Original Article

Effectiveness of radiology modalities in diagnosing and characterizing brain disorders

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ABSTRACT

الأهداف: تم استكمال الأشعة التقليدية بالعديد من الطرق الجديدة لتصوير الجسم، وكان التصوير المقطعي المحوسب (CT) والتصوير بالرنين المغناطيسي (MRI) مفيدًا للغاية. تهدف الدراسة الحالية إلى ملاحظة دقة الأشعة المقطعية والرنين المغناطيسي في تقييم الاضطرابات العصبية.

المنهجية: استخدم هذا البحث بأثر رجعي التصوير المقطعي أو التصوير بالرنين المغناطيسي لتشخيص وتوصيف اضطرابات الدماغ. تمت الدراسة من. واعتبرت سجلات المرضى الذين يعانون من اضطراب عصبي مؤهلة للتضمين، بغض النظر عن وقت ظهور الأعراض، أو شدة الأعراض، أو التشخيص السريري النهائي. معايير الاستبعاد لهذه الدراسة شملت المرضى الذين لم يخضعوا لفحص التصوير المقطعي أو التصوير بالرنين المغناطيسي. تم إجراء اختبار مربع كاي لملاحظة الارتباط بين متغيرات الدراسة. تم تحليل ما مجموعه 3155 حالة.

النتائج: كان المرض المصاحب الأكثر انتشارًا هو اضطراب شحوم الدم 670 (21.6%) يليه ارتفاع ضغط الدم 548 (17.6%). تم تأكيد اضطرابات الدماغ بشكل عام في 2426 (77%) من المرضى. وقد لوحظ أن نصف المرضى 1543 (48.9%) تم تشخيص إصابتهم بالسكتة الدماغية. وقد وجد أن دقة التصوير المقطعي والرنين المغناطيسي كانت 78% و74% على التوالي. لم يتم العثور على ارتباط بين الطرائق ونوع المريض والجنس مع تأكيد الأمراض (p=>0.05).

الخلاصة: كشفت دراستنا أن التصوير المقطعي والرنين المغناطيسي كانا دقيقين بنسبة تزيد عن 75% ولم يكن هناك فرق بين الطريقتين للكشف عن الاضطرابات العصبية.

Objectives: To observe the accuracy of Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) scans in evaluating neurological disorders.

Methods: This retrospective research used CT or MRI to diagnose and characterize brain disorders. Patients' records suffering from neurological disorders were considered eligible for inclusion, regardless of the time of appearance of symptoms, the severity of their symptoms, or their final clinical diagnosis. The exclusion criteria for this study involved patients who did not undergo either a CT or MRI scan. A chi-square test was performed to observe the association between the study variables. A total of 3155 cases were analyzed.

Results: The most prevalent comorbid was dyslipidemia 670 (21.6%) followed by hypertension 548 (17.6%). Overall brain disorders were confirmed in 2426 (77%) patients. It was observed that half of the patients 1543 (48.9%) were diagnosed with stroke. It was found that the accuracy of CT and MRI was 78% and 74% respectively. The association of modalities, patient type, and gender with the confirmation of diseases was not found significant (p=>0.05).

Conclusion: Our study revealed that CT and MRI were accurate by more than 75% and no difference was between both techniques to detect neurological disorders.

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Neurological disorders impact the nervous system, giving rise to a wide array of symptoms stemming from structural, biochemical, or electrical irregularities within the brain, spinal cord, or other nerve structures.

These disorders pose unique challenges within the healthcare system due to interconnections of the complex nervous system, making their diagnosis, management, and treatment among the most demanding tasks in healthcare.[1] The severity of neurological diagnostic issues has been reduced because of the increasing dynamics and the introduction of contemporary technology that enhances the provision of acute neurological care.[2] Based on a comprehensive review of both medical literature and records, the nervous system is susceptible to around 600 disorders.[1] These disorders include dementia, epilepsy, cerebrovascular disease, and Alzheimer's. Stroke, Parkinson's disease, multiple sclerosis, brain tumors, neuro-infections, and traumatic illnesses of the nervous system (brain trauma and autism) are all included.[3]

Brain diseases affect people worldwide, regardless of age, gender, level of education, or wealth. Brain cancer is considered among the most fatal types of cancer, posing the greatest mortality risk and being largely incurable.[4] In the United States, an estimated 1520 cases of brain cancer are reported each year, impacting over 100,000 people. For the last 10 years, the survival rate of brain cancer patients has remained steady, at 75%.[5] With the progress of cancer treatment treatments, there has been a rise in brain metastasis as well as an increase in survival instances. Furthermore, this has led to the development of more sensitive diagnostic imaging methods.[6]

The introduction of new diagnostic imaging techniques such as CT, Nuclear Medicine (NM), and Magnetic Resonance Imaging (MRI) has been very beneficial because these technologies rely on three-dimensional anatomical models of the human body. The diagnosis of malignancies is critical for the evaluation of neurological disorders since it allows for the identification and establishment of the necessary course of action, followed by the sketching of treatment programs for evaluating prognosis. In terms of the objective of sophisticated methods, MRI is utilized to evaluate cerebrovascular damage, excluding other common causes of neurological problems.[7] Furthermore, the MRI of the brain provides for the supplementation of the probable diagnosis of the specific AP form.[8] The improvement of MRI has increased our knowledge of the diverse neurobiological alterations, which is predicted to lead to the development of novel neuroimaging technologies.[9]

Generally, MRI is considered more effective than CT due to its ability to provide superior soft tissue resolution, enhanced contrast, reduced bone artifacts and volume-related issues, as well as direct multi-planar imaging. This enables MRI to detect even the smallest metastases during the scanning process.[4] Computed Tomography (CT) is preferred over MRI for diagnosing a stroke due to its greater efficacy and practicality, as well as its ability to detect increased sensitivity of Intracranial Haemorrhage (ICH). Several consistent epidemiological studies have evaluated the implementation of sophisticated imaging techniques.[10] Previous research indicates that the emphasis was previously on examining the clinical occurrence of stroke, myocardial infarction, or mortality during the follow-up period.[11] The outcomes of these investigations have significantly contributed to the assessment of illness state growth, disease knowledge, and comprehension of challenging disease processes.

One of the previous research revealed advancements in diagnostic imaging techniques, particularly CT and MRI, for neurological disorders, but failed to report the diagnostic accuracy of these modalities.[12] There is a need to determine the diagnostic accuracy of CT and MRI in evaluating neurological disorders and perform a comparative analysis to ascertain whether one modality outperforms the other. Additionally, by investigating associations with patient demographics, such as gender and patient type, it would be possible to attain an in-depth understanding of how these factors may influence disease confirmation.

Advancements in diagnostic technology have alleviated some diagnostic challenges. Still, the underlying causes of many disorders remain areas of research, and improving survival rates, particularly for fatal diseases. The integration of diagnostic technologies and their impact on patient outcomes warrant further investigation. Considering the varying degrees of severity observed in neurological disorders and the increasing adoption of the three imaging technologies, the study uses them to obtain insight into their usefulness in the evaluation of neurological problems. The research anticipates that the study's findings will help neurological care professionals get the best diagnostic outcomes in the early phases when ambiguity is greatest. Therefore, the aim was to observe the accuracy of CT and MRI scans in evaluating neurological disorders. This is likely to contribute valuable insights to the field of neuroimaging, aiding healthcare professionals in selecting the most effective imaging technique for diagnosing neurological disorders and addressing the practical clinical need for accurate and timely diagnosis.

Methods.

Study participants and clinical diagnosis. This retrospective research used CT or MRI to diagnose and characterize brain disorders at King Abdulaziz University Hospital King. Permission and approval were attained from the Unit of Biomedical Ethics, Research Ethics Committee (REC), King Abdul-Aziz University, NCBE Registration Number: (HA-02-J-008). The study took place from August 2022 to January 2023. Patients' records suffering from neurological disorders were considered eligible for inclusion, regardless of the time of appearance of symptoms, the severity of their symptoms, or their final clinical diagnosis. Patients who had neither undergone CT nor MRI were excluded from the study. Exclusion criteria were MRI contraindications and symptoms indicative of subarachnoid hemorrhage.

Ethical consideration. The research was conducted according to the principles of the Declaration of Helsinki.

Imaging techniques and analysis. A 1.5 T scanner for MRI (GE Signa, General Electric, Milwaukee, WI, USA) was employed and patients who completed gradient-echo and diffusion-weighted MRI sequences were enrolled in the study. Gradient-echo imaging settings were 24 cm field of view, 800 ms repetition time, 20 ms echo duration, 30° flip angle, and 256192 acquisition matrix. Field of view was 24 cm, TR was 6000 ms, TE was 72 ms, acquisition matrix was 128128, and b values were 0 and 1000 s/mm^2 isotopically weighted. Both sequences produced 20 continuous, 7 mm thick, axial-oblique slices. The study did not evaluate additional imaging sequences. We used either a Somatom Plus scanner (Siemens, Iselin, NJ, USA) or a Light speed scanner for non-contrast CT (General Electric). The orbit meatal plane was used to capture images with a 5 mm slice thickness, covering the region from the base of the skull to the vertex.

Two experienced neurologists, who were not part of the patient's treatment and were blinded to the clinical information, analyzed the images. Readers were given digital pictures using commercially accessible software that allowed them to change contrast, brightness, and image size. None of the photos had patient identifiers. The MRI interpretation involved presenting images from gradient-echo and diffusion-weighted imaging sequences to the readers, with the diffusion-weighted imaging sequences including b=0 and T2-weighted images. In cases where the gradient-echo images were rendered non-interpretable due to motion artifacts, the readers were instructed to detect hemorrhage using the b0 component of the diffusion-weighted images. For CT interpretation, readers were provided with sets of images optimized for bone windows and standard brain windows, along with the option to adjust the brightness and contrast of the displayed images.

Table 1 - Characteristics of participants.

Variables	Frequency	Percentage (%)
Modality		
CT	2105	66.7
MRI	1050	33.3
CT - BRAIN C-	1741	55.2
CT - BRAIN C-/+	364	11.5
MRI - BRAIN C-	287	9.1
MRI - BRAIN C+/-	763	24.2
Type of Patient (n=3155)		
Emergency	951	30.1
In-patient	1220	38.7
Out-Patient	789	25.0
Unknown	195	6.2
Co-morbid (n=3108)		
Defibrillation	26	0.8
Kidney disorders	250	8.0
Alzheimer's disease	10	0.3
Asthma	80	2.6
Cancer	43	1.4
Heart Failure	198	6.4
COPD	40	1.3
Dementia	25	0.8
Diabetes	520	16.7
Hypertension	548	17.6
Dyslipidemia	670	21.6
ESRD	8	0.3
Hyperuricemia	16	0.5
Hyperthyroidism	67	2.2
Liver diseases	56	1.8
Thrombus	6	0.2
Seizures	12	0.4
Parkinsonian disease	4	0.1
CABG	13	0.4
Others	516	16.6
Reason for examination (n=3155)		
Abnormal CSF	12	0.4
Blurred Vision	287	9.1
Decrease level of consciousness	231	7.3
Disorientation	232	7.4
Dizziness	543	17.2
Dysarthria	54	1.7
Headache	650	20.6
Left side numbness	55	1.7
Slurry speech	87	2.8
High blood pressure	620	19.7
Unknown	158	5.0
Others	226	7.2
Confirmation of brain disorders through scan (n=3155)		
Confirmed brain disorders through scans	2426	77
Brain disorders not confirmed through scans	729	23

ESRD - end-stage renal disease, CABG - Coronary artery bypass graft surgery, CSF - Cerebrospinal fluid

Table 2 - Cox regression analysis of factors associated with adverse outcomes (HR: hazard ratio).

Predictors	Death or mRS ≥ 3		HR	95% CI	*P*-value
	n/N	%			
Age (>=40)	3/41	7.3	2.0	0.34-12.48	0.427
Gender (male)	2/33	6.1	0.66	0.07-6.36	0.720
Sinus (multiple)	5/83	6	0.69	0.07-6.733	0.757
Concomitant cerebral bleeding (yes)	1/23	4.3	0.39	0.42-3.67	0.410
Finding (complete thrombus resolution)	2/17	11.8	2.14	0.14-42.38	0.609
Finding (partial Resolution)	1/24	4.2	0.86	0.05-13.24	0.887

Table 3 - Association of scan modalities with the confirmation of brain disorders.

Modality	Confirmed brain disorders through scans	Brain disorders not confirmed through Scans	Accuracy (%)
CT (n=2105)	1650	455	78%
MRI (n=1050)	776	274	74%
P-value			0.286

Table 4 - Association of patient type with the confirmation of brain disorders

Patient type	Modality		*P*-value
	CT	MRI	
Emergency			
Confirmed brain disorders through scans	766	52	0.468
Brain disorders not confirmed through scans	133	0	
In-patient			
Confirmed brain disorders through scans	600	240	0.492
Brain disorders not confirmed through scans	217	163	
Out-Patient			
Confirmed brain disorders through scans	218	465	0.584
Brain disorders not confirmed through scans	50	56	

Table 5 - Association of gender with the confirmation of brain disorders.

Gender	Modality		*P*-value
	CT	MRI	
Female			
Confirmed brain disorders through scans	616	435	0.953
Brain disorders not confirmed through scans	381	146	
Male			
Confirmed brain disorders through scans	831	337	0.222
Brain disorders not confirmed through scans	277	132	

Data analysis. We utilized Statistical Package for Social Sciences (SPSS) version 23 for data analysis. The main hypothesis tested was whether MRI outperforms CT in diagnosing all types of acute strokes. The diagnostic accuracy of CT and MRI diagnoses was assessed as the ultimate clinical diagnosis. Descriptive statistics were conducted, with frequencies and percentages calculated for categorical variables, and mean standard deviation reported for numeric data. The chi-square test was employed to examine the relationship between 2 categorical variables, with a p-value of <0.05 considered statistically significant.

Results. A total of 3155 cases were analyzed. The mean age of participants was 42±25.3 years and 1578 (50.1%) were females. Out of the total, CT and MRI were done in 2105 (66.7%) and 1050 (33.3%) cases respectively and patients and the head were the most reported body part for scan 3022 (96%). The most frequent type of patient was in-patient 1220 (38.7%). The most prevalent comorbid was dyslipidemia 670 (21.6%) followed by hypertension 548 (17.6%). Overall brain disorders were confirmed in 2426 (77%) patients as shown in **Table 1**. The reasons for examination were evaluated and it was revealed that headache 650 (20.6%) followed by high blood pressure 620 (19.7%) were mostly reported. The diagnosis was confirmed through scans reported in **Table 2** and it was observed that half of the patients 1543 (48.9%) were diagnosed with stroke. The accuracy of the modalities used for the scan was evaluated and a comparison was made between the CT and MRI. It was found that CT detected brain disorders in 1650 cases out of 2105 and accuracy was found (78%). Moreover, MRI detected brain disorders in 776 cases out of 1050, and accuracy was found 74%. However, the association of modalities with the confirmation of diseases was not found significant (p=0.286) as shown in **Table 3**. The association of patient type and gender was also evaluated with the confirmation of brain disorders and they were also not found statistically significant (p=>0.05) as presented in **Tables 4 & 5**.

Discussion. Advanced technologies such as Electroencephalography (EEG), MRI scan, positron emission tomography (PET scan or PET images), single photon emission-computed tomography (SPECT), CT scan or CAT scan, electromyography (EMG), and arteriogram are used to identify neurological illnesses. These diagnostic tests practitioners in confirming or exclude the presence of a neurological illness or other medical disorders. The EEG is used to record brain cell activity through the skull to aid physicians in discovering and monitoring brain abnormalities to diagnose brain-related diseases such as epilepsy, degenerative disorders, autism, migraines, certain seizure disorders, sleep disorders, and brain tumors.[13-17] MRI examinations are valuable for identifying issues in the brain and spinal cord because they offer detailed images of bodily structures, including tissues, bones, organs, and nerves.[13,16,17] A CT or CAT scan utilizes X-rays and a computer to generate cross-sectional images of the body to look for brain abnormalities to find the site of strokes and detect neurological problems such as blood clots, tumors, degenerative diseases, and malignancies.[15] The present study was done to observe the accuracy of CT and MRI scans in evaluating neurological disorders.

Headaches were one of the most common causes of examination, according to our study. According to research by Holle and Obermann,[3] patients with unusual clinical symptoms are more likely to undergo neuroimaging. The findings indicated that occipital lobe involvement was accompanied by symptoms such as vision loss, blurred vision, and different ophthalmological indications. We found that the majority of patients had a stroke, and the most frequent causes of examination were headaches and hypertension. In comparison to other evaluation methods, the neurological disease examination yields a better outcome. These results are consistent with research by Holle and Obermann[3] that used neuroimaging technologies to diagnose headache problems. The accuracy of CT and MRI has been subject to varying assessments in the literature. Certain studies have exhibited a preference for MRI over CT, while others have indicated that both imaging modalities are equally effective in identifying neurological disorders.

The MRI has been recommended as a superior neuroimaging method in the study by Degnan and Levy.[18] But according to our research, there were no differences between CT and MRI when it comes to diagnosing neurological problems. In another investigation, unremarkable MRI results were frequently discovered. These findings also differ from those of Jindal et al.,[19] who compared the effectiveness of MRI imaging with CT neuroimaging. A study found that MRI was much more effective than CT findings in diagnosing numerous cerebral infarctions in middle-aged individuals, although we were unable to detect a relationship between age and diagnosis. Another study conducted on epilepsy reported that MRI is the preferred modality and exhibits superior performance compared to CT in detecting the underlying etiology. CT has the potential to function as a screening modality, while MRI would be utilized to delineate any anomalies detected on CT or in cases where CT results are negative.[20]

In a study, CT and MRI accuracy was found to be 83% and 84%, respectively, which was consistent with our findings. A study concluded that both CT and MRI imaging modalities can offer adequate diagnostic capabilities for primary brain lymphoma and they also suggested that it is imperative to conduct pathological examinations to confirm the diagnosis.[21]

The results of a study indicated that MRI was comparatively more efficacious than CT scan in diagnosing various neurological disorders and posits that MRI represents a comprehensive diagnostic modality for evaluating and diagnosing neurological disorders. They also emphasized that further research is necessary to conduct for direct comparison between the two modalities to determine the superior technique.[22] The current investigation has aided in determining the efficacy of both techniques in detecting neurological disorders. Considering the imaging principles for effectively treating stroke, the patient outcome is predicted to improve. The use of CT and MRI to examine diseases has transformed the neurological sector.

In a study,[23] it was determined that females were more likely to have a neurological disease. Clayton,[24] also reported similar findings by evaluating the neurological disease using MRI in females considering their brain structure and connectivity. Liu et al.[25] employed functional MRI and discovered that women with chronic migraines, unlike men showed higher brain dysfunctionality. These results were in contrast to ours, which showed no differences. Physicians consistently face the challenge of differentiating between migraines without any cerebral abnormalities and headaches associated with various forms of brain pathology.[3]

The SPECT scans are also employed in the diagnosis of malignancies, infections, degenerative spinal diseases, and stress fractures, especially following an MRI. Brain SPECT has been studied for various purposes, including the evaluation of acute ischemia, and stroke, the assessment of late ischemic damage, transient ischemic episodes (TIAs), monitoring the effectiveness of medical or surgical treatments, evaluating cerebral blood flow reserve, calculating prognoses, and assessing the outcomes of interventional procedures.[26] The limitation of our study was that we were unable to employ SPECT technology on our patients because it was not available at our institute.

Our study revealed that CT and MRI were accurate and no difference was between both techniques to detect neurological disorders. Moreover, the confirmation of diagnosis among the patient type and gender was found similar when CT and MRI were employed. There is a strong recommendation for the integration of SPECT technology alongside CT and MRI, as this imaging modality plays a crucial role in screening patients who might benefit from medical and surgical interventions. It also aids in the rapid diagnosis of ischemia to prevent irreversible brain damage and in identifying viable tissue at risk. The SPECT's role in screening individuals who may benefit from medical and surgical interventions is a novel and important aspect of our study, as it contributes to the rapid diagnosis of ischemic conditions, helping prevent irreversible brain damage and identifying at-risk tissue. These findings collectively emphasize the critical need for multi-modal approaches in neuroimaging and offer a promising avenue for improving patient outcomes in the field of neurological disorders.

However, the present study's findings that CT and MRI demonstrate comparable accuracy in diagnosing neurological disorders and that patient type and gender do not significantly impact diagnosis with these modalities suggest the need for further investigation into specific clinical scenarios and demographic variables that might influence diagnostic outcomes. Additionally, the recommendation for integrating SPECT technology alongside CT and MRI for enhanced screening and diagnosis calls for future research focusing on the optimization of multi-modal approaches, technological advancements, and the application of advanced analytics to improve the precision of neurological disorder diagnosis. These efforts aim to refine personalized diagnostic strategies and elevate patient care in this field.

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