Limitations of Conventional Radiography

Computed tomography (CT) is an imaging procedure that uses ***special X-ray equipment*** to create detailed pictures, or scans, of ***areas inside the body***. It is also called ***computerized tomography***, or ***computerized axial tomography (CAT)***.

The term tomography comes from the ***Greek words tomos*** (a cut, a slice, or a section) and ***graphein*** (to write or record).

Computed tomography (CT) is ***noninvasive*** and produces ***cross-sectional images*** of the body. Each cross-sectional image represents a ***"slice"*** of the person being imaged. These cross-sectional images are used for a variety of ***diagnostic and therapeutic purposes***.

Limitations of Film-Based Radiography

- The major shortcoming of radiography is the ***superimposition*** of all structures on the film, which makes it difficult and sometimes impossible to distinguish a particular detail (Fig.1). This is especially true when structures differ only ***slightly in density***, as is often the case with some tumors and their surrounding tissues.

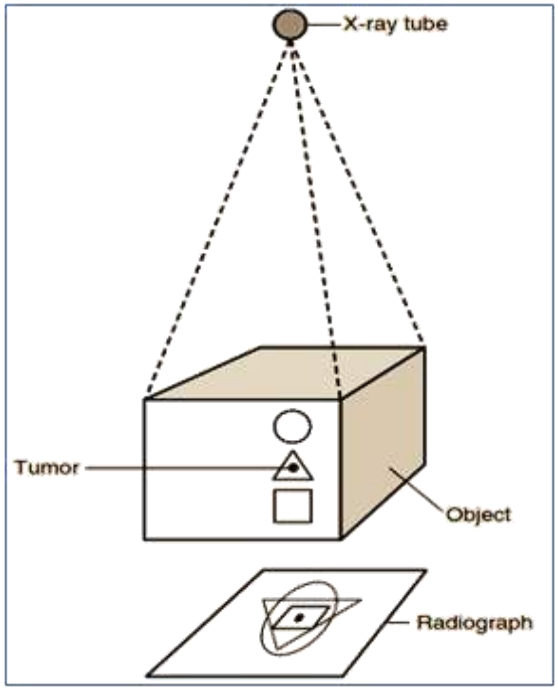


Fig. 1: The major shortcoming of radiography is that the superimposition of all structures on the radiograph makes it difficult to discriminate whether the tumor is in the circle, triangle, or square.

- A second limitation is that radiography is ***a qualitative rather than quantitative*** process (Fig. 2). It is difficult to distinguish between a ***homogeneous object of non-uniform thickness*** and a ***heterogeneous object*** (Fig. 2) (includes bone, soft tissue, and air) of uniform thickness.

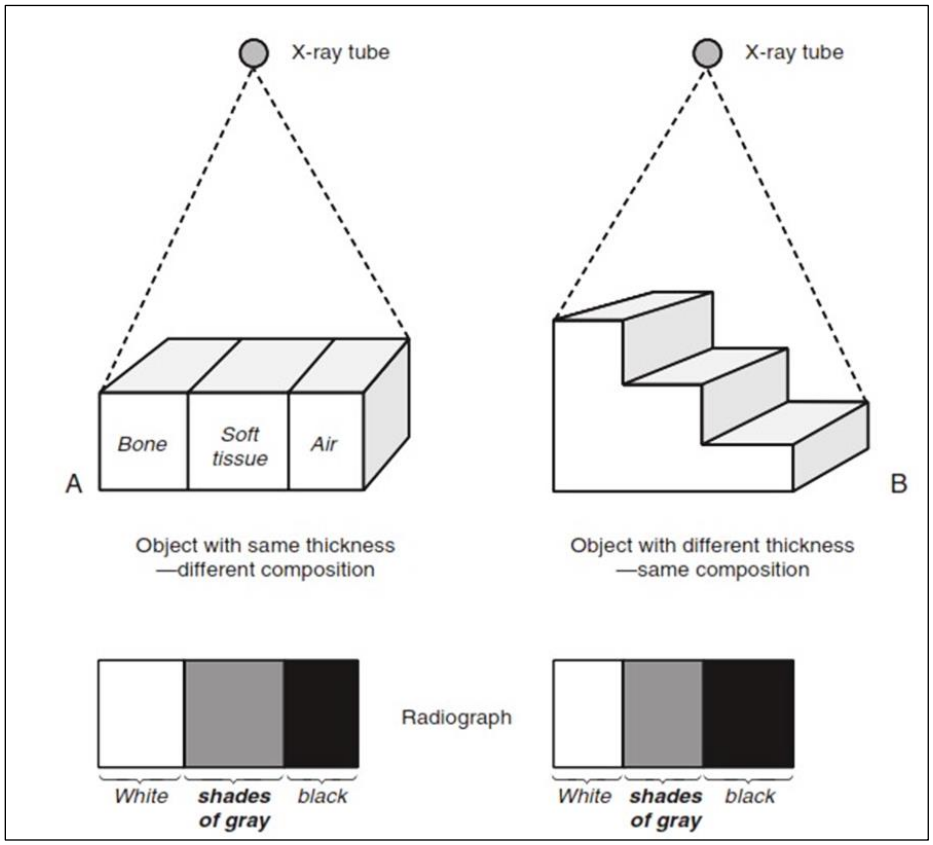


Fig. 2: Radiography is a qualitative rather than quantitative procedure. Two radiographs can appear the same although the two objects, A and B, are entirely different.

Limitations of Conventional Tomography

The problem of ***superimposition*** in radiography can be somewhat ***overcome by conventional tomography***. The most common method of conventional tomography is sometimes referred to as ***geometric tomography*** to distinguish it from CT (Fig. 3).

When the ***X-ray tube and film are moved simultaneously in opposite directions***, ***unwanted sections can be blurred*** while the ***desired layer or section is kept in focus***.

The immediate ***goal of tomography is to eliminate structures above and below the focused section***, or the focal plane. However, this is difficult to achieve, and under no circumstances can all unwanted planes be removed.

The ***limitations*** of tomography include ***persistent image blurring*** that ***cannot be completely removed***, ***degradation of image contrast because of the presence of scattered radiation*** created by the open geometry of the X-ray beam, and other ***problems resulting from film-screen combinations***.

In addition, both radiography and tomography ***fail to adequately demonstrate slight differences in subject contrast***, which are characteristic of soft tissue. Radiographic film is not sensitive enough to resolve these small differences because typical film-screen combinations used today can only discriminate X-ray intensity differences of ***5% to 10%***.

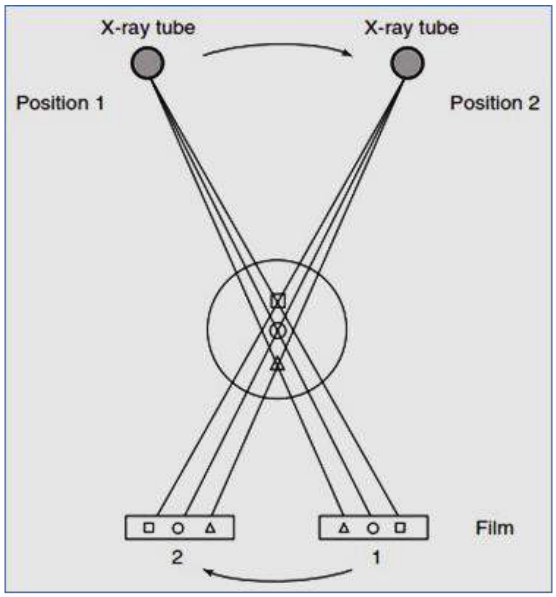


Fig. 3: Basic principles of conventional tomography. The X-ray tube and film move simultaneously and in opposite directions to ensure that the desired section (○) of the patient is imaged by blurring out structures above (□) and below (Δ) the plane of interest (○).

The limitations of radiography and tomography result in the ***inability of film to image very small differences in tissue contrast***. In addition, ***contrast cannot be adjusted after it has been recorded*** on the film. Digital imaging modalities such as CT, for example, can alter the contrast to suit the needs of the human observer (radiologists and technologists) by use of various digital image ***post-processing techniques***.

CT scans can be performed on every region of the body for a ***variety of reasons*** (e.g., ***diagnostic, treatment planning, interventional, or screening***). The ***cross-sectional*** images generated during a CT scan can be ***reformatted in multiple planes***, and can even generate three-dimensional images which can be viewed on a computer monitor, printed on film or transferred to electronic media. Although most commonly used in medicine, CT is also used in other fields, such as ***nondestructive materials*** testing, to study ***biological and paleontological*** specimens.

CT differs from the conventional radiography in two significant ways:

- First, CT forms ***across-sectional image***, ***eliminating the superimposition*** of structures that occurs in plane film imaging because of compression of 3D body structures onto the two-dimensional recording system.
- Second, ***the sensitivity of CT to subtle differences*** in X-ray attenuation is at least a ***factor of 10 higher*** than normally achieved by screen-film recording systems because of the virtual elimination of scatter.

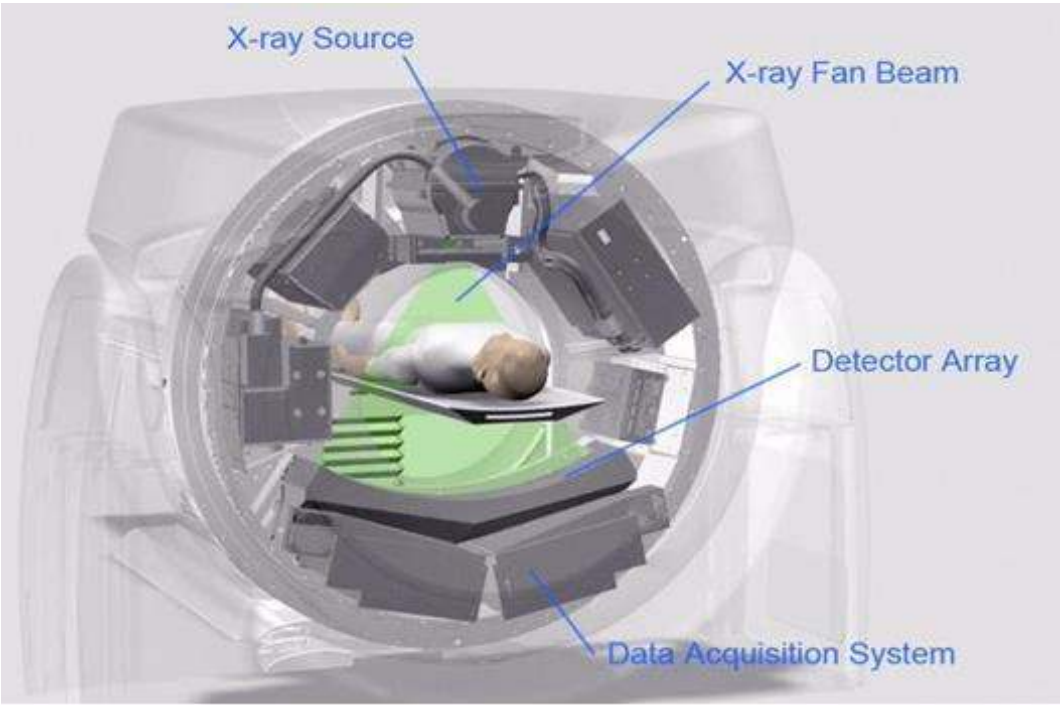


Fig. 4: Schematic of a CT system

Purpose of CT scan

CT-scans provide ***detailed cross-sectional images*** of various internal structures, for example, internal organs, blood vessels, bones, soft tissue etc., and can be used for:

- ***Diagnostic purposes***
- ***Guidance for specific treatment*** or further tests: surgeries, biopsies and radiation therapy
- ***Detection and monitoring of conditions***: Cancer, heart disease, lung nodules, liver masses.

Technique

Digital geometry processing is used to generate a ***3D image*** of the inside of an object from ***a large series of 2D X-ray images*** taken around a ***single axis of rotation***.

- In the ***circular opening*** a flat "patient couch ***(table)" is mounted***, the diameter measures between ***24-28 inches***. The ***patient lies*** flat onto the table and can be adjusted upwards, downward, frontwards or backwards to position for imaging.
- The ***table moves the patient into the gantry*** and the ***X-ray tube rotates*** around the patient. The scanner ***gantry contains the rotating portion that holds the X-ray tube generator and the detector array***. As X-rays pass through the patient to the detectors, a ***computer system acquires*** and performing the ***necessary calculations to go from measurements to a viewable image***.
- One cross-sectional slice of the body is obtained for each complete rotation. ***Multiple shots*** are taken as the scanner rotates and ***these are called "profiles"***. Within one rotation about ***1,000 profiles*** are acquired. A two-dimensional image (slice) is formed when a ***full set of profiles from each rotation*** that are ***analyzed by a computer*** are compiled.