Computed Tomography in the 21st Century: Current Status & Future Prospects

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***Abstract**: Computed Tomography has come a long way since its inception in the seventies to evolve as one of the primary imaging investigation of the present era. This review article will provide an overview of the history and development of the CT technology from a 'CAT scanner' of the early times to the 'MDCT scanners' of the recent times. The current clinical applications of the CT imaging will be discussed with illustrative examples followed by a brief note on the workflow in a modern hospital. The principle and advantages of 'Dual-source' CT scanners and 'new-generation' MDCT scanners will be addressed. The future of CT imaging will talk mainly about the role and relevance of 'fusion' imaging and the 'quantitative' CT imaging. The economics of CT imaging in the present healthcare will be addressed in brief, followed by an overview of radiation concerns in CT. The alternative options like Ultrasound and MRI will be discussed in brief with emphasis on the need to judiciously use the imaging algorithm in clinical practice. At the very end, the article provides a brief message to adopt a 'patient-centric' approach and 'problem-solving' attitude in clinical radiology for the betterment of the patient and his/her sufferings.*

HISTORY & EVOLUTION OF CT: FROM CONCEPT TO CLINIC

In late seventies, the use of Computed tomography (CT) for clinical applications in diagnostic imaging indeed sparked a revolution in the field of medical engineering. This cross-sectional imaging technique provided an in depth insight into the anatomy and pathological processes in the human body and promised to overcome many of the limitations of plain radiographs. The invention of computed tomography is certainly one of the greatest innovations in the field of radiology after the X-rays were discovered in 1895. This was also duly acknowledged and G.N. Hounsfield & A.M. Cormack received the Nobel Prize in medicine for the invention of CT in 1979. This growth story is one of the most interesting examples in the evolution of Medicine which highlight the man's unending zeal for the better[1]. CT technology gradually evolved from 'mere concept' to a 'technological marvel' in the seventies and later on from a single-detector 'CAT' (Computerised Axial Tomography) scanners to spiral scanners in the nineties to the state-of-the-art MDCT (Multi-detector CT) & Dual-source scanners.

The development of the first CT scanner was started in 1967 by Godfrey Hounsfield who was an engineer at British EMI Corp. According to his hypothesis, careful measurements of x-ray transmission through a subject at many positions across the subject and at a sufficient number of angles, should be able to determine attenuation differences of as less as 0.5% which is possibly sufficient to distinguish between soft tissues[2]. Based on this concept, the first clinical CT scanner was then built and installed at Atkinson-Morley Hospital in England in September 1971.

THE INITIAL CT SCANNERS.

The first CT scanner (also called as EMI device) was a dedicated head scanner in which the patient's head was scanned using a single-narrow-beam, single-detector assembly and cylindrical water-filled phantom[3]. The combination of linear translation followed by incremental rotation is called translate-rotate motion which was an integral component in the first-generation scanners. As the acquisition time was long, these early scanners were only used for head scanning. In late 1974, second-generation CT scanners were introduced used which incorporated multiple narrow beams and multiple detectors. However, the geometry employed was again rotate-translate motion, as in the first generation scanners[4]. Second-generation scanners were able to attain scan times as low as 20 seconds. At this point of time, scanning of the body was finally feasible as single plane acquisition was feasible within a breath hold for most patients. Subsequently, the translation motion of the tube was abolished. The detector array is rigidly linked to the x-ray tube, so that both the tube and the detectors rotate together around the patient to follow rotation–rotation geometry. These third-generation scanners reduced the single plane scan time to as low as 5 seconds. Third-generation CT scanner however, requires extremely high detector stability and matching of detector responses. The result is an image 'ring artifact' which may result from detector inaccuracies as small as 0.1%[1]. By late seventies, another design was suggested which incorporated a large stationary ring of detectors, with the x-ray tube alone rotating around the patient. This design led to the fourth generation CT scanners. The basic designs of these CT scanners of the early days are illustrated in figure 1. In electron-beam CT (EBCT), the electron beam is electronically swept along the 360° circumference of the target from where X-rays are generated[5]. These scanners were mainly used for cardiac imaging. High equipment cost is however, a big disadvantage with EBCT.

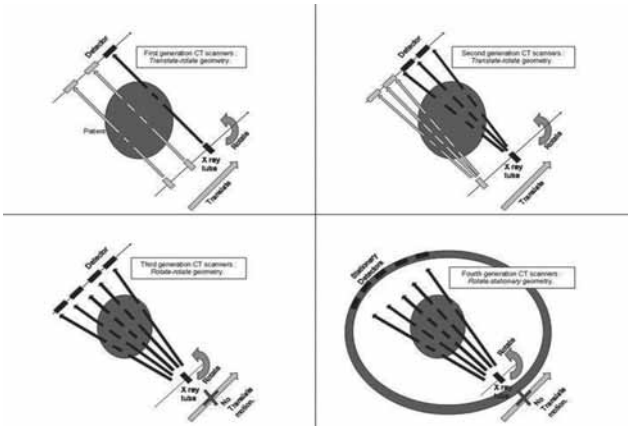

***Figure 1:** Line diagrams to illustrate scanner assembly in different generations of CT scanners. Evolution of CT technology truly highlights men's unending zeal for the better.*

'SLIP-RING' TECHNOLOGY AND THE ARRIVAL OF SPIRAL CT SCANNERS.

In an attempt to reduce the inter-scan delays, an innovative concept of 'Slip-ring' was introduced whereby a low-voltage ring could pass electrical power to the rotating components without fixed connections[6]. Continuous rotation of tube and detector-assembly was possible which led to the development of whole new spiral CT (Figure 2). Real-time CT fluoroscopy also became feasible which incorporated real-time tableside image viewing and table positioning through foot pedals.

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