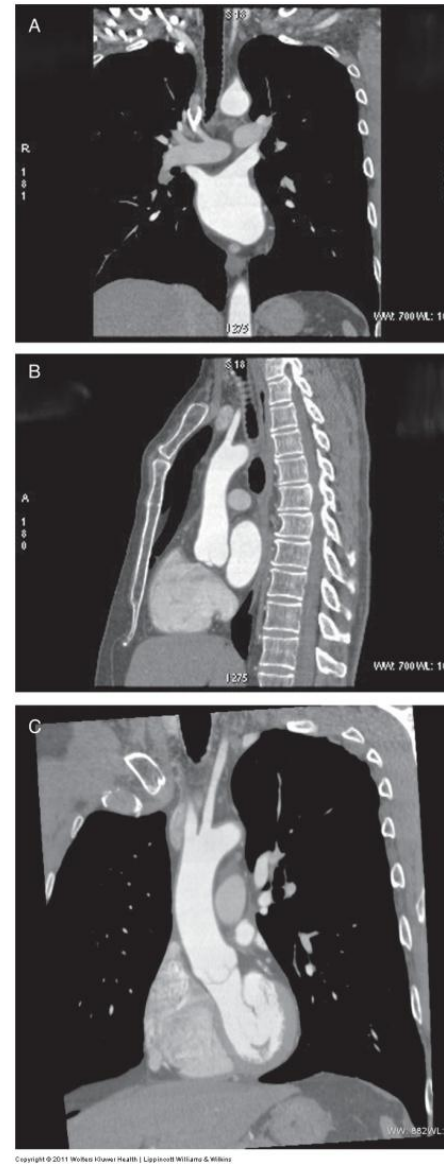
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Multiplanar Reformation

- Coronal
- Sagittal
- Oblique



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3D Reformation

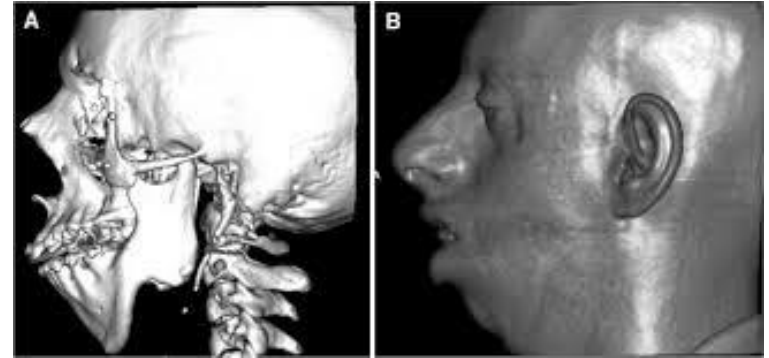
- **3D Reformations seek to represent the entire scan volume in only one image**
- **3D techniques manipulate or combine CT values to display an image**
 - **the original CT value information is not included**
- **Two Types of 3D Reformation or Rendering**
 - **Surface rendering (SR) or Shaded Surface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



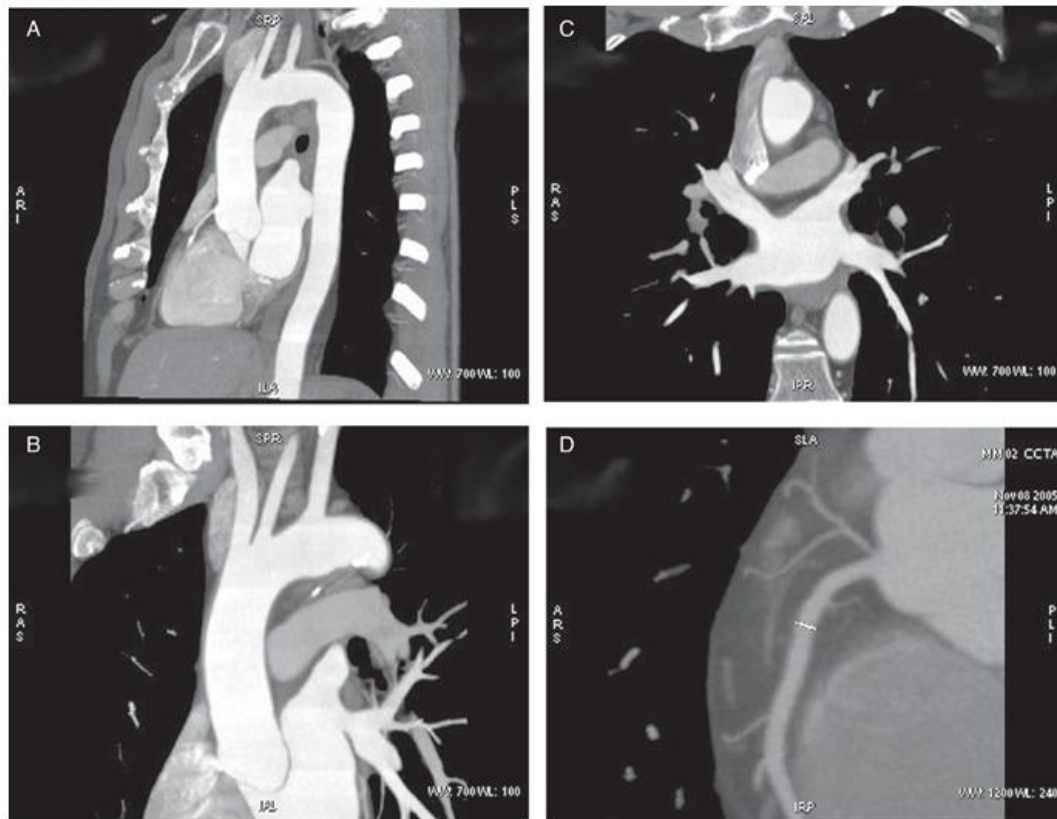
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MIP Projection Display

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



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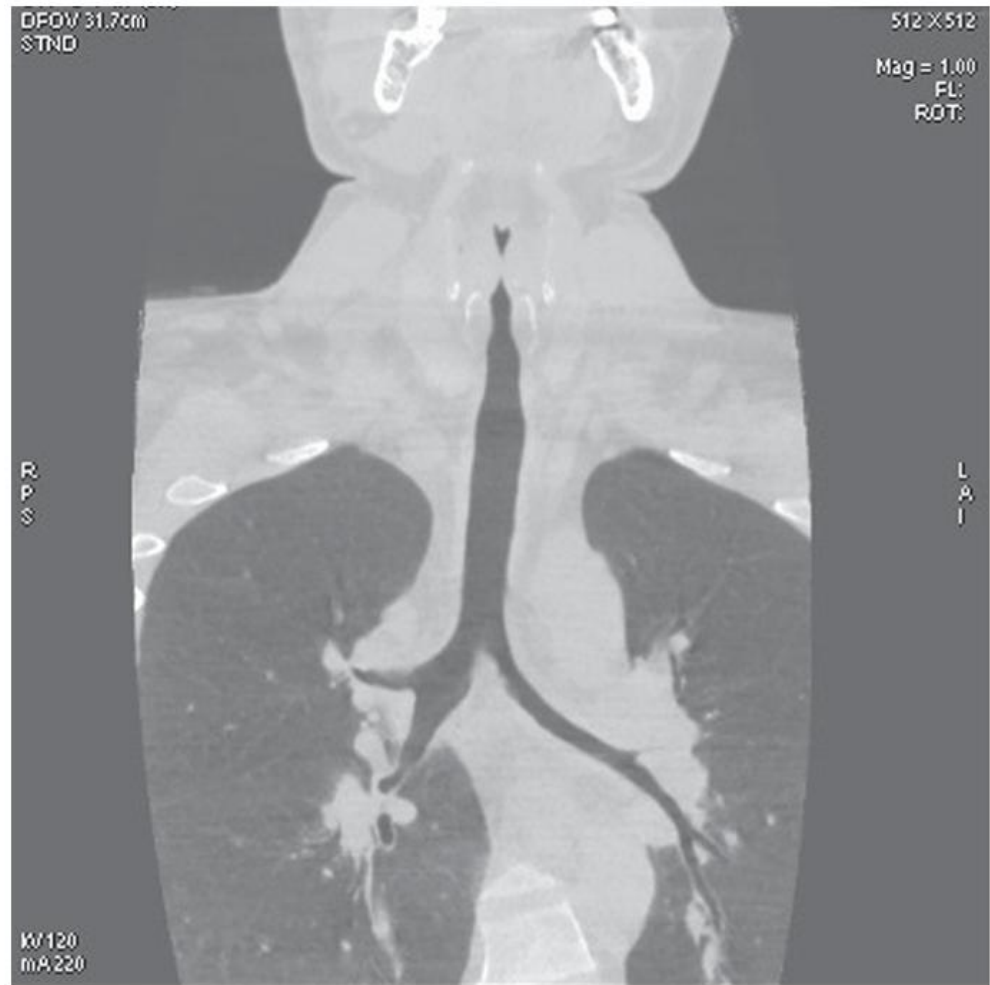
MIP Limitations

- 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**



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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



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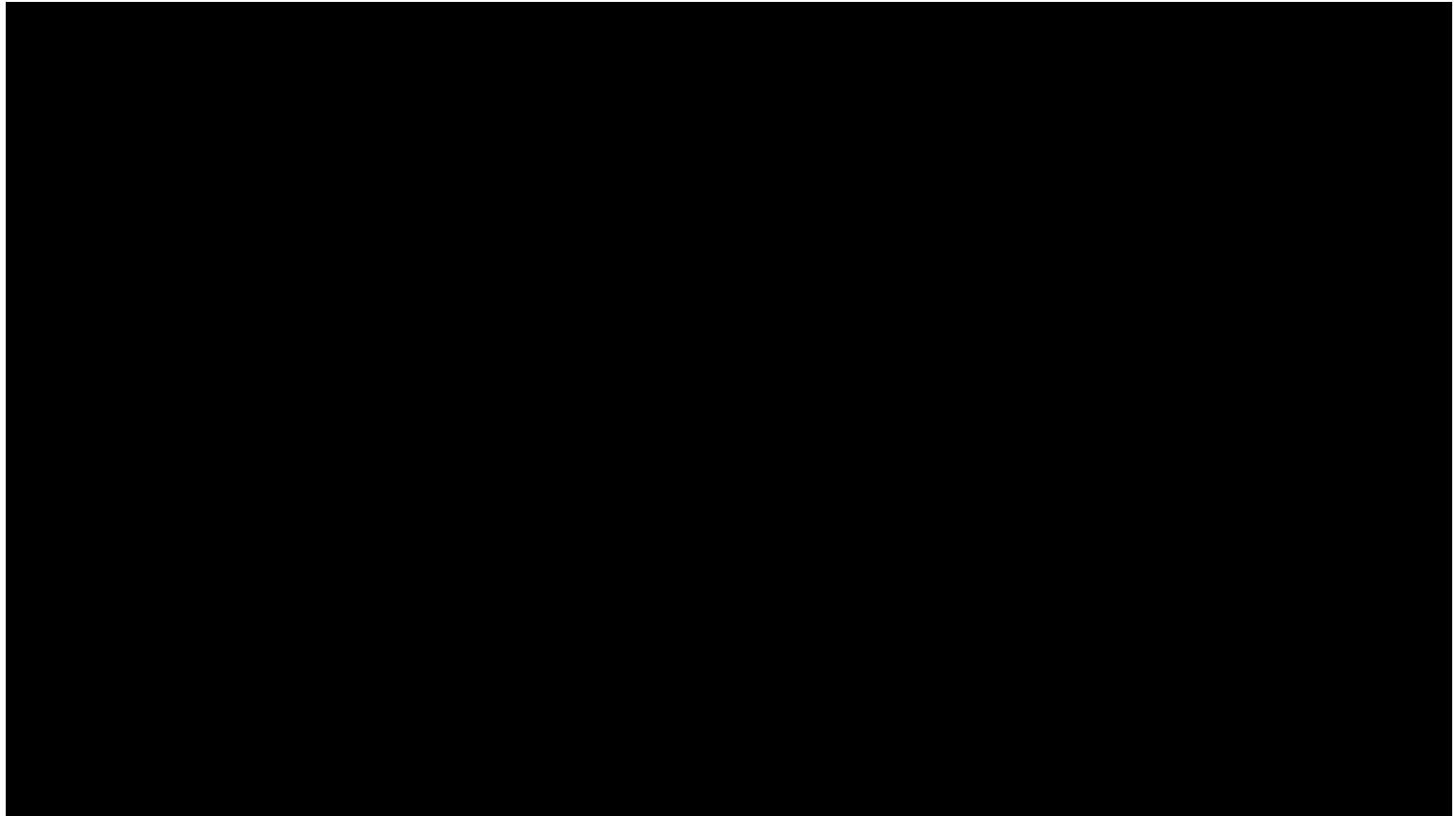


Applications of Virtual Endoscopy

- **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 cholangiopancreatography)**
- **Evaluate the inner ear (virtual labyrinthoscopy)**



Video of Vitruval Colonoscopy



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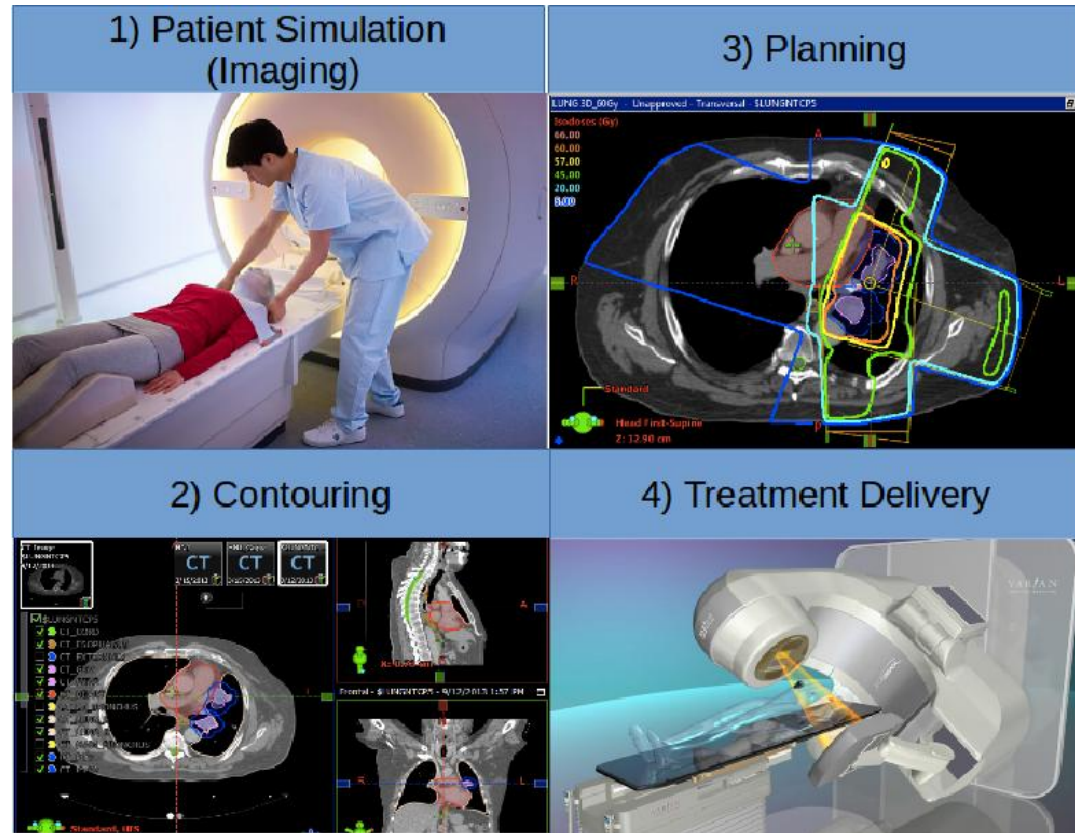
Factors That Degrade Reformatted Images

- **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**

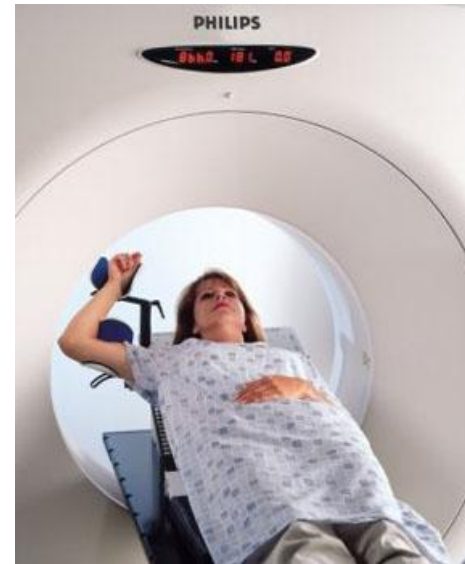
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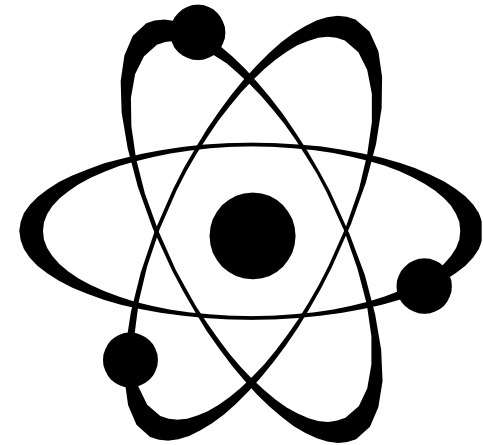
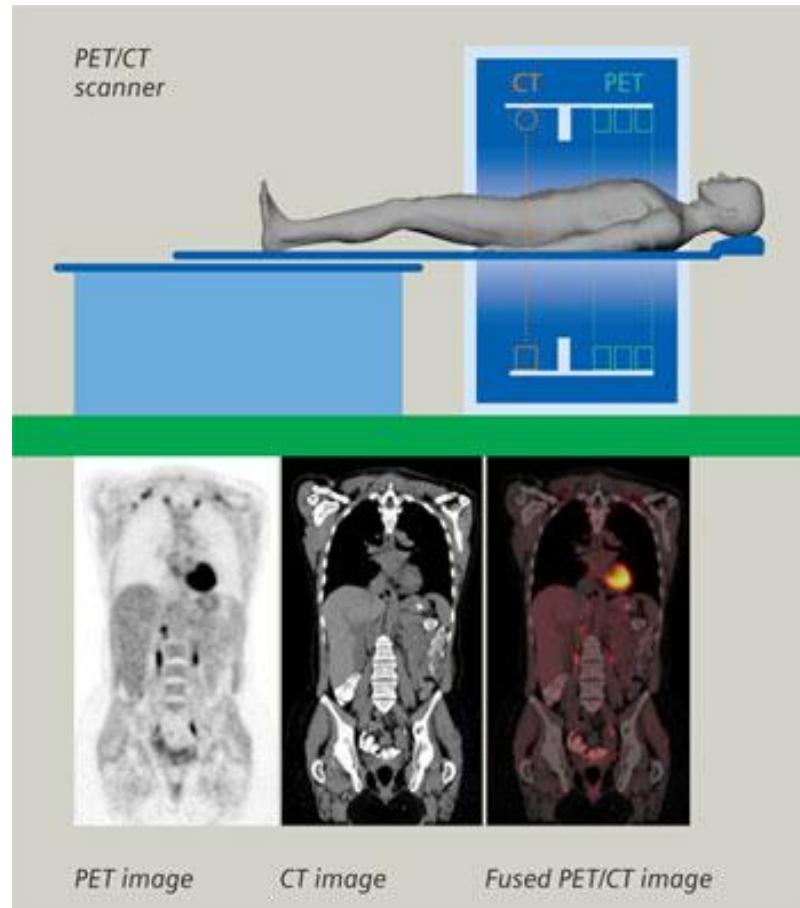


CT Therapy Planning

- Flat Table Top
- Larger Gantry
- Immobilization devices



PET/CT Fusion Imaging



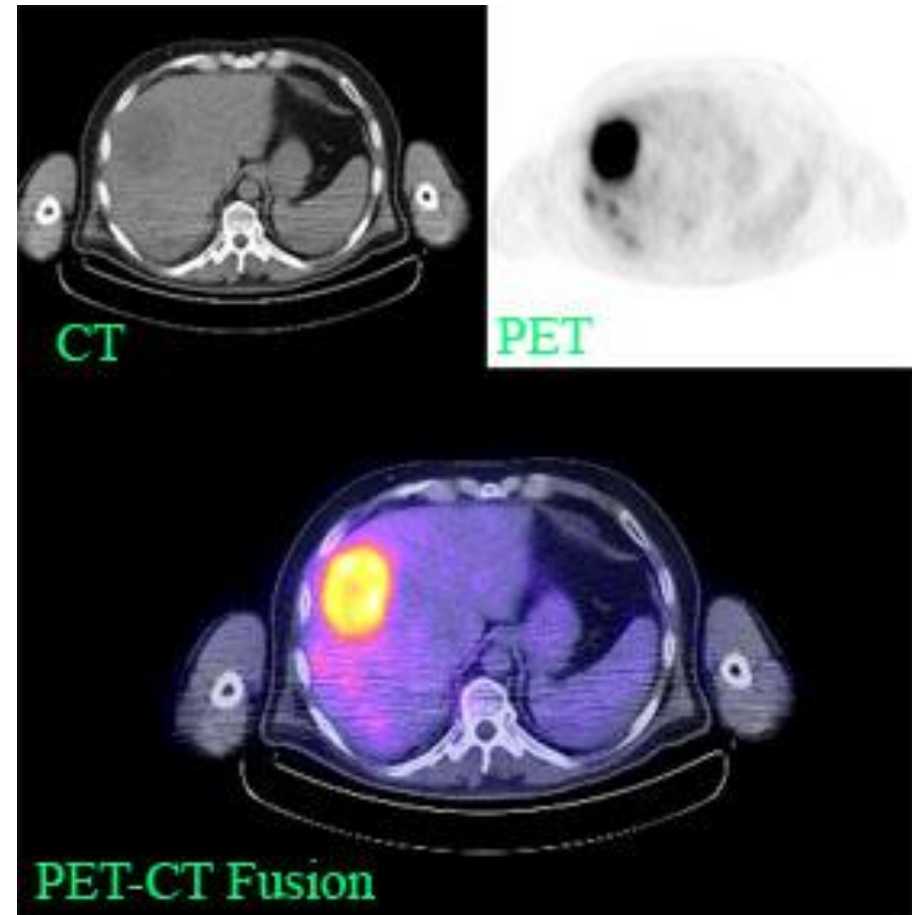
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What is PET/CT

- 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**

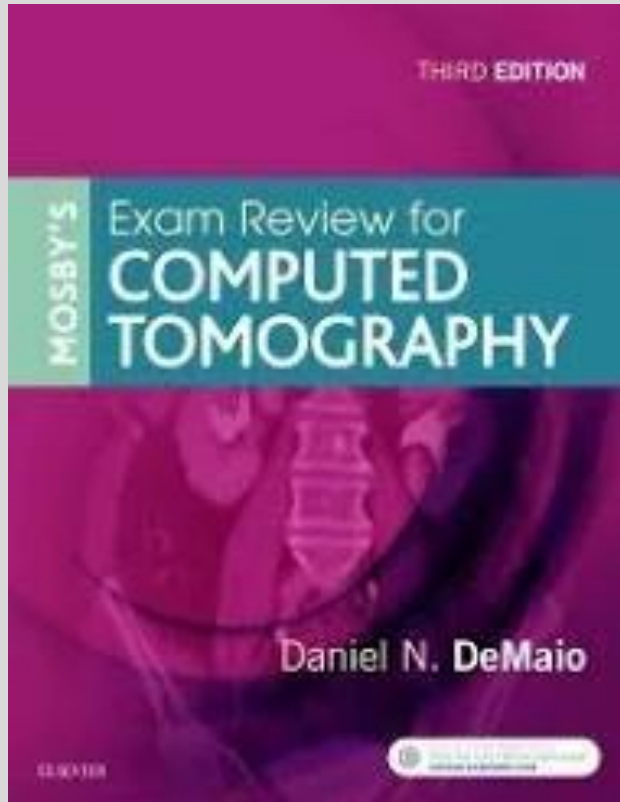


Who Can “DO PET/CT

- **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



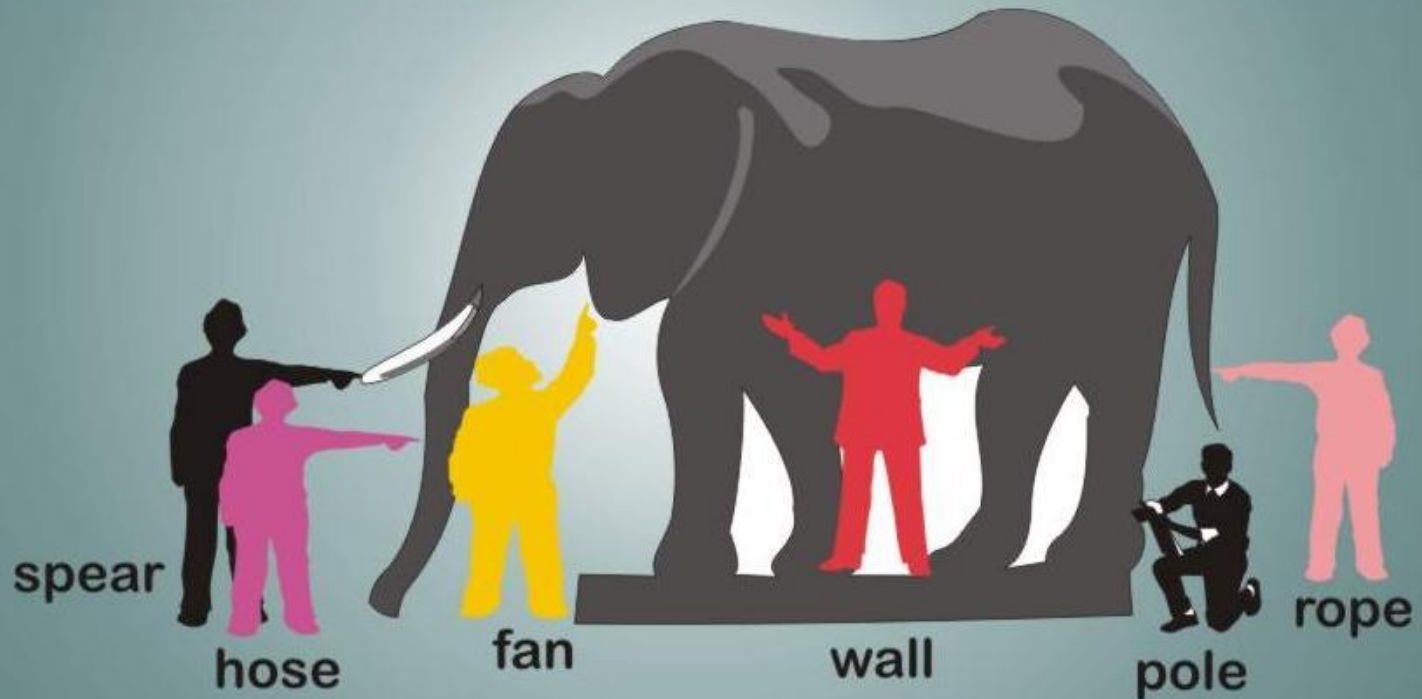
- **Highly Recommended**
- **Online Version has hundreds of questions for practice with explanations**
- **Mock Registry and Mock Registry of individual sections.**

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