ROLE OF COMPUTERIZED AXIAL TOMOGRAPHY IN DIAGNOSIS AND FOLLOW-UP OF NEUROPSYCHIATRIC DISORDERS

A Review Article

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INTRODUCTION

Since the advent of computerized tomography scan in 1973 by the English physist Hounsfield and the neuroradiologist Ambrose, computerized tomography scan has become one of the most important methods of investigation in neurological disorders.

Being an easy rapid non-invasive method of viewing the brain structures with no significant distress to the patient, computerized tomography scan has become an increasingly demanded method by both physicians and patients. With increasing demands for computerized tomography scan and the every day evolution of new generations of computerized tomography scan apparatuses, a multitude of studies have described the appearance of computerized tomography scan images in every specific clinical condition. This stream of publications has become such a torrent that some commentators suggested that the uncontrollable desire to write about computerized tomography scanning is a symptom of a new disorder: computerized tomography scan hyperpyrexia or CAT fever (Shapiro & Wymann, 1976). Clinicians have questioned whether the superior imaging ability of computerized tomography scan is translated into improved patient's care and whether the computerized tomography scan is reducing the cost of health care or adding to it. Many studies have attempted to analize the overall clinical value of this new neuroradiological technique. In Egypt, there are a few computerized tomography scan centers, no more than five which were mostly introduced in the last few years, and there are a few Egyptian papers about computerized tomography scans e.g. CAT studies in schizophrenia by Okasha et al. (1982). Other studies in different neurosurgical subjects were made as well e.g. computerized tomography studies in head injuries by Abdel Hamid & Madkour (1981), computerized tomography studies in intracerebral haematomas (1982) by Madkour, computerized tomography studies in epilepsy by Abdel Hamid and Madkour (1982).

The selection of this review is an attempt to follow this new evolutionary investigation in our country.

AIMSOF THE WORK

1. To provide a historical review about the computerized tomography scan, its evolution through its successive generations; to provide the normal appearance of the brain as an important step for appreciating the abnormalities.

2. To provide a review of literature in the different subjects of the neuropsychiatric field of practice to be available for a thorough research in each particular field later on.

3. To define the present indications and limitations of computerized tomography scan.

METHOD

To fulfil the aims of this work, one had to follow one of two methods: The first is the clinical study of cases of different disorders, a method which needs a reasonable number of cases in each topic to give significant results, a choice which was improbable as it needs a longer time specially with the non-availability of computerized tomography scan in our university hospitals. The second method which is followed in this study, is to collect and review as much as possible of the published literature in the different aspects of the neuropsychiatric field with the aim of providing a basic background for a thorough study in every specific topic.

HISTORICAL REVIEW

The development of computerized tomography by the physist Hounsfield (1973) and its clinical introduction by the neuro-radiologist Ambrose (1973) in England have had a profound effect on the practice of neurology. The significance of Hounsfield's development to radiology may eventually be considered as second only to Roentgen's discovery of X-rays.

The technology of the computer has been applied to diagnostic radiology with impressive results by mathematical analysis of the absorption of X-ray photons passing through soft tissues from numerous angles. A cross-sectional image can be reconstructed which provides remarkable pictorial and quantitative differentiation of these tissues to a degree not possible with conventional radiology. Computerized tomography is a non-invasive technique and thus there is no associated morbidity.

It is worthy to note that Hounsfield's work was based on principles suggested and developed in rudimentary form by Oldendorf (an American neurologist) in 1961. Oldendorf's attempt was unsuccessful because of computer limitations at that time, the use of a relatively small number of films at different angles and the large amount of scattered radiation reaching the film as a result of exposing the entire skull for each film. The considerable improvement in computer technology in 1960s resulted in instruments which could perform thousands of computation within a very short time interval and with a high degree of efficiency. Hounsfield combined modern computer technology with other newer developments and made it possible to produce the first computerized device: the EMI scanner in 1972. The original EMI scanner was restricted to investigation of the head in the horizontal cross section. Computer tomographic units capable of examining the entire body as well as the head were introduced more recently: ACTA scanner, delta scanner the newest generation of EMI scanners, Densitone, ND 8000 and CE 10.000.

Basic Principles:

In conventional radiography, the image on the x-ray film (the degree of blackening) is directly proportional to the amount of absorption of X-ray photons as they pass through various tissues. Thus bone absorbs a high proportion of the incident beam, while an air-containing structure (as the lung) absorbs relatively few photons. The reduction in intensity of the incident X-ray beam by a given structure is related to the thickness of that structure, its density and its atomic number. In the energy range used in diagnostic radiology, materials of high atomic number are able to absorb much more radiation than are low atomic number materials. The percentage absorption is roughly proportional to the cube of the atomic number. The linear attenuation (absorption) coefficient (u) of a particular tissue is the quantitative measure of the absorption of X-rays by a unit thickness of that tissue. Bone with a high concentration of calcium (atomic number = 20) has a much higher (u) than do soft tissues, which consist chiefly of hydrogen, carbon and oxygen (atomic numbers of 1, 6 and 8 respectively) and is therefore easily differentiated from adjacent muscles or viscera on a radiograph. However, the difference in X-ray absorption between the various solid organs, muscles and other soft tissues (except for fat) is in the range of only 1% to 3%. A differential absorption of 5% or more is generally required to distinguish different soft tissues on the plain radiography.

On the other hand, computerized tomographic devices are able to differentiate between many different soft tissues where the difference in absorption may be as little as 0.5%. This is accomplished by making, from different angles, literally thousands of measurements of the absorption coefficients of tiny portions of tissue within relatively small 'slices' of the structure being examined. The emerging radiation which has passed through the structure is detected not by X-ray film but rather by a scintillation crystal (sodium iodide or calcium fluoride), similar in composition to the crystals used in probes & scanners in nuclear medicine to detect radiation emitted from radio-active isotopes. Such crystals emit a visible blue light in proportion to the intensity of the radiation striking the crystals. This light is detected by a sensitive photocell which trasforms it into an electrical signal. In an analogue-digital converter, the electrical signals are converted into numerical data. These data are fed into a computer which simultaneously performs thousands of computations and arranges the results into a quantitative digital display which represents the linear absorption coefficient of each bit of tissue (the pixel) within the 'slice'. This numerical display can be directly printed on paper or converted into analogue form to create an image on a cathode ray tube or television monitor which can then be photographed. The cathode ray osciloscope or T.V. image is not only pictorial, but also quantitative in that the degree of blackness of any point in the image is proportional to the attenuation or absorption of X-rays at that point. Thus each number on the paper print-out and each point on the pictorial display correspond to the computer linear attenuation coefficient (u) of the tissue at that particular location. Different colors can also be assigned to groups of these numbers and the pictorial display viewed on a color television monitor.

Technique:

The X-ray tube is mounted on a straight track located on the side of an oval frame or gantry, and directly opposite on a parallel track are located one or more crystal detectors. The head is placed in the centre of this scanning gantry and is immobilized during the study (with the original EMI scanner, it was necessary to surround the portion of the head to be examined with a tightly fitting water-bag to provide a reference material & ensure consistent results). The plane of the slice is usually not truely horizontal but is rather oriented at an angle of 20° to 25° toward the feet, so that the lowest slice roughly corresponds to a line drawn from the roof of the orbit through the external auditory canals. This ensures that most of the brain particularly the posterior fossa, is included in the examination. The

X-ray tube moves in a straight line on a tangent to the circle within which the head is centrally located and the crystal detectors which are firmly attached to the scanning yoke mechanism make the same tangential scanning motion in the same direction on the opposite side of the head. The X-ray tube is energized continuously during the scan with a carefully controlled voltage & current regulator, resulting in an extremely constant output of highly collimated radiation. For the EMI scanner, during each scan pass the crystal detectors make a series of 240 independent transmission readings of 5 msec duration. After each single transit, the gantry rotates 1° and the scan is repeated; this sequence continues in 1° increments for 180°. Thus, for each 'slice' examined, a total of 43, 200 (180 x 240) separate but intersecting measurements of radiation intensity are obtained. The total time required to complete this cycle of 180° varies with different types of equipment and is currently being markedly shortened by new improvements. Originally, this time was about 4½ minutes later reduced to 2 minutes and in some units has been reduced to 20 seconds by employing multiple detectors & radiation beams. After completion of 180° scan, the head is repositioned by moving the patient farther into or out of the gantry as desired and the entire cycle is repeated. Usually a completely examination consists of 6 or 8 scans more or less, which can be varied according to the clinical problems. The total time for an average complete study with a 4½ minute cycle per cut is 25 to 30 minutes.

Sensitivity & Radiation dose:

Computed tomography is approximately 100 times more sensitive than conventional radiography. By this method very small differences in tissue density (approximately 1.5%) can be distinguished. The radiation dose is small; a complete examination of the head being in the range of 1.0 to 2.5 rads. This is approximately the same as the exposure for a few lateral views in conventional radiography. Because the X-ray beam is tightly collimated, there is less scattered radiation than in conventional radiography; thus the total radiation dose to the contents of the cranial cavity from a complete tomography study; has been estimated at only one third of the dose from a single lateral skull radiography (Perry & Bridges 1973).

Computerized tomography Numbers:

In computerized tomography scanners, radiation transmission measurements are made at many angular orientations around the patients, covering a total arc