Spiral (Helical) CT in Hepatic Focal Lesions

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Essay

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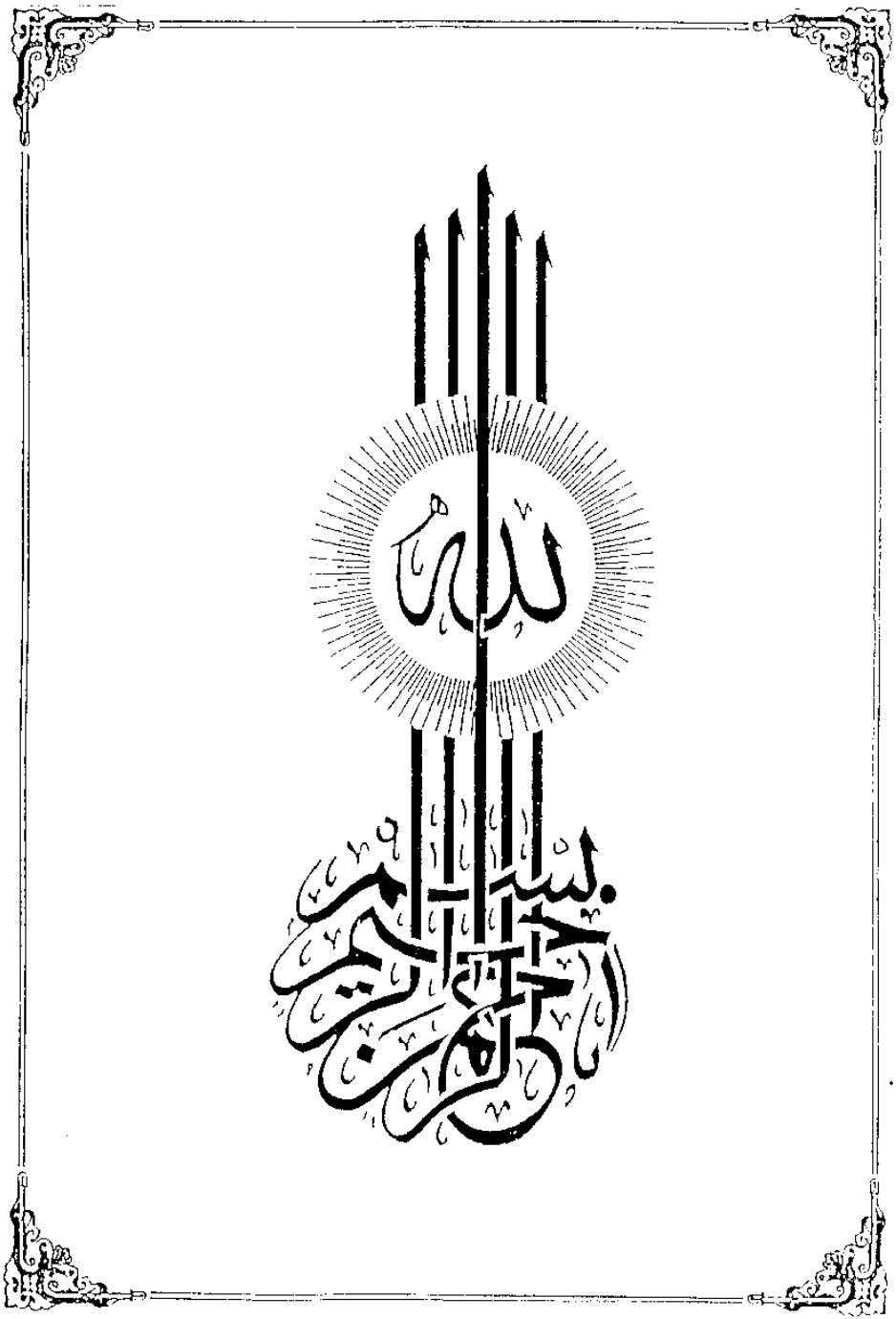

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TO GOD . EVERY THING IN LIFE IS RESUMED

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PHYSICAL PRINCIPLES OF HELICAL (Spiral) CT

Historical Review of CT scanners:

The world's first x-ray CT scanner, which made in Debut in 1972, required several minutes to acquire a single tomographic image. Since then, there has been strong demand in the medical field for faster scanning and an increased scan range of the target region. As a result, one of the main goals in the development of new scanners has been to achieve a shorter scan time, not only by minimizing the time required to acquire a single image, but also by introducing new scan techniques such as rapid-sequence scanning, as well as by developing high -speed dedicated image reconstruction units, higher capacity x-ray tubes with a shorter coolings times and other devices **(Tohki et al, 1991).**

The possibility of generating cross-sectional images, which is the basic principle of CT scanning was first proven by the Austrian mathematician J.H.Radon. According to Radon, in order to reproduce an entire plane, data must be acquired for all possible angular directions at each point contained in the plane. However, in actual practice, only a limited number of angular directions is sampled **(Lawi et al, 1979).**

In CT, X -rays are projected into the object from various directions, the X-rays passing through the object are detected by detectors, and a cross sectional image is generated by computing the X-ray absorption for each point in the sectional plane . A number of methods for acquiring data from

various directions have been developed, and CT scanners which employ these various methods are classified according to these methods in "generations" **(Katakura et al, 1989)**.

1.First generation (translate/ rotate):

In first generation CT scanners,the object to be scanned is placed between the x-ray tube and a detector, a narrow beam of X-rays(called a pencil beam) is projected into the object, and data is acquired.Data is first acquired by linear movements(translate), which provides the projection data for a single direction .then, projection data is acquired in the same manner after the angle is changed (rotate), by repeating these linear and rotational operation alternately, projection data is acquired for a number of directions. This method is faithful to the basic principles of CT scanning and has a number of advantages (for example, it is theoretically immune to the effects of scattered X-rays), however the scan time can be as long as 4or 5minutes per slice, so this method is applicable only to regions which can be kept motionless during prolonged scanning, such as the head (fig 1.1) **(Aradate et al,1991)**.

2.Second generation(translate/rotate):

In second generation CT scanners, the translate/rotate method is employed but, a slightly diverging (3to 15 degree) "fan beam" is used instead of a pencil beam, and a detector array (6to 60 channels) matched to the shape of the x-ray fan beam is employed. In this way, projection data for multiple angular directions is obtained in a single linear(translate)

movement, and the scan time is reduced to 10 to 20 seconds (fig1 2) **(Lawi et al, 1991)**.

3.Third generation (rotate /rotate):

This is the most popular scanning method employed today.In third-generation CT scanners, a relatively wide fan beam (30 to 60 degree) is used. The fan beam covers the entire scanning field, so projection data for one direction is acquired at one time, and data acquisition is completed in a single rotation.The scan time for third generation CT scanners is only 1 to2 seconds (fig 1.3) **(Aradate et al,1991)**.

4.Fourth generation(stationary/rotate and nutate /rotate):

In fourth-generation (stationary/rotate) CT scanners, the circumferential detector array(ring) remains stationary, and the x ray tube is rotated inside it. A fan beam is employed, as in third generation scanners (fig 1.4 A), however, the original projection data from the x-ray tube is rearranged as shown in (fig 1.4 B) so that the diverging projection data centered around the detector can be used as the projection data for image reconstruction **(Aradate et al,1991)**.

In fourth- generation (nutate /rotate) CT scanners, a circumferential detector array (ring) is employed, as in stationary/rotate scanners, but the x-ray tube is rotated outside the detector array. This permits the diameter of the detector array to be reduced, resulting in higher spatial resolution. Since the x-ray tube rotates outside the detector array, the detector array must

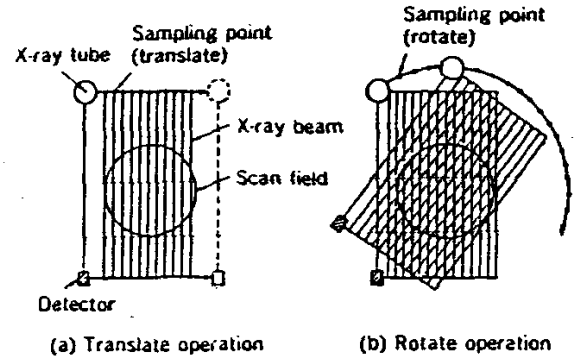

Figure1.1 First Generation (translate/rotate).
(quoted from Aradate et al , 1991)

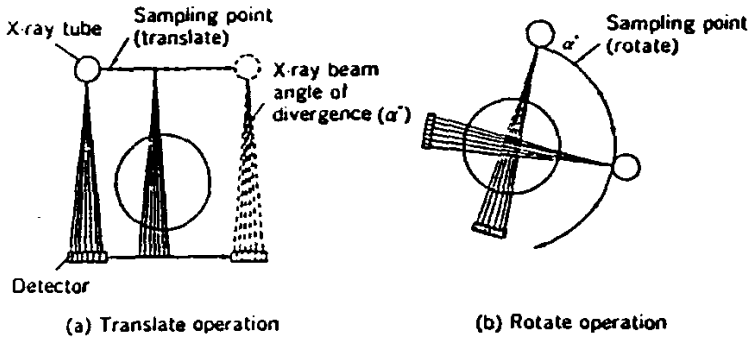

Figure1.2 Second Generation (translate/rotate).
(quoted from Aradate et al, 1991)

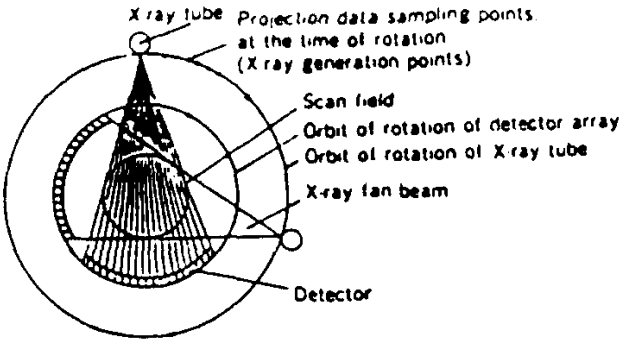

Figure 1.3 Third Generation (rotate/rotate).
(quoted from Aradate et al , 1991)

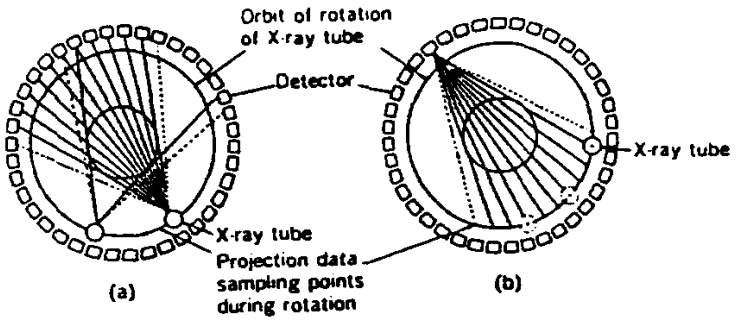

Figure 1.4 Fourth Generation (stationary/rotate, showing detector fan).
(quoted from Aradate et al,1991)

nutate to a void blocking the fan beam. The scan time of such systems is 1 second (fig 1.5) **(Aradate et al,1991)**.

Helical (spiral) CT has dramatically changed the performance of body CT scans **(Crawford et al,1990)**. The elimination of respiratory misregestration artifacts, the minimization of motion artifacts and the production of overlapping images without additional radiation exposure are the most important technical advantages of helical CT **(Costello et al,1991)**.

In this chapter we will focus our attention on the physical aspects of spiral CT as imaging modality for evaluation of hepatic focal lesions.We are not going to extend our scope of discussion to involve the physical aspects of other indications of spiral CT, in order no to load this chapter with unnecessary complex material.

PRINCIPLE OF HELICAL SCAN:

The principle of Helical scan will be discussed, comparing it with the conventional CT scan. The multislice scan method employed in conventional third generation CT scanners illustrates in (fig 1.6), shows the X-ray tube and the detector array are positioned on opposite sides of a target region,and projection data is acquired by rotating them around the target region by one full rotation, much of the progress in CT scanners has involved minimizing the scan time by increasing the rotational speed ,and today some CT scanners are able to achieve speeds of one rotation per second, however, in conventional CT scanning, each scan acquires a tomographic image of only a single slice. Thus, scanning must be repeated

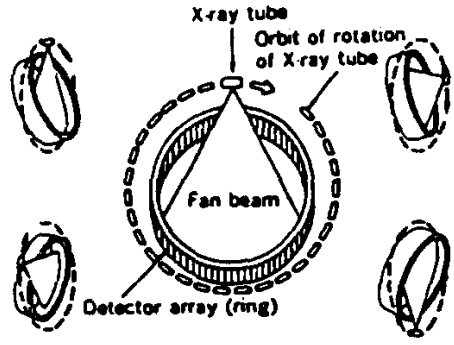

Figure 1.5 Fourth Generation (nutate/rotate, showing nutation of the detector array).
(quoted from Aradate et al, 1991)