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Neuroimaging of Epilepsy by using Computed Tomography Procedure

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Abstract

high-resolution computed tomography (CT) and magnetic resonance (MR) imaging play important roles in the evaluation and classification of seizure patients by virtue of their ability to identify epileptogenic lesions. CT is one of the most widely used imaging techniques for evaluating abnormalities of the central nervous system. Its widespread availability at emergent care facilities, high sensitivity detection of life-threatening lesions, and rapid scan time have made CT the most widely used imaging study for screening patients with new onset seizures, patients whose seizure was accompanied by head trauma, a focal neurological deficit, or persistent alternation in mental status were also found to be at high risk. A Computed Axial Tomography scan (CAT or CT scan) is a non-invasive and painless test. CT scans produce cross-sectional images (tomographs) of areas in the body that will be examined to look for abnormalities (eg. scar tissue, blood clots or tumours). For epilepsy, this usually involves a scan of the head to look for possible origins of seizures. In Temporal Lope Epilepsy (TLE), Mesial temporal sclerosis (MTS) and neuronal migration disorders. Mesial temporal sclerosis is the most common cause of temporal lobe epilepsy. CT imaging correlates of those histological changes are hippocampal volume loss and architectural distortion (secondary to neuronal cell loss), and increased signal on images (due to gliosis). Extrahippocampal changes, such as atrophy of mammillary body, amygdala, column of the fornix, and parahippocampal white matter can also be seen with MTS. Mesial TLE was associated with reductions of N-Acytel Asparta in frontal grey, and white matter, which is consistent with other data suggesting more widespread involvement. The objective of this study are to review the roles of conventional CT imaging in patients with epilepsy, and to discuss its potential role in seizure imaging.

Introduction

Prior to the advent of cross-sectional imaging, evaluation and classification of seizure patients was based on electroencephalography (EEG) data and clinical findings. Detection by EEG of abnormal electrical activity remains the definitive means to document the presence of epilepsy[1]. However, classification of seizures based solely on EEG and clinical findings can result in the misclassification of some patients, In children this seizures may consist of starling or lip smacking and therefore may be confused with the absence seizures. Generalized absence seizures are described by mean of 10 second lapses in conscienceness;

During this time the cypernatics attack person appears to be staring into space and the eyes may rolls upwards. Typically, they occur in children and disappear by adolescence. In practically view to most common seizures which terms the tonic-clonic seizures with generalized convolutions; have two phases. Tonic phase plays the initial trigger fall down and loose consciousness and body become rigid. Through out the clonic period, the body extremities jerk and twitch. Tonic-clonic seizure is the most visible, the obvious type of epilepsy. Pseudo-seizures (psychogenic seizures), a quite common could attach any one, start with rapid breathings, triggered by anxiety, pain and the person build up a carbon dioxide in their bodies and change their chemistry specially the acidity of the blood[2,3].

Today, high-resolution computed tomography (CT) and magnetic resonance (MR) imaging play important roles in the evaluation and classification of seizure patients by virtue of their ability to identify epileptogenic lesions[4]. CT is one of the most widely used imaging techniques for evaluating abnormalities of the central nervous system. Its widespread availability at emergent care facilities, high sensitivity detection of life-threatening lesions, and rapid scan time have made CT the most widely used imaging study for screening patients with new onset seizures. patients whose seizure was accompanied by head trauma, a focal neurological deficit, or persistent alternation in mental status were also found to be at high risk[5,6].

Seizures may occur in up to 10% of the population, whereas epilepsy is a chronic disease characterized by recurrent seizures that may affect 2% of the population. Although primarily defined by EEG abnormalities, it is presently recognized that epilepsy is often associated with gross or subtle structural or metabolic lesions of the brain[7]. Modern neuroimaging is useful in the diagnosis of the abnormalities underlying the epilepsies, but the information provided by imaging techniques can also contribute to the proper classification of certain epileptic disorders and can delineate the genetics underlying some syndromes[8]. Neuroimaging is even more important for those patients who have medically intractable seizures[9]. Advances in technology to localize focal epileptogenic substrates, especially that of high-resolution structural imaging with magnetic resonance imaging (MRI), have substantially improved the success of surgical treatment. This research compares available imaging modalities, their specific role in patients with epilepsy, and practical applications of imaging data in the management of patients with epilepsy[10].

Computed tomography (CT) uses ionizing radiation and can generate excellent hard tissue imaging contrast with moderately good soft tissue resolution. CT has a number of advantages, and those include lower cost, scan speed, ready accessibility, and easy use, which provide a relatively reliable imaging modality for most patients. In addition, last-generation CT scans can generate images of the brain in seconds.

Although the use of CT for patients with epilepsy has been greatly diminished by MRI, CT is still the technique of choice for the investigation of patients with seizures and epilepsy under certain conditions. In the neonate and young infant, CT is often of secondary or adjunctive importance, but it serves as a significant backup role to ultrasound[11]. CT can accurately detect hemorrhage, infarctions, gross malformations, ventricular system pathologies, and lesions with underlying calcification. In older children and adults, CT is the technique of choice in the perioperative state because it can rapidly detect recent hemorrhage, hydrocephalus, and major structural changes. One should recognize that the sensitivity of CT in patients with epilepsy is not higher than 30% in unselected populations[12]. The objective of this study are to review the roles of conventional CT imaging in patients with epilepsy, and to discuss its potential role in seizure imaging.

Methodology

Voxel and anatomically-based methods may be applied in longitudinal studies to identify subtle changes in the brain and to determine the effects of epilepsy. A Computed Axial Tomography scan (CAT or CT scan**)** is a non-invasive and painless test. CT scans produce cross-sectional images (tomographs) of areas in the body that will be examined to look for abnormalities (eg. scar tissue, blood clots or tumours)[13]. For epilepsy, this usually involves a scan of the head to look for possible origins of seizures. The machine CT is a medical imaging method employing tomography created by computer processing Fig1. Digital geometry processing is used to generate a three-dimensional image of the inside of an object from a large series of two-dimensional X-ray images taken around a single axis of rotation. CT produces a volume of data which can be manipulated, through a process known as "windowing", in order to demonstrate various bodily structures based on their

looks like a large box with a donut shaped hole in the middle (a gantry). The patient lie on a platform that slides in and out of the gantry as the x-ray rotates around. Low radiation x-rays pass through the body and are captured by detectors. Computers use this information to produce a 2-D image of the area. The majority of previous cross-sectional studies have inferred that more severe hippocampal damage is associated with a longer duration of epilepsy and a greater number of seizures. Longitudinal studies, however, are necessary to ascribe cause and effect[13].

ability to block the X-ray/Röntgen beam. Although historically the images generated were in the axial or transverse plane, orthogonal to the long axis of the body, modern scanners allow this volume of data to be reformatted in various planes or even as volumetric (3D) representations of structures. Although most common in medicine, CT is also used in other fields, such as nondestructive materials testing[14].

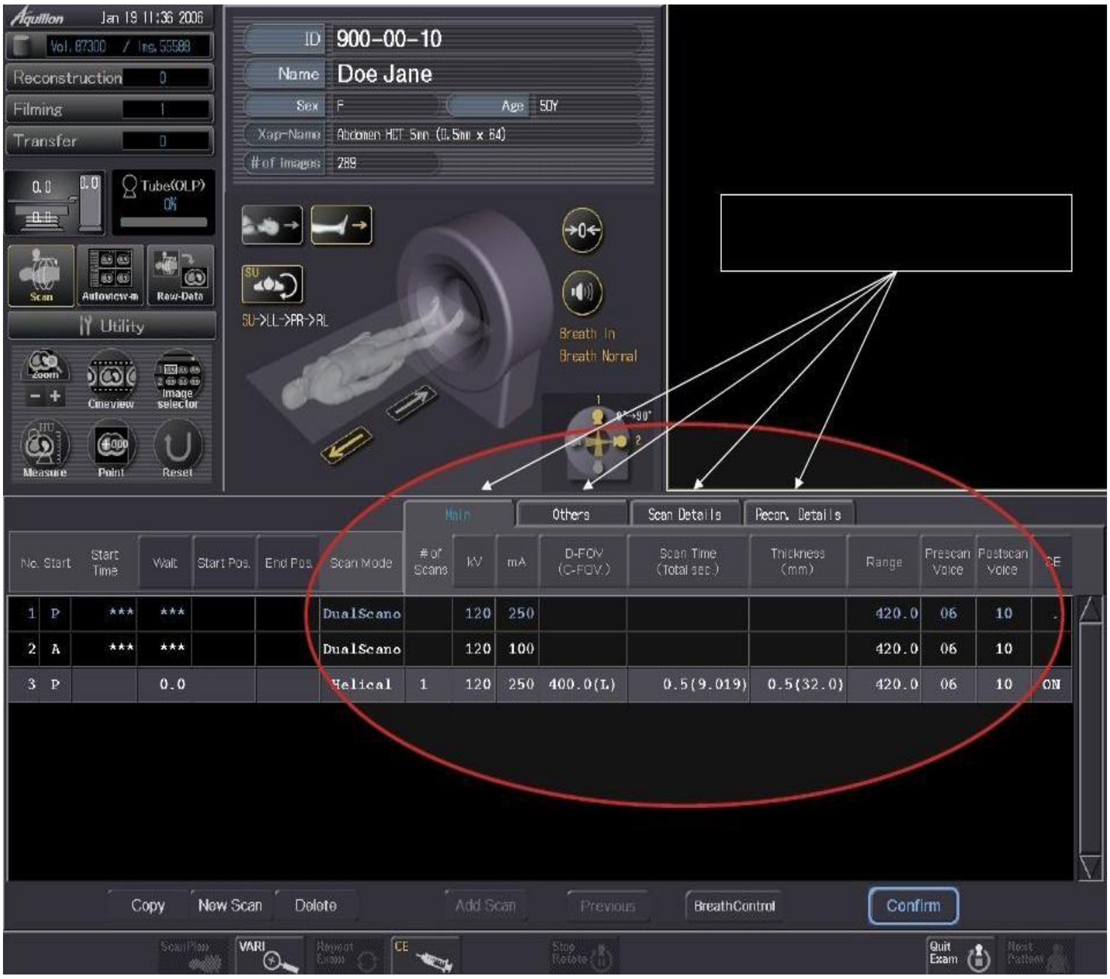

Fig 1. illustrate the software of CT scan (Toshiba Aquilion CT 64 scanner) instruments.

Results

In Temporal Lope Epilepsy (TLE), Mesial temporal sclerosis (MTS) and neuronal migration disorders. Mesial temporal sclerosis is the most common cause of temporal lobe epilepsy. CT imaging correlates of those histological changes are hippocampal volume loss and architectural distortion (secondary to neuronal cell loss), and increased signal on images (due to gliosis). However, detection by standard CT imaging is difficult due to the small size of the hippocampus (normally 1.5 to 3.5 cc) and the small differences that can occur normally (right hippocampus can be 0.6 cc larger than the left while the left should be no more than 2 cc larger than the right). Diagnosis therefore requires a high-resolution sequence capable of detecting such minor changes. At the CNI, we use a 3mm thick high resolution coronal sequence oriented perpendicular to the long axis of the hippocampus. Hippocampi are then visually assessed for decreased size, abnormally high signal intensity, and architectural distortion. At some institutions, hippocampal volumes are determined in order to detect even more subtle volume loss.

Extra hippocampal changes, such as atrophy of mammillary body, amygdala, column of the fornix, and parahippocampal white matter can also be seen with MTS.

Mesial TLE was associated with reductions of N-Acytel Asparta in frontal grey, and white matter, which is consistent with other data suggesting more widespread involvement.

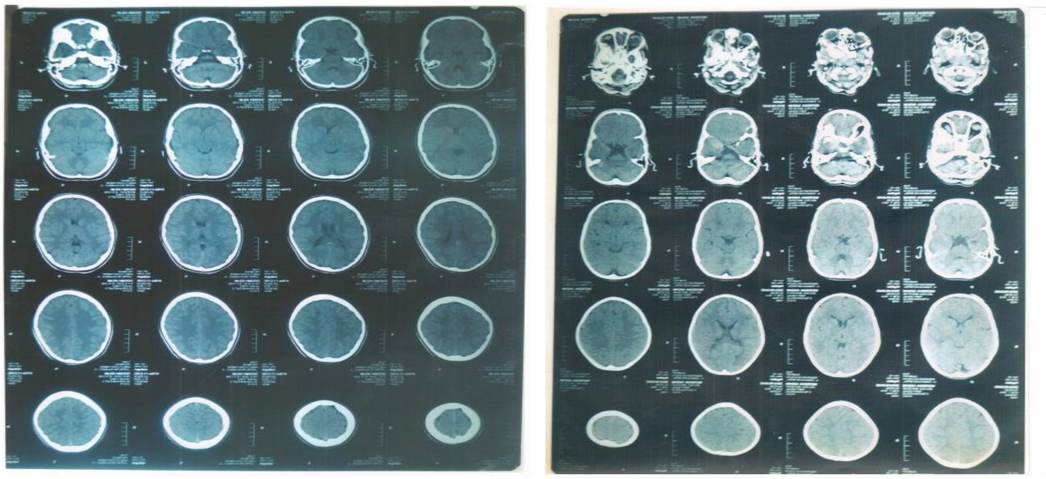

Fig 2. Case1 at left is a boy and Case 2 at the right is a girl diagnosed with epilepsy, had been treated with medications for 4 years. During the last year, he had continued to have seizures, even with a change in antiseizure medications. High-resolution coronal T2- weighted image demonstrates the classic imaging changes of mesial temporal sclerosis. The left hippocampus (solid arrow) is smaller than the right and exhibits subtle architectural distortion. These changes correlate with neuronal volume loss on histopathological studies. The white matter volume in the left paraphippocampal gyrus (solid arrow head), a secondary sign of MTS, is also decreased.

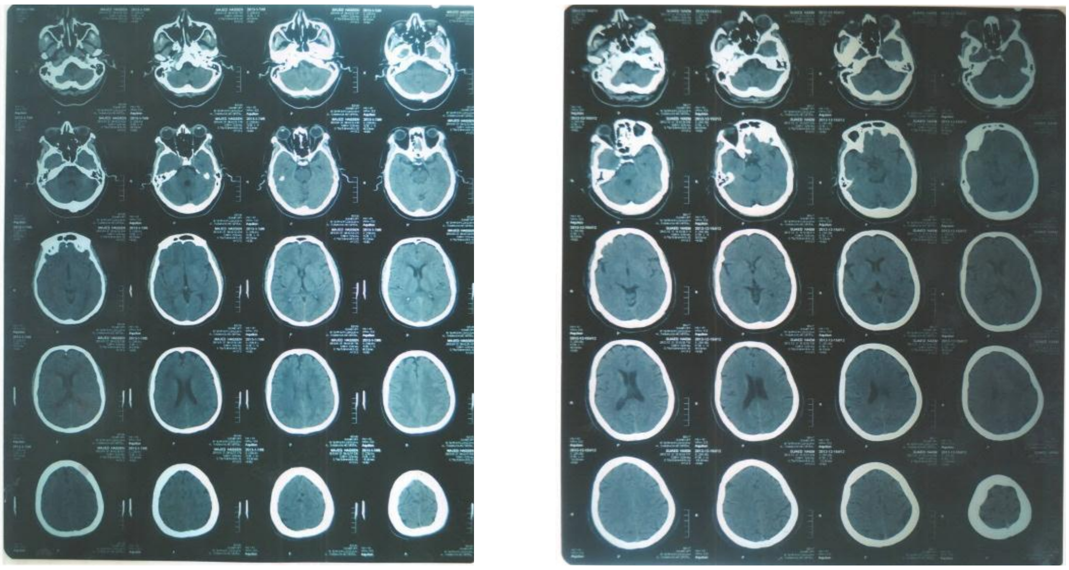

Fig.3 Control normal cases where all the slices showed Axial T2-weighted image demonstrates normal nodular foci lining the ependymal surface of the lateral ventricles bilaterally. Axial inversion-recovery image optimized for gray matter-white matter differentiation better depicts the extent of the bilateral nodular heterotopia. The identical signal intensity of the nodules and cortical gray matter confirms the diagnosis between the normal and abnormal cases mentioned above in fig.2.

Discussion

CT is a medicine imaging method that allows for the quantitative and qualitative evaluation of regional cerebral perfusion. CT is more readily available than positron emission tomography (PET) and is considerably less expensive[15].

CT is not indicated for the majority of patients with epilepsy but has an important role in the investigation of surgical candidates. The use of CT in epilepsy stems from the known association of seizures with increased regional cerebral perfusion. Numerous studies using dynamic and static CT have demonstrated interictal temporal hypoperfusion in up to 50% of patients with well-documented temporal lobe epilepsy. However, 5–10% of patients may demonstrate hypoperfusion in the contralateral temporal region raising the possibility of false lateralization[16]. CT scans may be useful as baseline studies for comparison with MRS studies in selected patients. In Temporal Lope Epilepsy (TLE) caused by HS, 1H spectroscopy MRS showed reduction of NAA and increases of choline-containing compounds, creatine + phosphocreatine, reflecting neuronal loss or dysfunction and astrocytosis, and also an elevation of glutamate and glutamine in epileptic hippocampi that were structurally normal[17,18,19].

The majority of previous cross-sectional studies have inferred that more severe hippocampal damage is associated with a longer duration of epilepsy and a greater number of seizures. Longitudinal studies, however, are necessary to ascribe cause and effect. Two recent studies have suggested atrophy of the hippocampus occurring over three years of active epilepsy in patients attending epilepsy clinics[4,18]. A large community-based study has shown that those with a history of a prior neurological insult had smaller neocortical volumes and an accelerated rate of brain atrophy, and that in patients with newly diagnosed epilepsy without a history of prior insult the rate of atrophy was no different from age-matched controls. Patients with chronic epilepsy, however, were more likely to have had significant loss of neocortical, hippocampal or cerebellar volume over 3.5 years[5]. Further, on a more sensitive voxel-based analysis, 54% of those with chronic epilepsy, 39% of those with newly diagnosed seizures and 24% of controls had areas of brain volume loss[16]. These studies implied that secondary brain damage might occur in the context of chronic epilepsy. The next step is to identify the aetiological factors and how to intervene to prevent this process

CT, proton MRS has proven to be a sensitive measure to detect metabolic dysfunction in patients with TLE. However, it remains to be clarified whether this additional information adds to the overall management of the patients. With its high sensitivity, metabolite abnormalities can be detected in brain regions distinct from the seizure focus and it remains difficult to disentangle which abnormalities cause seizures or are their consequences. Some indication can be taken from a large study performed in 82 patients with refractory TLE that found in both the ipsilateral and contralateral temporal lobe a low NAA/Cr ratio that was negatively correlated with the duration of epilepsy[8]. Patients with frequent generalized tonic-clonic seizures had lower NA/Cr than patients with no or rare generalized tonic-clonic seizures. Independent but supportive are the findings of reversibility of metabolic dysfunction in homotopic brain areas after successful surgery[19]. This suggests that ongoing seizures may induce additional neuronal damage, which will progress in parallel to the duration of the epilepsy.

If this is the case, MRS may be important in providing a metabolic marker for disease progression after the CT scan detection. One can speculate whether, in future years, CT, MRS evidence of disease progression may modify treatment. Another area with potential therapeutic impact is that of neurotransmitter MRS studies. Glutamate and -amino- butyric-acid (GABA) can be measured using MRS editing techniques as a completely step to CT scan crudely evaluation[20].

Research suggests that intracellular glutamate concentrations are elevated in the epileptogenic human hippocampus and neocortex. The high glutamate content may contribute to the epileptic state by increasing cellular excitability. Studies have also shown that cellular glutamate content is abnormal in patients treated with antiepileptic drugs. Studies support a key role for GABA levels and, in turn, GABA release in the regulation of cortical excitability and epilepsy. Primate models of photosensitive epilepsy have low GABA levels and seizures improve with GABAergic drugs[14]. Similarly, AEDs that increase GABA or enhance GABAergic inhibition block the photoparoxysmal response in photosensitivity epilepsies. Petroff et al.[7] showed that up to two-thirds of patients with refractory focal epilepsy treated with traditional AEDs have below normal occipital lobe GABA levels. In healthy controls without epilepsy, topiramate, gabapentin, and lamotrigine may increase intracellular brain GABA within 3 h of the first oral dose[3]. An epilepsy patient with low GABA levels may benefit from an AED that increases cellular GABA or perhaps lowers cellular glutamate. Thus, it is possible that MRS may provide biochemical information useful when treating epilepsy in the near future.

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الخلاصة

أن التصوير الإشعاعي باستعمال الكمبيوتر ذو قدرة تحليل عالية الدقة (CT) وكذلك آلية التصوير الرنين المغناطيسي (MR)، أصبح لهما أدوار مهمة في التقييم وتصنيف مرضى حالة الصرع، من خلال أمكانية هذه الآليات على تشخيص القرح والأورام التي تؤدي إلى حالة الصرع. أن التصوير الإشعاعي ثنائي الأبعاد (CT) هو من التقنيات المستعملة بشكل واسع لتشخيص الحالات غير الطبيعية للنظام العصبي المركزي. أن توفر هذه الأجهزة في جميع أجنحة الطوارئ، والتقدير عالي الحساسية للقرح المهددة للحياة، وسرعة الفحص جعل من هذه الطريقة الاكثر استعمالا لدراسة المسح السريع لحالات الصرع في مراحلها الاولى، او الحالات التي يرافقها ورم في الدماغ، أو التبدل المستمر في الحالات الذهنية والتي تعتبر من الحالات الخطرة. يعتبر هذا الفحص غير مؤلم، ويوفر صور مقاطع عرضية لمناطق الجسم التي تفحص لإظهار الأنسجة غير الطبيعية مثل الندب وتكتل الدم أو الأورام.

في حالات الصرع يشمل الفحص عادة عمل مسح صوري للرأس للبحث عن المصادر المحتملة لحالة الصرع.

في حالة صرع الجزء الصدغي للدماغ أو ما يسمى بتصلبات الصدغ TLE والتي تعتبر السبب الأكثر احتمالا لهذا النوع من الصرع. أن أكثر التغيرات النسيجية التي يمكن ملاحظتها من خلال استعمال CT هو حجم قرن الذاكرة Hippocampus، وتورم الجسم اللبني ، وكذلك التغيرات في النسيج المحيط بالدماغ المتمثل بالام الحنون، وما يشترك معها في اختزال مادة NAA ، والتي تكون مع البيانات الأخرى الصورة الواضحة في مثل هذه الحالات.
أن الغاية من هذه الدراسة هي بيان أهمية التصوير الإشعاعي ثنائي الأبعاد لمرضى حالات الصرع ولمناقشة دورها الفعال في التشخيص.