COMPUTERS IN NUCLEAR MEDICINE

History of computers:

- 1500 bc, abacus invented in China.
- 1600ad, Pascal invented calculating machine
- 1889 Herman Hollerbith invented a machine that processed information from punch cards.
- 1939 Atanasoff and Berry invented binary system. Binary system is now the basis for all computer data.
- 1961 first minicomputer invented.
- 1971 first microcomputer invented.

Computers in Nuclear Medicine

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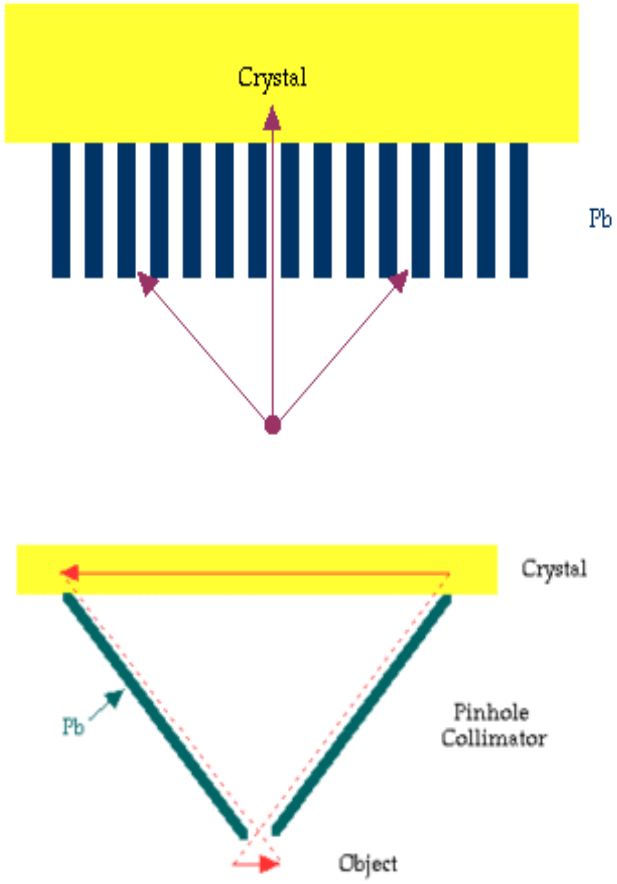

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Binary System: 1 or 0

- information is stored by computers is represented by either 1 or 0.
- Users enter and receive information to and from the computer in a visual or text format, not in binary system. Computers analyze and "translate" inputs into digital form of binary system.
- Typically, images are stored in either a byte mode or a word mode.
- 8 bits make up 1 byte, 16 bits make up 1 word.
- 2^n-1: number of counts stored in either 1 byte or 1 word. "n" is the number of bits stored. Since the first number is always 0, we subtract 1 from 2^n.
- Maximum number of counts in one byte: 2^8-1 (always starts with 0; therefore, we subtract 1) Total number of counts stored in one byte is 255
- Maximum number of counts in one word: 2^{16}-1

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- Hardware:
  - CPU: Central processing unit. Regulate system operation. Perform computations, interact with memory to execute programs.
    - CU- control unit
    - ALU- arithmetic logic unit
  - Memory: storage of information with ready access
    - ROM: read only memory.
    - RAM: random access memory.
  - Data Storage: storage space for information while not in use
    - Hard Disk
    - Floppy Disk
    - Optical Disk
    - Magnetic Tape
  - Input/Output: devices that allow users to feed information into computer for processing and receive information after it has been processed.
  - Camera Interface: output from the camera is fed into the computer to make an image and store it.
    - ADC: analog to digital converter.
    - Newer systems have ADC built into each detector. No outside ADC devices used.

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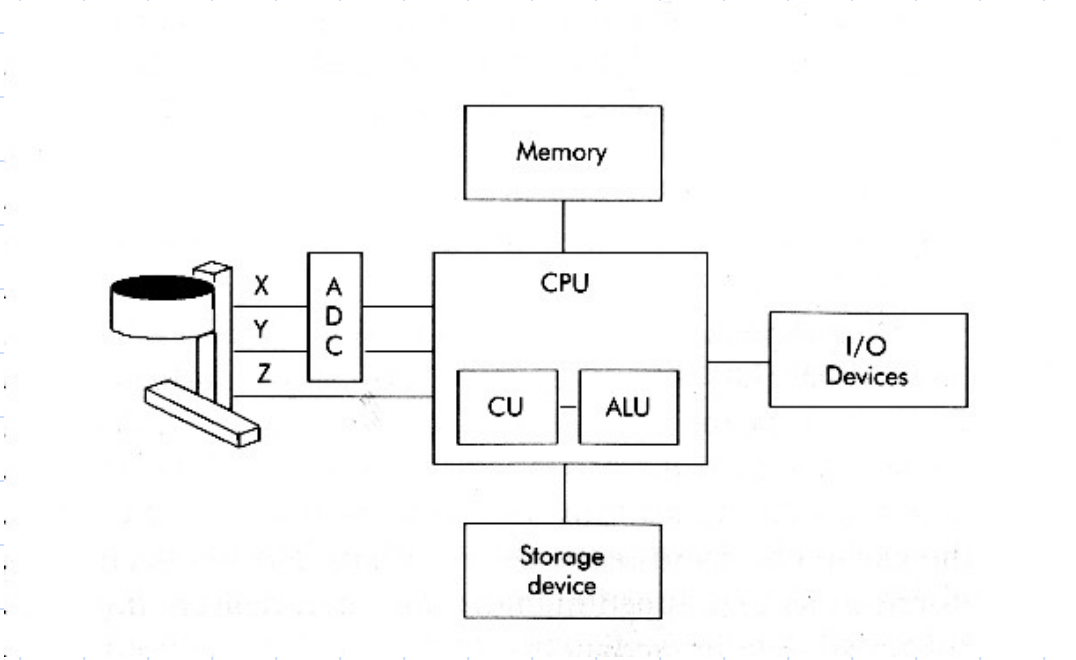
- Software:
  - System Software: (Operating systems) creates environment for other software to run in. Controls hardware and user interfaces. Example: Windows XP, Mac OS, Linux.
  - Programming language: software that allows users to design more software. Example: C++, Visual Basic, JAVA.
  - User Software: Programs that allow for data manipulation and task performance. Philips Jetstream, Pegasys, Autoquant, etc.



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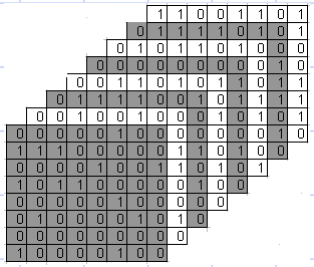
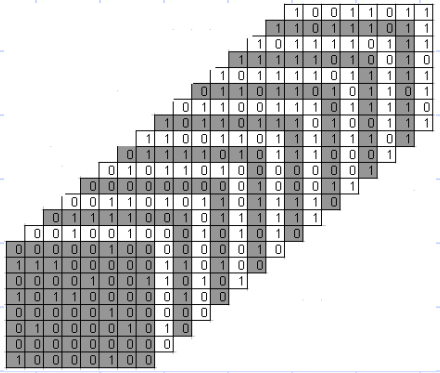
- Image Acquisition:
- Each count that is recorded by the camera carries three signals. X, Y and Z. X and Y are location coordinates, while Z is the energy pulse.

7	0	2	4	4	1	7	9
1	4	4	7	8	4	0	4
4	4	9	9	1	0	7	1
1	4	1	1	0	2	8	9
9	4	9	0	9	1	9	9
0	9	0	7	0	7	2	0
7	2	7	7	7	4	4	4
1	0	4	0	7	1	0	0





Matrix example and pixel depth illustration byte mode vs. word mode.

- Each pixel can store only a limited number of counts. Pixel overflow results when the number of counts exceeds the maximum value a pixel can hold. The pixel with the highest count is assigned the brightest intensity.

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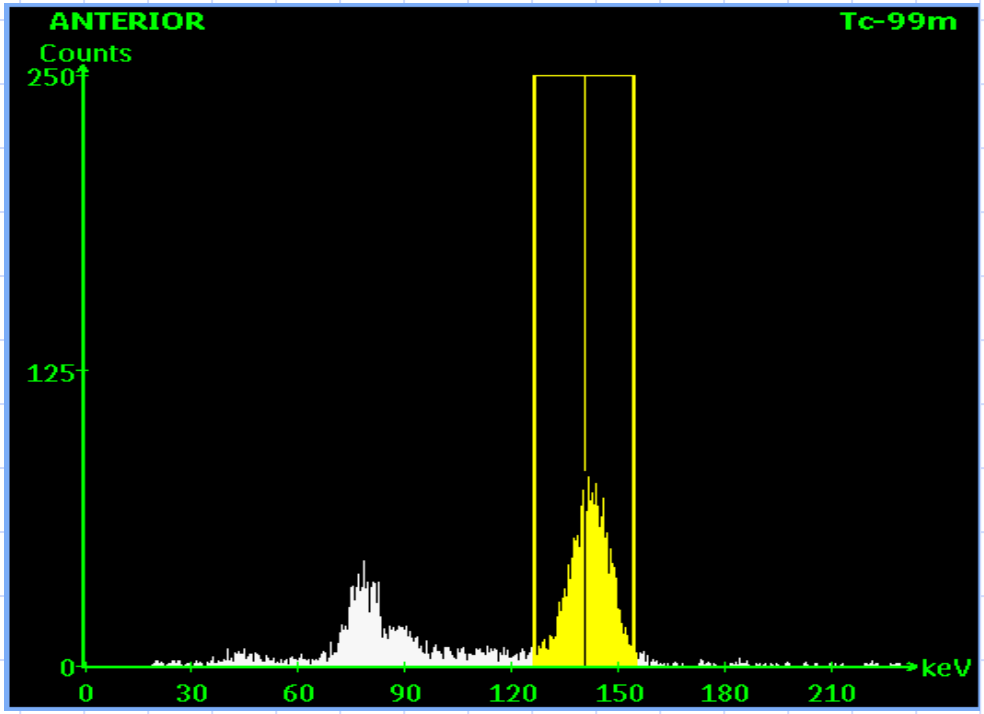
Z pulse: Energy of each photon is analyzed according to the energy window selected. If the energy falls outside the selected window, then that photon is not recorded on the image. Typical window for most isotope is 20%. For Tc99m, the window of accepted energy is from 126 keV to 154 keV.



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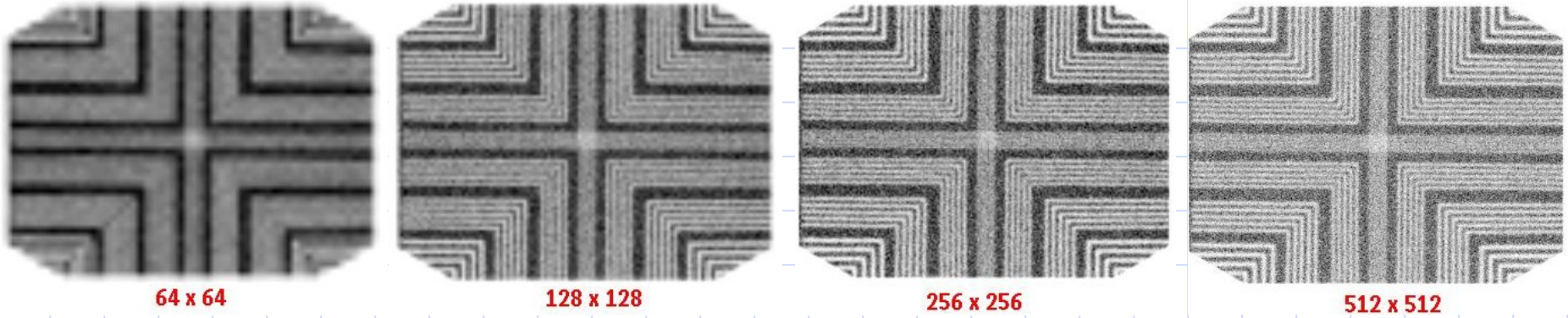
- Two types of resolution in Nuclear Medicine:
  - Spacial resolution: ability to see detail. In NM also means to able to see between two closely located hot spots on an image. Example, ability to see space between vertebrae on a bone scan, etc.
  - Temporal resolution: ability to see detail in respect to time. Example: visualization of activity in left vs. right kidney or a renal scan. The actual image detail may not be as relevant as much as "how long" does it take for the isotope to localize in a given organ.
- Proper matrix size selection:
  - Common matrix sizes: 64x64, 128x128, 256x256, 512x512.
  - The larger the matrix size the higher the spacial resolution.
  - The larger the matrix size the more counts are needed to create a good image.
  - Higher matrix sizes can be reframed to smaller matrix sizes, but not vice versa.



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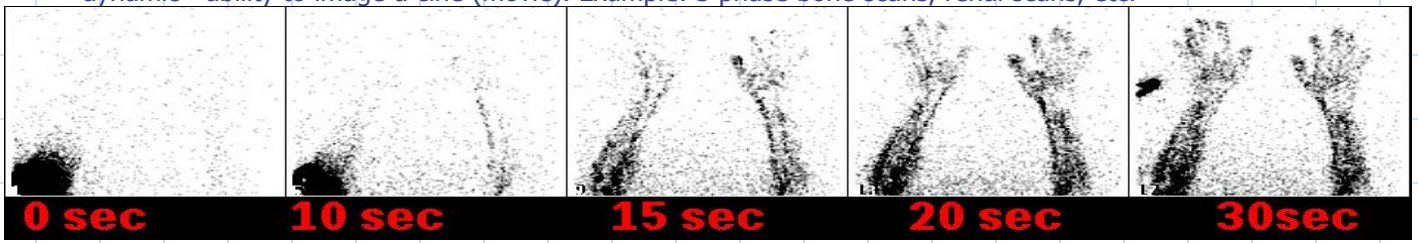
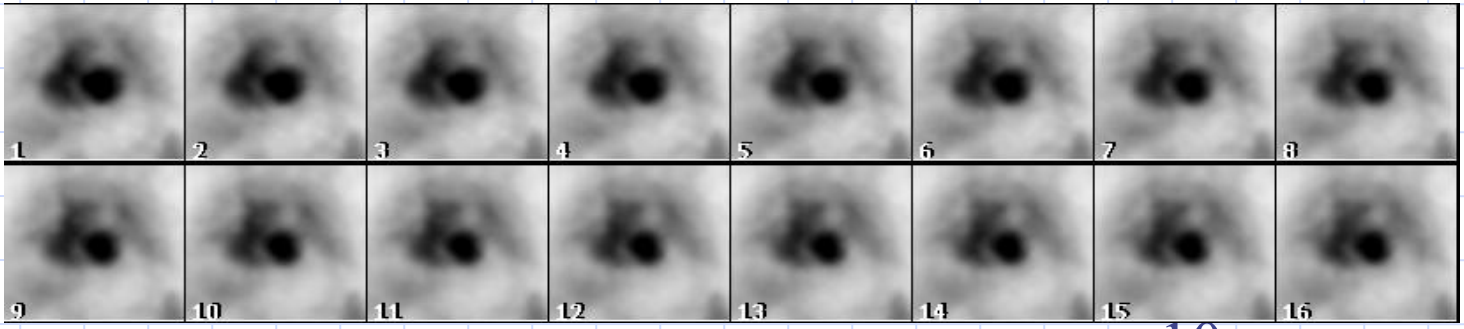
- Types of Acquisition:
  - dynamic- ability to image a cine (movie). Example: 3 phase bone scans, renal scans, etc.



  - Static - ability to obtain a single image with high resolution. Example: bone scans, Hida scans, etc.

  - Gated - imaging according to physiological triggers. Example: MUGA.



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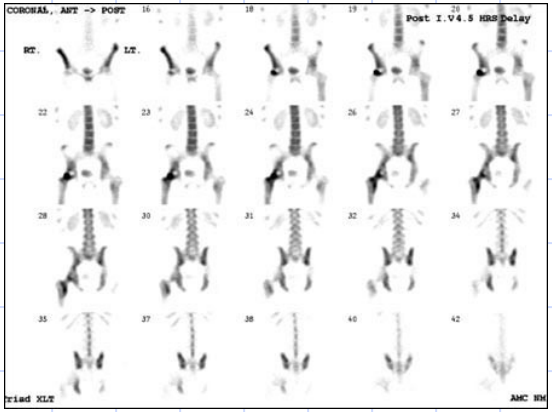
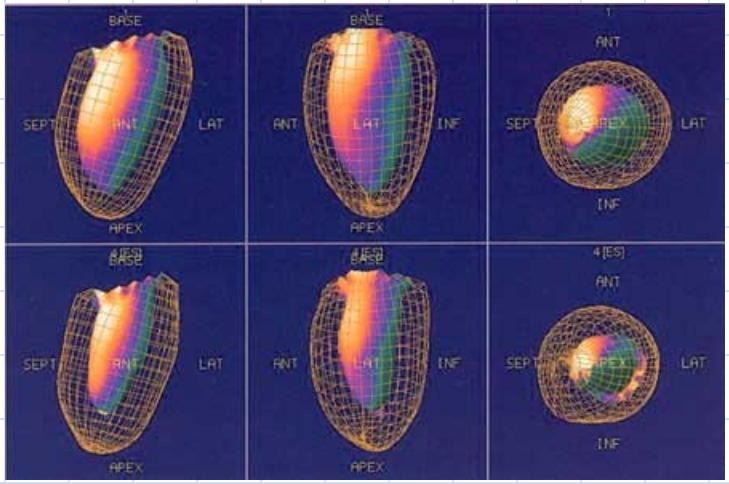
- SPECT (single photon computed tomography). – rotating the camera while acquiring images 360 degrees. Example: bone SPECT.



- gated SPECT- 3D imaging with physiological triggers. Example: MPI SPECT.



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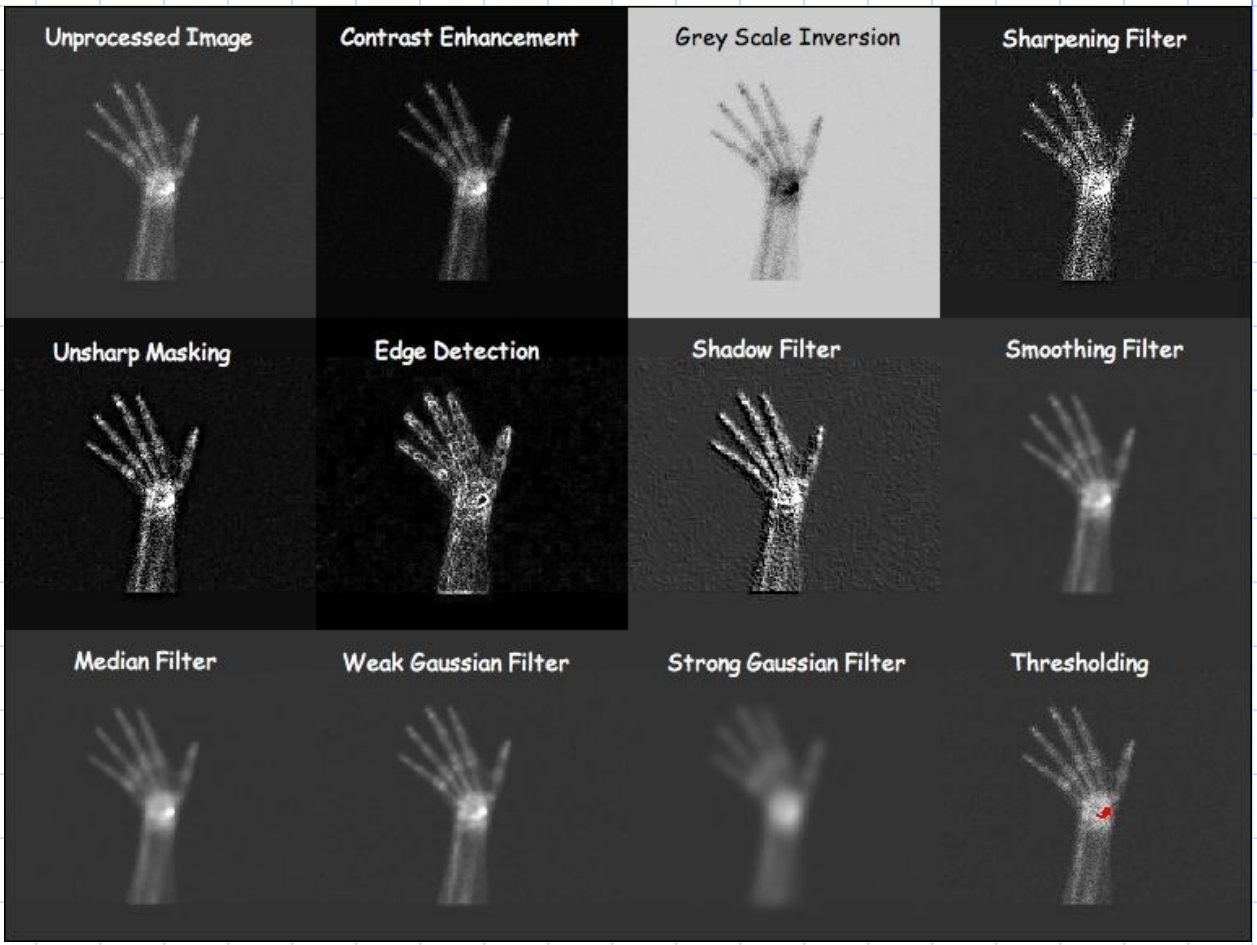
- Image smoothing: ability to manipulate images in order to obtain a smoother or sharper image.
- Common uses:
  - Eliminate noise.
  - Add blur.
  - Remove blur.
  - Edge detection.
  - Image smoothing.



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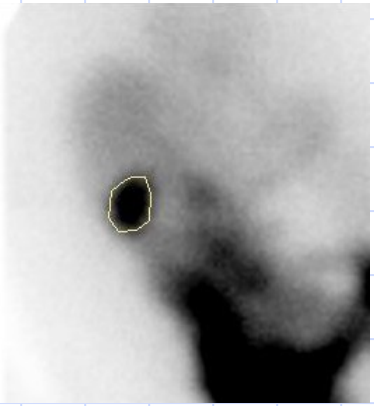
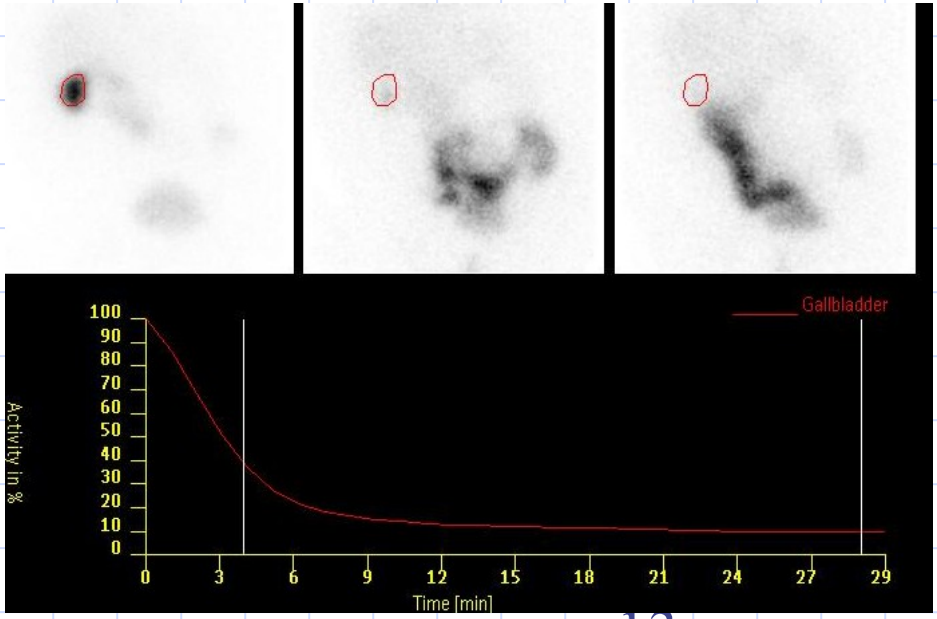
- Time Activity Curves (TAC)
  - quantifications of activity into a curve or a function.
  - curves may be compared to previous studies to see changes with time.
  - curves from two same organs may be compared between each other.
- ROI: region of interest. In order for a computer to process data, a user needs to define where the edges of the organ are by drawing around an organ.
- Common procedures that require ROI and TAC:
  - gastric emptying, renal scans, gallbladder ejection fraction, left ventricle ejection fraction.





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Networks: ability to share data, share printers, backup data, present data off-site

1. Token-ring network (old). Used to connect several NM cameras and NM workstations only.
2. Star network (old). Used to connect several NM cameras and NM workstations only.
3. Bus Network (common). Used to connect all modalities and all workstations, even from off-site.

PACS: picture archival and communications system. Most common network found in many imaging facilities and hospitals.

- All images by all modalities can be shared and are stored in one common format (DICOM).
- No need to print films. Images are accessible from within the network or from outside the network through the internet.
- Images are automatically archived and can be easily restored.
- Urgent cases can be interpreted quickly from off-site.