Ministry of Higher Education and Scientific Research
Al-Mustaqbal University College
Radiological Techniques Department

Radiological Equipment Techniques

Al-Mustaqbal University College

3rd Class

Radiological Techniques Department

By

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Lecture 8: Computed Tomography

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Computed Tomography

Computed Tomography is a medical imaging technique that uses X-rays to obtain structural and functional information about the human body. So, CT is a method for acquiring and reconstructing an image of a thin cross-section of an object. It is based on measurements of x-ray attenuation through the section using many different projections. This is achieved by rotating both x-ray tube and detectors around the patient.

- the image differentiates various types of soft tissues (e.g., gray matter, white matter, blood, tumor, cerebrospinal fluid, etc.). When digital image data manipulation is added, CT provides more diagnostic information than any other ionizing radiation imaging modality.
- The word "tomography" is derived from the Greek tomos (slice) and graphy (to write).
- The invention of CT has been credited to Godfrey N. Hounsfield for his work in 1970–1971, Hounsfield was a research engineer with Electro-Musical Instruments Ltd. (EMI),. His original scanner was built on a lathe bed and required 9 days to produce a single-section image.
- Thereafter, it has undergone several changes with an increase in the number of detectors and decrease in the scan time. The changes were majorly on the X-ray tube and detector arrangements

The difference between a CT scan from a conventional radiograph

CT differs from conventional radiography in two significant ways:

■ CT forms a cross-sectional image, eliminating the superimposition of structures that occurs in plain film imaging because of compression of three-dimensional (3D) body structures

■ The sensitivity of CT to subtle differences in x-ray attenuation is at least a factor of 10 higher than normally achieved by film screen recording systems because of the virtual elimination of scatter.

CT	MRI
CT scans utilize X-rays to form images inside the body	while MRI (magnetic resonance imaging) uses powerful magnetic fields and radiofrequency pulses
Exposure to ionizing radiation (X-rays)	MRIs do not ionizing radiation (X-rays).
CT scans are quick, painless, and noninvasive.	MRI scans are not invasive, but they are noisy, take more time, and may cause claustrophobia (anxiety due to being in the enclosed space of the machine).
MRI scans are costlier than CT scans.	MRI scanners may cause a safety issue due to its strong magnets.
different soft tissues can See but not well characterized	MRIs provide more detailed information about the inner organs (soft tissues) such as the brain, skeletal system, reproductive system and other organ systems than is provided by a CT scan.

The Basic Principles of CT

Fundamentally a CT scanner makes many measurements of attenuation through the plane of a finite thickness cross section of the body. The system uses these data to reconstruct a digital image of the cross section in which each pixel in the image represents a measurement of the mean

attenuation of a box-like element (voxel) extending through the thickness of the section.

An attenuation measurement quantifies the fraction of radiation removed in passing through a given amount of a specific material of thickness Δx. Attenuation is expressed as:

$$I_t = I_0 e^{-\mu \Delta x}$$

Where, I_t *and* I_0 are the x-ray intensities measured with and without the material in the x-ray beam path, respectively, and μ is the linear attenuation coefficient of the specific material.

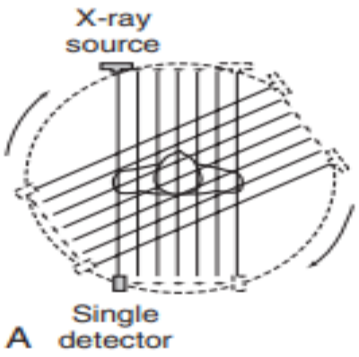
Generation Computed Tomography

Generation, the order in which CT scanner design has been introduced, and each has a number associated with it. Major adjustment in the technology of CT scanners were manifested in X-ray tube and detector movement and shape of beam (from pencil beam through narrow beam to fan beam)

- Number of detectors (from single detectors to multiple detectors).
- Detector arrangement.
- Slip ring technology (Rotating mechanism).

First-generation scanners

The scans were done using a water filled box. A narrow pencil width X-ray beam and a single detector mechanism were used for data acquisition.



- Scan was performed in a rotate-translate motion.

This scanners where limited because

1. Only head scans could be performed.

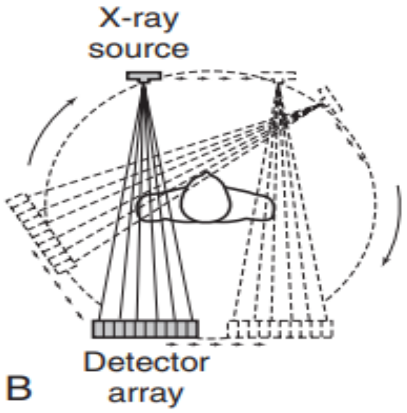
2. A thin x-ray beam passed linearly over the patient, and a
3. single detector followed on the opposite side of the patient.
4. The tube and detector were then rotated slightly, and the process was repeated until a 180° arc was covered.
5. Scan times were very long.

Second-Generation Scanners

were based on the fan beam geometry and translate-rotate motion.

The 2nd generation CT scanners were developed to overcome some of the challenges of the 1st generation scanners.

1- Fan-shaped x-ray beam was used
2- Although scan times were shorter than that of the original design, they were still very long.
3- Multiple detector (up to 30 detectors)



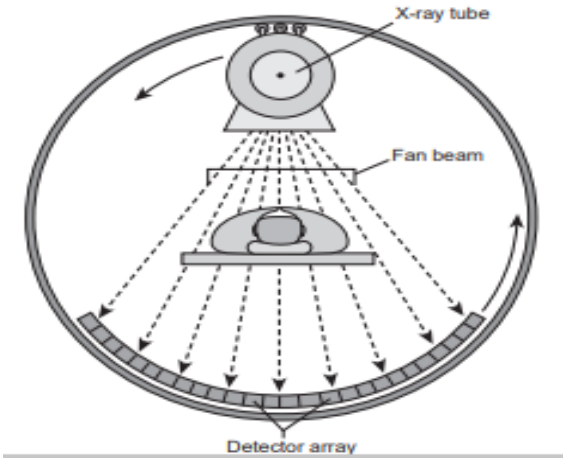
Third-Generation Scanners

scanners were based on fan beam geometry and complete rotation of the tube and detectors.

1- Consists of a detector array
2- Fan-shaped beam that covered the entire field of view and a detector array
3- The source and the detector array are rotated about the
4- patient

5- Produce an image in less than 100 ms.

- A disadvantage of the third- generation design is the more frequent occurrence of ring artifacts. Because the same bank of detectors is used repeatedly, even a very small misalignment of a single detector will result in visible ring artifact



Fourth-Generation Scanners

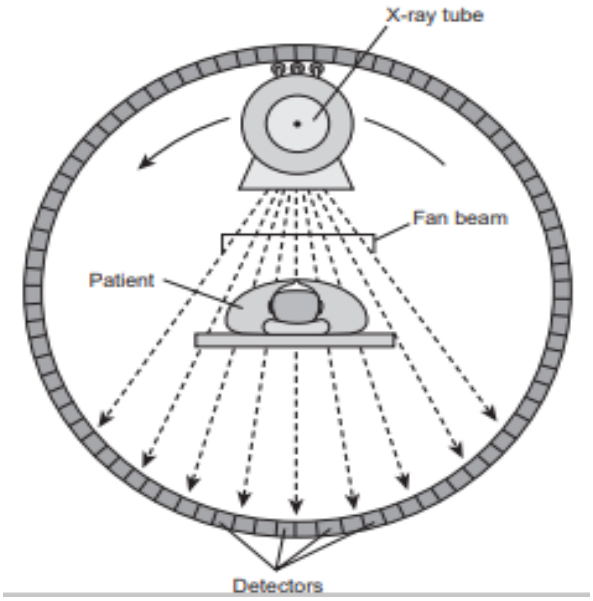
were based on fan beam geometry and complete rotation of the x-ray tube around a stationary ring of detectors

1- Type of beam: fan-shaped x-ray beam.

2. Fixed ring of detectors (more than 2000). The detectors are arranged in an outer ring which is fixed round the gantry.

3- Rotate and stationary (x-ray source rotates, but the detector assembly does not

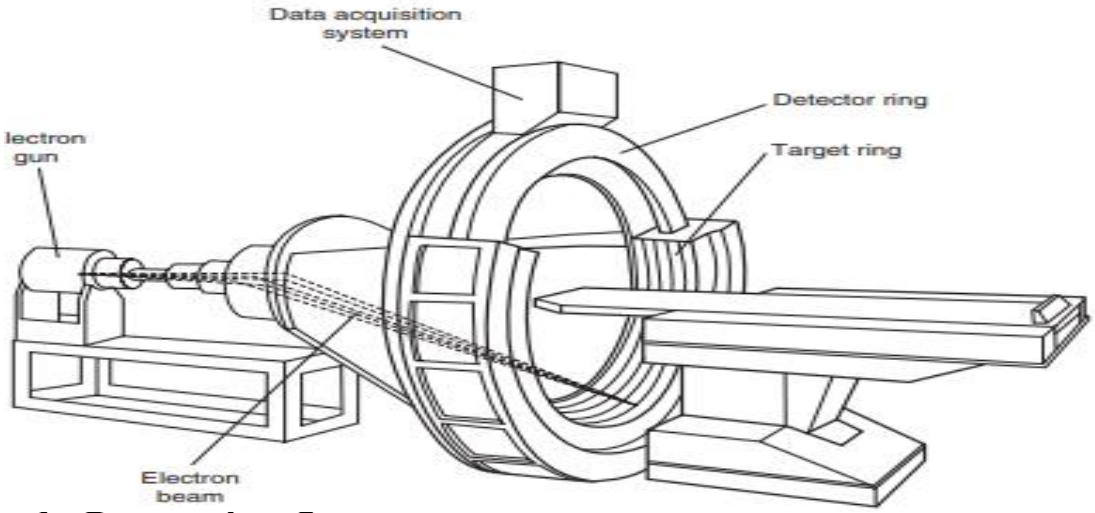
4- Subsecond imaging time.



Fifth-generation scanners

were developed primarily for high-speed CT scanning.

An electron beam is emitted from a cathode and focused on a track of tungsten anode target from which X-rays are produced and collimated into a fan beam for use in CT scans.



Sixth-Generation Scanners

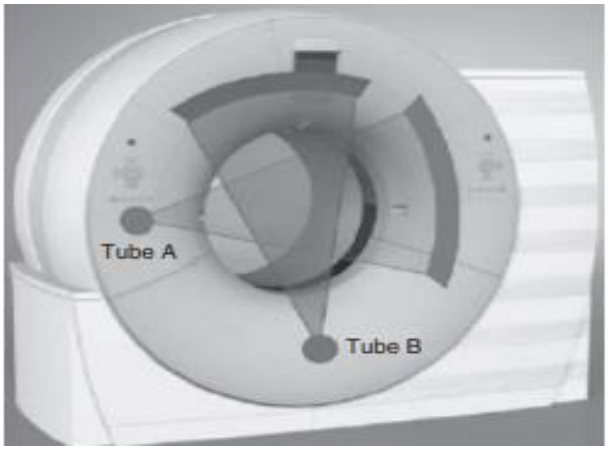
Have multiple x-ray tubes and detectors. These scanners are intended specifically to image moving structures, such as the heart.

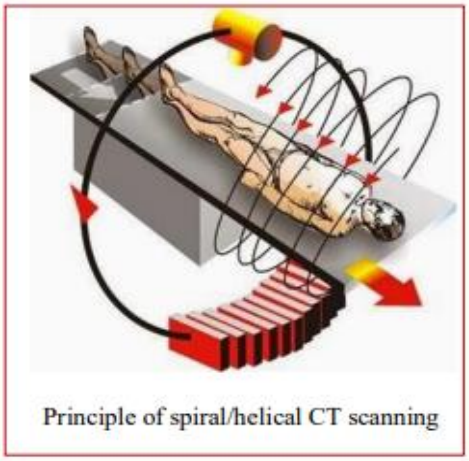
1- Helical/spiral CT was introduced in 1989, based on Generation Three.
2- Single x-ray tube and single row detector.
3- Slip ring replaced with the x-ray tube voltage cables enables continual tube rotation
4- Helical CT scanners acquire data while the table is moving.
5- the total scan time required to image the patient can be much shorter.
6- Allows the use of less contrast agent and increases patient throughput.
7- In some instances the entire scan is done within a single breath-hold of the patient

All generations of CT scanners (except 4th gen.) required winding and unwinding of connection cables causing inter-scan delays. Slip ring was designed to eliminate this.

A slip ring is a drum with grooves along which electrical contractor brushes slide. Data are transmitted from detectors via various high capacity wireless technologies thus allowing continuous rotation.

- This enables the helical scan where data are collected continuously as the patient moves through the rotating gantry.





Principle of spiral/helical CT scanning