Multi-Knowledge Electronic Comprehensive Journal For Education And Science Publications(MECSJ)
Issues 79 (2024)
ISSN: 2616-9185

The role of magnetic resonance imaging techniques in the diagnosis of neurological diseases (stroke) in Saudi hospitals

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Abstract

Magnetic resonance imaging (MRI) techniques are considered vital tools in the diagnosis of neurological diseases, especially in cases of stroke. In Saudi hospitals, these techniques are increasingly used to provide accurate and rapid diagnosis, which contributes to improving treatment and patient outcomes. MRI helps determine the type of stroke (ischemic or hemorrhagic), assess the severity of the injury, and identify the affected areas in the brain, which enables doctors to develop an accurate treatment plan. It also contributes to monitoring the patient's clinical changes after a stroke, allowing early intervention to prevent the condition from worsening. According to previous studies, MRI is the most accurate scanning method in cases of stroke. Recent developments in MRI technology have led to its increased use as an imaging platform in the normal clinical treatment of stroke. The medical field in the Kingdom is also witnessing a remarkable development in the use of this technology, thanks to the continuous development of medical devices and hospital infrastructure, which enhances the opportunities for improving healthcare for patients.

Keywords: Imaging techniques, MRI, neurological diseases, stroke, Saudi Arabia.

Multi-Knowledge Electronic Comprehensive Journal For Education And Science Publications(MECSJ)
Issues 79 (2024)
ISSN: 2616-9185

1. Introduction

Cerebrovascular disease is the leading cause of death among women and the second leading cause of death among men in developed countries [1]. Another important contributor to dementia and cognitive impairment is cerebrovascular disease [2]. The majority of functional disability is due to stroke, the most common cardiovascular disease. Stroke is one of the most serious neurological diseases affecting human health, and early diagnosis has become a crucial factor in reducing its complications. In this context, the importance of medical imaging techniques such as magnetic resonance imaging (MRI) emerges, which can provide accurate images of the brain and determine the extent of injury more quickly and accurately [3].

A stroke occurs when blood flow to a part of the brain is interrupted, causing damage to brain cells. Strokes are divided into two main types: ischemic stroke (resulting from a blocked blood vessel) and hemorrhagic stroke (resulting from a ruptured blood vessel) [4]. Rapid and accurate diagnosis of stroke is essential to determine the most appropriate treatment, and one of the tools that contribute significantly to this diagnosis is medical imaging techniques, such as magnetic resonance imaging. Ninety percent of stroke patients experience neurological sequelae, and one-third of them are unable to return to their pre-stroke level of daily living activities [2,3]. The "time is brain" philosophy guides the treatment of stroke patients. This idea, often based on neuroimaging, highlights the need for emergency medical care for stroke patients. Delay

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ISSN: 2616-9185

in diagnosis can cause irreversible damage because every minute of delay causes damage to brain tissue [5].

In the acute phase, multimodal magnetic resonance imaging is useful for stroke diagnosis and selection of therapeutic options [6]. In the acute phase, it is crucial to identify stroke early and differentiate it from stroke mimics [7]. The causes of stroke are revealed by MRI data, which influence the prognosis and are therefore crucial in determining the best course of treatment. MRI lesion mismatch profiles help us assess the potential risks and benefits of thrombolysis by providing information about salvageable tissue or the age of the ischemic lesion [8]. For stroke patients, MRI may be preferable to initial CT for a number of reasons. Better treatment decisions may result from accurate MRI data about the timing, location, or subtype of stroke [9]. It has been suggested that a clear representation of the infarct will enhance patient education and compliance with suggested preventive measures [10].

Magnetic resonance imaging techniques are non-invasive imaging tools that rely on strong magnetic fields and radio waves to capture accurate images of internal organs and tissues in the body. In the Kingdom of Saudi Arabia, magnetic resonance imaging techniques have witnessed significant development in recent years. Awareness of the importance of magnetic resonance imaging in diagnosing neurological diseases, including stroke, has increased. In the Kingdom, many hospitals and medical centers are equipped with advanced magnetic resonance imaging techniques, which contribute to improving diagnosis and treatment [1, 5]. This research focuses on studying the role of MRI techniques in

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Issues 79 (2024)
ISSN: 2616-9185

diagnosing stroke in the Kingdom of Saudi Arabia, and its impact on patient treatment and the quality of healthcare.

1.1 Problem statement and Questions

The problem of the study is that MRI techniques are not used adequately in diagnosing strokes in some areas of the Kingdom, either due to lack of awareness or lack of medical equipment in some health facilities. This leads to delay in diagnosis, and thus delay in appropriate treatment. There are also challenges related to providing these techniques in some rural areas. Therefore, the problem of the study lies in the following main question: "**What is the role of MRI techniques in diagnosing neurological diseases (stroke) in Saudi hospitals?**"

This main question is subdivided into the following sub-questions:

1. How effective is magnetic resonance imaging (MRI) in diagnosing stroke compared to other techniques such as computed tomography (CT)?
2. How does MRI contribute to the diagnosis of different types of stroke (ischemic and hemorrhagic stroke) in Saudi hospitals?
3. What are the challenges facing Saudi hospitals in using MRI techniques effectively to diagnose stroke?
4. How can the use of MRI techniques in diagnosing stroke be improved through training and professional development of staff in Saudi hospitals?

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1.2 Research Significance

The importance of this study stems from the importance of magnetic resonance imaging (MRI) techniques, as they are one of the most important tools used in diagnosing neurological diseases, including stroke, as they allow obtaining accurate and clear images of the brain without the need for surgical intervention. In Saudi hospitals, research on the role of these techniques in diagnosing stroke is of particular importance, as it helps improve the accuracy of diagnosis and early treatment, which contributes to reducing complications that may result from delayed treatment. In addition, MRI examination contributes to the early identification of pathological changes in the brain such as blood clots or bleeding, which facilitates making quick and appropriate treatment decisions. Therefore, conducting such research on this topic is expected to have high positive repercussions and importance, which can be summarized as follows:

1) The research will contribute to expanding scientific knowledge about medical imaging techniques in the Kingdom of Saudi Arabia by focusing on the role of magnetic resonance in diagnosing stroke in the Kingdom.
2) Research in this field enhances understanding of how to better use these advanced techniques, and contributes to the development of medical protocols for diagnosis and treatment in Saudi hospitals, which raises the quality of health care provided to patients.

3) This research will provide a scientific basis that can help decision makers in the Kingdom improve treatment strategies and improve the efficiency of healthcare services.
4) The research will stimulate further studies on the applications of magnetic resonance imaging in other neurological diseases, and encourage development in healthcare technology.

2. Magnetic Resonance Imaging (MRI)

Magnetic resonance imaging (MRI) is one of the most versatile and popular diagnostic imaging modalities in modern medicine. When MRI was first developed in the latter half of the 20th century, it completely changed the clarity and resolution of internal structures [11]. MRI is a safer option for many patients, especially those who require repeated imaging, than other imaging modalities such as X-rays and CT scans because it uses strong magnetic fields and radiofrequency pulses to create high-resolution images without the use of ionizing radiation. The capabilities of MRI technology have been greatly enhanced by advances over time. These advances have made it possible to use MRI in a variety of medical specialties, including orthopedics, cancer, cardiology, and neurology [12].

The creation of diffusion tensor imaging (DTI), which provides information about the integrity of the brain’s white matter, and functional MRI (fMRI), which allows real-time monitoring of brain activity, are notable advances in MRI. In addition, the advent of high-field MRI devices, such as the 7-tesla MRI, has advanced spatial resolution, allowing scientists and medical professionals to see complex structures that were previously inaccessible. Despite these advances, long scan times, high prices, and requirements for specialized knowledge continue to pose problems with MRI [13]. MRI will become increasingly essential for medical imaging in the future as further research and technological advances resolve these limitations. Magnetic resonance imaging (MRI) is a sophisticated, non-invasive imaging method that creates accurate images of internal body components, particularly soft tissues such as the brain, muscles, and organs [14]. Because MRI does not use ionizing radiation like other imaging modalities, it is safer for patients, especially those who need to be imaged frequently. MRI creates images using radiofrequency (RF) pulses, intense magnetic fields, and the intrinsic magnetic properties of atomic nuclei, especially hydrogen [15].

3. Neurological Diseases (Stroke)

Cerebrovascular diseases are serious health conditions that can affect quality of life by causing disabling consequences, such as dysarthria, paralysis, and memory loss [16, 17]. In addition to clot formation, selective occlusion, cerebral arterial stenosis, and brain tissue hemorrhage, stroke occurs when blood vessels supplying the brain rupture or become blocked [18]. Stroke may result from these events if there is a significant reduction in oxygen and blood supply to the brain. Stroke is the most preventable cause of death [19], accounting for approximately 10% of deaths worldwide [20] and one in five stroke victims die annually. Although its incidence may fluctuate between countries, the risk factors for stroke are mostly those also prevalent in other non-communicable diseases, such as diabetes, blood pressure, obesity, smoking, and alcohol abuse [21, 22]. There is a “golden time” of less than an hour from the onset of symptoms for acute stroke management, during which time wise diagnostic and therapeutic decisions may result in less severe consequences. The most common findings supporting stroke are weakness or numbness, loss of vision or blurred vision, sensory disturbance, altered consciousness, dizziness and loss of balance, difficulty swallowing, headache, and speech difficulties [23]. Prompt and accurate diagnosis is essential, as in other life-threatening situations. Because brain tissue is destroyed for every minute of delay, delayed diagnosis can result in permanent damage [24, 25]. In an effort to speed up the diagnosis of stroke, a number of stroke assessment scales have been developed, including the Face-Arm Speech Time (FAST), the Cincinnati Prehospital Stroke Scale (CPSS), the Los Angeles Prehospital Stroke Scale (LAPSS), and the Melbourne Ambulance Stroke Scale (MASS). Other severity rating scales include the Los Angeles Movement Scale (LAMS), the Kurashiki Prehospital Stroke Scale (KPSS), and the National Institutes of Health Stroke Scale (NIHSS). While more complex scales may be less sensitive and thus miss more cases, simpler scales such as the CPSS and FAST have been shown to be sufficiently sensitive for therapeutic applications [26]. Imaging is the primary method used to arrive at a definitive diagnosis, even though several important clinical symptoms, such as speech difficulties, arm weakness, and facial drooping, may suggest stroke at first assessment

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[27]. Therefore, judicious selection of imaging technology may lead to early diagnosis of acute stroke, which is life-saving [28].

4. The role of magnetic resonance imaging techniques in stroke

In the case of stroke, MRI tests can provide accurate images of the brain, which helps in diagnosing stroke by revealing the areas of the brain damaged by ischemia or bleeding. MRI can be used to determine the size and location of the injury, which enhances the ability to make effective treatment decisions. MRI can also help distinguish between ischemic and hemorrhagic stroke. The treatment response varies between the two types, so quickly identifying the exact pattern of injury can save the patient’s life. In addition, MRI helps in assessing the progression of stroke over time, which is important in determining the effects of injury on the brain, in addition to monitoring the patient’s response to treatment [1].

Stroke is a devastating medical disorder that accounts for more than 5% of all deaths. Stroke is the leading preventable cause of death. When acute stroke is detected, there is a chance to prevent its negative effects in less than an hour. Since neuroimaging is required to diagnose stroke, appropriate use of neuroimaging may help save time and design the best treatment for the patient [28]. MRI generates high-resolution images that show the presence, size, and location of acute stroke, but it is important to recognize the progression of the condition and avoid time-consuming procedures [29]. MRI has been shown to provide similar results to any

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other imaging modality for diagnosing acute hemorrhage in a large body of previous research.

Takeshi Imura et al. [30] conducted a comprehensive review to collect information on the use of MRI to predict walking ability in stroke patients. They reported that eight MRI investigations based on structure or function revealed that MRI could predict walking ability. They also showed that MRI is the most effective method for scanning the location and size of stroke, and predicting the patient's ability to walk. MRI is more accurate in ruling out cerebral hemorrhage, and MRI with DWI is more accurate in identifying acute ischemic stroke, as claimed by Amin Akbarzadeh et al. [31].

According to a related study by Pragati Kakar et al. [32], multimodal MRI is a valuable tool for diagnosing ischemic stroke and determining the location and size of the infarct area, both of which are crucial details that can help clinicians choose the best interventions and manage stroke patients effectively. In another systematic review by XiaoHong Zhang et al. [33], it was found that MRI is the most efficient technique for diagnosing and managing stroke. Among the MRI modalities, DWI has been shown to have greater diagnostic value for ischemic stroke. On the other hand, MRI has been reported to be of great clinical importance in the diagnosis of stroke [34]. MRI clearly shows the size and location of the infarct.

MRI can be used to diagnose ischemic stroke and decide on treatment plans in the acute phase [35]. Early detection of ischemic stroke and

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differentiation from stroke mimics is critical during the acute phase [36]. Several imaging findings from MRI sequences help identify stroke processes that influence prognosis and, as a result, are critical to treatment choices. By revealing information about salvageable tissue or the age of the ischemic lesion, MRI lesion mismatch profiles help us evaluate the potential risks and benefits of thrombolysis [37]. Previous MRI-based thrombolysis trials have used some of these parameters, but the results have been unsatisfactory. While the use of a few parameters may be readily applicable, other valuable information for stroke diagnosis, mechanism identification, and potential risk and benefit assessment may be overlooked [38].

MRI is one of the most accurate imaging techniques for diagnosing stroke, providing high-resolution images of brain tissue and blood, which helps to pinpoint the affected areas more accurately than computed tomography (CT). While CT is a quick and effective tool for detecting brain hemorrhage in emergency situations, MRI has a better ability to detect ischemic stroke, especially in the early stages. MRI is also able to provide precise details about changes in brain tissue and chemical reactions within the brain. Given this, MRI offers significant advantages in diagnosing stroke more accurately and in detail than CT, which contributes to making better treatment decisions [1].

MRI is an essential tool in diagnosing both the main types of stroke: ischemic stroke and hemorrhagic stroke. In ischemic stroke, where the blood vessels supplying the brain are blocked, MRI can quickly detect the affected areas by imaging the tissue and identifying areas of ischemia.

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Techniques such as diffusion weighted imaging (DWI) enable doctors to detect changes in damaged tissue before they become apparent on a CT scan. In hemorrhagic stroke, where internal bleeding occurs in the brain, MRI can image the exact size and location of the bleeding, helping to determine the type and size of the bleeding more accurately than CT scans. In Saudi hospitals, MRI is used to provide accurate information about the patient’s health condition and thus determine an appropriate treatment plan [28].

5. The effectiveness of MRI compared to other techniques (CT scan)

In the early 1990s, before diffusion-weighted imaging and gradient-echo imaging became commonplace, the first comparisons of MRI and CT in the diagnosis of acute stroke revealed that acute infarcts were more evident on MRI than on CT, and that these modalities were similar in their ability to detect intracranial hemorrhage [39]. Diffusion-weighted imaging first appeared in the mid-1990s and has shown higher sensitivity for detecting small lesions and diagnosing stroke than conventional MRI, particularly in the first hours after stroke onset. 5,9 Potential biases in patient selection and image evaluation limited the initial results comparing diffusion-weighted MRI with CT, which indicated a sensitivity of 86–100% for diffusion-weighted imaging and 42–75% for CT [40].

Because it enables diagnosis and determination of the necessary course of action, followed by drawing up therapeutic strategies to assess their

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prognosis, the identification of malignant tumors is essential for the evaluation of neurological diseases. Given the goal of advanced methods, MRI is used to evaluate cerebrovascular damage and exclude other common causes of neurological disorders [41]. In addition, brain MRI can be used to support the possible diagnosis of a specific type of AP [42, 43]. The development of MRI has expanded our knowledge of complex neurobiological changes, which is expected to lead to the development of new neuroimaging techniques [44]. Computed tomography (CT) is also commonly used in conjunction with magnetic resonance imaging (MRI) due to their relationship as well-established methods for identifying metastatic disease. Based on the combination of improved soft tissue resolution, enhanced contrast enhancement, partial reduction in bone artifacts and volume effects, and direct multiplanar imaging, which enables the detection of even the smallest metastases on scanning, MRI is generally believed to be more effective than CT [42]. However, since CT is more practical and efficient than MRI and can also detect intracranial hemorrhage (ICH) with high sensitivity, it is seen as the better option for stroke diagnosis [45].

The various imaging techniques available range from magnetic resonance imaging (MRI) to computed tomography (CT) [38, 39]. CT comes in a variety of forms, such as non-contrast CT, contrast-enhanced CT (CTP), and head and neck CT angiography (CTA). With regard to MR imaging modalities, a number of measures, including head and neck MR angiography (MRA), fluid-attenuated inversion recovery (FLAIR), gradient-recalled echo (GRE), apparent diffusion coefficient (ADC), and diffusion-weighted imaging (DWI), may be useful [46,47]. DW MRI is more sensitive than non-contrast CT for the very early detection of acute ischemia, and has been shown to be more effective than first- and second-order CT and MRI in the evaluation of patients presenting within 24 hours, although CT remains the imaging modality of choice in the early management of acute stroke [48].

More visually available contrast will be provided by contrast with CT, which requires a greater amount of water molecule activity and retention as well as more time to show detectable contrast [49]. This accuracy is primarily due to the ability of DW imaging to show subtle differences in the diffusion of water molecules across membranes during cytotoxic edema. Although CT provides a more accurate view of tissue and vascular pathology, it is usually the first-line imaging study in most medical centers due to patient contraindications, intolerance to MRI, time required, and other factors [50].

Non-contract head CT is a popular choice for early acute stroke evaluation due to its wide availability, rapid scanning capabilities, and simplicity in identifying cerebral hemorrhage. However, methods such as multimodal CT/MRI protocols appear to be useful for stroke prevention, diagnosis, monitoring stroke progression, and the effectiveness of therapeutic treatments [51]. In addition, carotid ultrasound should be performed to assess the arterial status for arterial occlusion, decreased blood flow, and potential sources of occlusion after initial drug administration and passage of the acute emergency phase. The size and location of the cerebral infarct are important factors in determining the

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subtype of stroke (cerebral ischemia, subarachnoid hemorrhage, and intracerebral hemorrhage) [52]. Hypoattenuation, loss of gray-white matter distinction, tissue swelling, edema, hyperattenuation of the middle cerebral artery (MCA), infarction of the area of the arteries supplying the brain, and obliteration of the cortical sulcus on the affected side are the main characteristics of early signs of ischemic stroke on CT scans [53].

Based on the topographic involvement of the brain areas supplying the MCA, the Alberta Stroke Program Early CT Score (ASPECTS) is a quantitative scoring system that evaluates early stroke changes in the MCA [53]. One point is subtracted from the total of 10 points for each involved area. In addition, several clinical variants of ASPECTS have been developed, such as pc-ASPECTS, which evaluates stroke in the posterior circulation [54]. However, when it comes to MRI, DWI signal elevation is noticeable as early as the first few hours after ischemic stroke [54]. T1- and T2-weighted sequences show no significant changes during the early acute phase of ischemic stroke (0–6 h after stroke), although ADC mapping shows low signal intensity [55]. After 16 h, T1-weighted MRI often shows low signal intensity, while after 8 h, T2-weighted MRI usually shows high signal intensity [56]. Thus, the age of the infarction can be ascertained by the appearance of different MRI sequences.

6. The challenges facing Saudi hospitals in using MRI techniques

In Saudi hospitals, MRI is increasingly being used to diagnose strokes through continuous developments in technology, and these advanced

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tools contribute to improving the overall quality of healthcare in the Kingdom [57]. The availability of this technology in many hospitals allows doctors to obtain accurate and reliable results, which enhances the chances of early treatment and reduces complications of the disease. However, healthcare workers face challenges related to the widespread availability of this technology in all hospitals, as the high cost of MRI devices may be an obstacle for some medical facilities. However, the importance of MRI remains clear in reducing the rate of disabilities resulting from stroke, which makes enhancing its use in diagnosis vital [46].

Multimodal MRI reveals several useful parameters for determining treatment modalities for acute stroke. This technique is particularly useful when there are problems related to clinical imaging mismatch, occult stroke onset (awake or daytime strokes), or questionable stroke diagnosis (stroke mimics). However, despite the potential advantages of MRI, there are real-world problems that limit its application during the acute phase of ischemic stroke [57]. The long scanning time compared with CT is one of the main problems. Overall, the clinical outcome was better even if MRI-based thrombolysis judgments increased the needle insertion time [58]. Thus, it is clinically and practically feasible to use MRI for the treatment of acute stroke [59]. However, since “time is brain” during the acute phase of ischemic stroke, reducing the amount of time required evaluating and selecting a treatment course may increase the advantages of thrombolysis. Interestingly, a recent study found that 6-minute multimodal MRI with FLAIR and GRE on echo level had a valid

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diagnostic quality in patients with acute ischemic stroke. This may improve the use of MRI in the treatment of acute stroke [60]. Future studies should confirm the impact and utility of this model in the treatment of acute stroke. In addition, a number of new developments in MRI are being investigated, including high-resolution MRI of blood vessel walls, methods for measuring collateral flow, arterial spin labeling, and computational flow dynamics. These advanced imaging biomarkers may be useful in selecting a treatment course for acute ischemic stroke [61].

Despite the effectiveness of MRI in diagnosing stroke, Saudi hospitals face some challenges in using this technology effectively. The most prominent of these challenges is the high cost of MRI devices, which may limit their availability in some hospitals, especially in rural areas or hospitals with limited resources. In addition, MRI takes longer than CT scans, which may lead to delays in diagnosis and treatment in emergency cases [28]. The effective use of this technology also requires high skills from doctors and technicians, and some face challenges in training staff on advanced techniques to accurately interpret images. Moreover, some patients may face difficulty undergoing this examination due to the need to remain completely comfortable inside the device for a long period, which requires careful preparation for them [57].

Therefore, improving the use of MRI techniques in diagnosing stroke requires focusing on training and developing the skills of doctors and technicians in Saudi hospitals. This can be achieved by organizing periodic workshops and training courses on modern techniques in MRI

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and how to interpret images effectively. It is also important to enhance knowledge of advanced imaging methods such as diffusion tensor imaging (DTI) which helps in early stroke diagnosis. Innovation in training should be supported by using digital simulations to train staff on modern techniques in safe environments. In addition, collaboration between different departments such as neurology and radiology can be enhanced to ensure optimal use of MRI. By improving training and continuing education, the efficiency of using this technology in stroke diagnosis can be improved and better patient care can be provided [61].

7. Conclusion

Neuroimaging is an essential diagnostic tool. Its primary benefit in the diagnosis of stroke is that it allows physicians to identify patients most likely to benefit from specific treatments, such as clot-busting drugs and surgery. According to the studies examined, MRI is the most accurate imaging modality in stroke. Recent advances in MRI technology have led to its increased use as an imaging platform in the clinical treatment of stroke. Multimodal MRI is an effective tool for diagnosing ischemic stroke and determining the location and size of the infarct area, information that is crucial for physicians to select relevant medications and treat stroke patients efficiently. Currently, MRI enables accurate diagnosis of acute cerebral infarct lesions (including their size and location), identification of severe occlusion or narrowing of the arteries, and assessment of collateral flow. Some adverse ischemic changes can also be detected by MRI.

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In conclusion, MRI is a crucial tool in the diagnosis of stroke, especially in Saudi Arabia, where it contributes to improving diagnostic timing and therapeutic decisions. Despite some challenges in providing these technologies, the Kingdom's investment in developing the health sector and providing advanced imaging technologies is a positive step towards improving healthcare for patients with stroke. This research constitutes a starting point for understanding the role of MRI technologies in the diagnosis of stroke in Saudi Arabia, and contributes to enhancing scientific understanding of this technology and its usefulness in improving patient care. Based on the results of the study, recommendations can be summarized as follows:

1. Enhancing the dissemination of MRI technologies in all regions of the Kingdom, especially in rural areas.
2. Increase training of physicians and technicians on the use of MRI technologies to diagnose strokes.
3. Improve public awareness of the importance of early diagnosis of stroke and how to deal with the condition quickly.

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