Magnetic resonance imaging and intractable epilepsy: A systematic review

Fahad Alshehri
Department of Radiology, College of Medicine, Qassim University, Buraydah, Saudi Arabia

Address for correspondence:
Dr. Fahad Alshehri, Department of Radiology, College of Medicine, Qassim University, Buraydah, Saudi Arabia.
E-mail: f.alshehri@qu.edu.sa

Objective: Epilepsy is a chronic neurological disorder that occurs due to irregular neuronal activity in the central nervous system. The main job of a radiologist is to investigate the structural etiology in epilepsy patients. This study was undertaken to find out the importance of magnetic resonance imaging (MRI) in the screening of intractable epilepsy through a systematic search of literature.

Methods: A systematic review was performed using the PRISMA guidelines. Peer-reviewed studies on MRI and intractable epilepsy were retrieved from MEDLINE, ScienceDirect and Google Scholar. Moreover, studies cited in the key articles were also screened to increase the sensitivity and specificity of the systematic search.

Results: The database search till March 2022 found a total of 112610 articles. Out of them, only 10 highly selected articles were included in the study. The pooled data point out that the rapid development in MRI techniques and the functional MRI (fMRI) has now become more and more critical in the diagnosis and management of patients with epilepsy. In addition, the data also pointed out that MRI-based approaches are also very useful for post-operative epilepsy patients as it gives information about the quality of the surgery. The data collected showed that the MRI is the choice technique for the evaluation of patients with epilepsy.

Conclusions: The applicability of MRI in epilepsy diagnosis is highly accessible in all over the globe. The pooled data concluded that the MRI-based surgical approaches are extremely useful for the surgeons to provide three-dimensional imaging with superimposed real-time pointer details that have proved successful for epilepsy patients.

Keywords: MRI, intractable epilepsy, systematic review, functional MRI

Introduction

Epilepsy is a chronic disorder of the central nervous system which resulted due to the abnormal activities of the neurons.[1] According to the recent reports, more than 70 million individuals have been affected with this neurological disorder which led to increase the global disease burden worldwide.[2] A number of epidemiological studies reported that the epilepsy is globally common but its prevalence is more in the developing countries as compared with its reported prevalence in developed countries and the situation to handle the epilepsy patients in low-income countries day-by-day becoming worst.[3] Several epidemiologist’s investigated that the prevalence rate of epilepsy has significantly increased in the rural areas as compared to the urban regions and this trend has almost the same in all over the globe.[4,5] Several investigators have investigated the reason(s) why the prevalence of epilepsy has higher in low-income countries or rural areas and they reported that the prevalence of epilepsy has direct correlation with the availability of the medical facilities such as qualified radiologists, surgeons, and also the availability of imaging techniques, which have been usually lacking in the low-income countries or in the rural areas.[6,7] The availability of the sophisticated technologies including the magnetic resonance imaging (MRI) has been found to be very useful for the management of patients with epilepsy in all over the world.[8,9] Imaging of epileptogenic lesions through MRI not only provides the planning for the surgeons to perform epilepsy surgeries but also helpful for the post-operative follow-up.[10] According to the International League Against Epilepsy (ILAE) suggests that all individuals suffering from epilepsy ideally tested with high-quality imaging techniques including MRI.[11] Moreover, the National Institute of Health and Clinical Excellence (NICE) guidelines recommended that the structural abnormalities in the brain of children and adults suffering with epilepsy should be screened by MRI.[11,12] In modern world, functional MRI (fMRI) has now becomes the method of choice for the screening of epileptogenic lesions in
the brain of individuals suffering from epilepsy as it is more powerful, highly sensitive, and more accurate as compared with the conventional MRI technique. But still, the facility of fMRI in the rural regions or in low-income countries is not fully available due to the financial reasons, therefore, the radiologists working in these regions is still relies on the conventional MRI. Under such circumstances, the radiologists play a key role to determine and to locate the structural abnormality of epileptogenic lesions to provide an accurate information to the surgeons so that the surgeon can easily identify the epileptogenic lesions and perform the surgeries. In view of these, this systematic review was designed to update the role of the MRI in the screening of epilepsy by pooling of the available literature. The outcome of the pooling of selected studies clearly indicating that the MRI-based surgical systems provide a three-dimensional pictorial presentation of anatomic epileptogenic lesions with superimposed real-time pointer information to the surgeons that proved to be useful in epilepsy surgery. In general, the MRI-based therapies are extremely valuable for the management of patients with epilepsy.

Methods

PRISMA guidelines and the databases for systematic search of literature

The PRISMA guidelines part for a systematic search of literature was used in this systematic review. A systematic computerized search using the databases such as PubMed, ScienceDirect, and Google Scholar was used. We identified studies that reported data on the role of magnetic resonance imaging in intractable epilepsy. The articles we use include all types of studies ranging from case reports, observational studies, randomized controlled trials, systemic reviews, and meta-analysis. Any patient, including male, female, transgender, any ethnic, and from any location, can be included in this study. A study of the abstracts of the chosen articles was performed, and only those with data deemed suitable for review were shortlisted. However, the references found to be relevant were also assessed and reviewed to be included in this study. The following keywords were used for our regular search: Magnetic resonance imaging and intractable epilepsy. Only English language studies were included to avoid misinterpretation of translation. All the data used in this literature review are collected ethically and legally. The search method is summarized as a PRISMA flowchart in Figure 1.

Inclusion and exclusion criteria of the studies

We included all retrospective and prospective population-based studies measuring MRI in epilepsy. We considered studies for inclusion if they included a definition of MRI and epilepsy. We excluded studies if they explored only epilepsy. We excluded editorials, single cases, and case series, studies published only as abstracts, letters, or commentaries, studies of individual groups.

Ethical issues

This is a systematic literature review, and the information of patients directly obtained from the published literature. Therefore, ethical approval was not required.

Results

In this systematic review, our database search till March 2022 using the keywords MRI and epilepsy found 17360 articles on MEDLINE, 6650 articles on ScienceDirect, and 88,600 articles on Google Scholar found 112,610 articles. Out of them, only 202 articles were retrieved and rest were excluded after screening of titles and duplication. Out of 202 selected articles, 130 articles were excluded based on their relevancy of the abstract. Afterward, 72 articles were shortlisted and their full texts were accessed. After analyzing the full texts, 63 articles were excluded as these articles were not reported a clear outcome of the role of MRI in intractable epilepsy, few were excluded as their outcomes were based on significantly less sample size. The articles reported that the same previously published data were also excluded [Figure 1]. A total of 10 highly selective studies were included in this article. A study conducted on children with non-lesional epilepsy from Minya, Egypt, in 2021 by Abdelgawad et al. who showed that volumetric MRI is extremely useful in the analysis of non-lesional pharmaco-resistant childhood epilepsy. In 2021, another published study on the Kenyan children with early childhood epilepsy reported that the conventional MRI is useful for the detection a multiple clinical comorbidity in childhood epilepsy. In 2019, Bernasconi et al. from Quebec, Canada, showed that the structural MRI is very useful for the detection of noninvasive lesions in patients with epilepsy. Another interestingly study from Jammu Kashmir, India, pointed out that the conventional MRI is highly sensitive for the detection of epileptogenic materials, dysfunctionality in soft tissues and they reported that MRI is the best technique for the screening of pre-operative intractable epilepsy. Another study from Karnataka, India, showed that MRI with dedicated seizure protocol is best for the detection of epileptogenic lesions in one half of the new-onset seizures in epilepsy patients. An interestingly study from Hubei, China, by Zhao et al. in 2017 showed that Magic TV’s approach through conventional MRI significantly improved the diagnosis of epilepsy by reducing the outputs of negative findings. Kader K Oquz from Ankara, Turkey, showed that functional MRI is an important technique for the detection of hemodynamic and microstructural alterations in epileptogenic lesions. In 2012, a study from Madrid, España, conducted on the epilepsy patients with focal seizures reported that the structural MRI technique is useful in the detection of mesial temporal sclerosis and malformations of cortical development in epilepsy patients. Hui et al. from Hong Kong pointed out that the cranial MRI technique
is useful to show electroencephalographic results in patients with pre-operative epilepsy. A study from Washington DC, USA, by Jabbari et al. investigated that the conventional MRI has potential to detect focal ictal discharges in up to 85% of epilepsy patients with scalp electroencephalograms. The detailed characteristics with their outcomes are summarized in Table 1. In short, the applicability of MRI in epilepsy diagnosis is highly accessible to most of the population in developed economies. With the rapid development of MRI, exceptionally functional MRI (fMRI) is becoming more and more critical in the diagnosis and management of patients with epilepsy. The outcomes of this systematic review clearly point out that the MRI is choice technique for the evaluation of patients with epilepsy.

Discussion

This systematic review is provided an updated knowledge on the role of the MRI in the screening of structural abnormalities of the neural lesions in patients with epilepsy. The MRI examination plays a key role for the screening of epileptogenic lesions in patients with epilepsy, this may be conducted either through MRI technique alone or in combination with some other imaging techniques such as fMRI, MR spectroscopy, PET, and ictal SPECT. The performance of medical examination of epileptogenic lesions with these additional approaches provides an extremely valuable information about the epileptogenic lesions and its exact location in the brain, these additional approaches with MRI not only help the surgeons to perform epileptogenic lesional surgery but also help the radiologists to make their outstanding reports. In spite of the availability of these extraordinary functional imaging approaches but still the applicability of these approaches are limited. There have been several reasons but the most valid reason is the involvement cost in these techniques while applying for the analysis of anatomic epileptogenic lesions. Several investigators have reviewed all these additional techniques with MRI and all have

Figure 1: PRISMA flowchart for systematic literature search
Table 1: Characteristics of studies included in this systematic search of literature review

| Study group       | Year | Location               | Population                                         | Method                  | Outcome measurement                                                   | References |
|-------------------|------|------------------------|----------------------------------------------------|-------------------------|----------------------------------------------------------------------|------------|
| Abdelgawad et al. | 2021 | Minya, Egypt           | Children with non-lesional epilepsy                | Volumetric MRI          | Volumetric MRI is useful in detection for non-lesional pharmacoresistant childhood epilepsy | [19]       |
| Samia et al.      | 2021 | Nairobi, Kenya         | Children with early childhood epilepsy             | Conventional MRI        | Every third children among the studied population showed a positive yield for epilepsy including the detection of multiple clinical comorbidity by conventional MRI | [20]       |
| Bernasconi et al. | 2019 | Quebec, Canada         | Adults patients with epilepsy                      | Structural MRI           | Structural MRI is unique for non-invasive investigation in patients with epilepsy | [21]       |
| Maqsood et al.    | 2018 | Kashmir, India         | Adults patients with intractable epilepsy          | Conventional MRI         | Conventional MRI is highly sensitive for the detection of epileptogenic substrates, contraction of superior soft tissues, multianular capability, lack of beam hardening artifact, and lack of ionizing radiation. MRI is best for screening of pre-operative intractable epilepsy | [22]       |
| Pomnatapura et al.| 2018 | Karnataka, India       | Epilepsy patients with new-onset seizures          | MRI with dedicated seizure protocol | Epileptogenic lesions were detected in one half of new-onset seizures patients by MRI | [23]       |
| Zhao et al.       | 2017 | Hubei, China           | Epilepsy patients with structural abnormalities    | MAGIC TVs approach via conventional MRI | MAGIC TVs approach through conventional MRI improves the diagnosis rate by reducing false-negative results | [24]       |
| Kader K. Oguz     | 2012 | Ankara, Turkey         | Patients with epileptogenic lesions               | Functional MRI           | Functional MRI is useful in detecting hemodynamic and microstructural alterations in epileptogenic lesions | [25]       |
| Álvarez-Linera Prado | 2012 | Madrid, España         | Epilepsy patients with focal seizures              | Structural MRI           | Structural MRI is useful in detection of mesial temporal sclerosis and malformations of cortical development in patients with epilepsy | [26]       |
| Hui et al.        | 2003 | Shatin, Hong Kong      | Pre-operative epilepsy patients                    | Cranial MRI              | Cranial MRI detected electroencephalographic results in epilepsy patients | [27]       |
| Jabbari et al.    | 1986 | Washington, USA        | Partial complex epilepsy patients                  | Conventional MRI         | MRI detected focal ictal discharges in 85% of epilepsy patients with scalp electroencephalograms | [28]       |

Conclusion: These additional techniques are highly sensitive, more powerful, and accurate when performed with MRI. Application of these functional imaging techniques is not the same at all time but these have been usually implemented in their specific requirements for the screening of epilepsy such as electroencephalogram (EEG) which is extremely useful for the detection of epileptogenic lesions in the brain when it can be recorded during fMRI. Whereas, PET is highly useful for the detection of cortical dysplasia, which usually has not been detected by the conventional MRI technique in patients with epilepsy. Furthermore, epilepsy patients have also been screened by MRI-based invasive EEG monitoring and also through placing of intracranial depth recording electrodes. These approaches have provided a top level screening for the detection of highly complicated epileptogenic lesions. In addition, MRI-based screening guidelines for the surgeons have also been developed and implemented which provided three-dimensional knowledge with superimposed real-time details of epileptogenic lesions to the surgeons which have already been proven to be successful for the performing epilepsy surgeries. Not only have these, the post-operative MRI has also provided an information for the quality of surgery, whether it can be done in a correct manner and it also provides information whether the second round surgery should be needed. Further, almost all types of brain-associated major structural abnormalities including cortical resection, corpus callosotomy, and hemispherectomy have been screened and analyzed by MRI. Therefore, MRI application either alone or in combination with other functional approaches is highly applicable for the diagnosis of epilepsy patients. In this systematic review, we have provided the role of various types of MRIs for the screening of patients of different stages of intractable epilepsy. Using the keywords MRI and epilepsy, our systematic searched of literature initially found a total of 112,610 articles on MEDLINE, ScienceDirect, and Google Scholar. After reviewing studies title, abstracts, and full text at different stages, only 10 highly relevant studies were included in this study. In 2021, a study conducted by Abdelgawad et al. on children with non-lesional epilepsy in Minya, Egypt, reported that volumetric MRI is extremely useful in the analysis of non-lesional pharmacoresistant childhood epilepsy. In another study, Samia et al. from Nairobi, Kenya, reported that the conventional MRI has potential to detect multiple clinical comorbidity in childhood epilepsy. Furthermore, Bernasconi et al. from Quebec, Canada, in 2019 reported that the structural MRI is very useful for the detection of non-invasive lesions in patients with epilepsy. Importantly, a study by Maqsood et al. from Jammu Kashmir, India, pointed...
out that the conventional MRI is highly sensitive for the
detection of epileptogenic materials, dysfunctionality in soft
tissues and they reported that MRI is the best technique for the
screening of pre-operative intractable epilepsy.[22] Moreover,
Ponnatapura et al. from Karnataka, India, in 2018 reported that
MRI with dedicated seizure protocol is best for the detection
of epileptogenic lesions in one half of the new-onset seizures
in epilepsy patients.[23] Furthermore, Zhao et al. from Hubei,
China, reported that Magic TVs approach through conventional
MRI improves the diagnosis of epilepsy by reducing negative
outcomes.[24] In another study, functional MRI found to be
an important technique for the detection of hemodynamic
and microstructural alterations in epileptogenic lesions.[25]
In addition, another study showed that the structural MRI
technique has potential for the analysis of mesial temporal
sclerosis and malformations of cortical development in
epilepsy patients.[26] In another study, cranial MRI
 technique was found to be useful for presenting findings
in electroencephalographs in patients with pre-operative
epilepsy.[27] Moreover, conventional MRI was also found to
be an important for the detection of focal ictal discharges in
patients with scalp electroencephalograms epilepsy.[28] All
these data clearly pointed out that all types of MRI whether
perform alone or in combinations with other techniques are
extremely useful for the screening of intractable epilepsy.

Conclusions

The applicability of magnetic resonance imaging for the
diagnosis of epilepsy is highly accessible in all over the globe.
With the advancement in the MRI technique, this can be also
applying with additional approaches. The functional MRI has
now becoming more and more critical in the diagnosis and
management of highly complicated epilepsy patients. The
outcomes of this systematic review clearly point out that the
MRI is a choice technique for the evaluation of epileptogenic
lesions. The pooling of selected studies clearly indicating that
the MRI-based surgical approaches provide three-dimensional
pictorial details with superimposed real-time surgeons pointer
information for the epilepsy patients, which already been
proved successful in epilepsy surgery. In addition, the data also
pointed out that MRI-based approach is also very useful for
post-operative epilepsy patients as it gives information about
the quality of the surgery. In short, the MRI-based therapies are
extremely valuable for the management of patients with epilepsy.

Authors’ Declaration Statements

Availability of data and material

The data used in this study are available and will be provided
by the corresponding author on a reasonable request.

Competing interests

None.

ORCID link of the submitting author: https://orcid.org/0000-0001-5755-7350

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