



Role of DWI in Evaluation of Cerebrovascular Insult: Systematic review study

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ABSTRACT

Diffusion weighted MR imaging is a gold standard technique to evaluate cerebrovascular insult in brain. Help to assess the initial stroke, predict future outcomes and help to diagnosis the ischemic stroke, DWI helps to distinguish between strokes from stroke mimics; DWI ADC shows the stroke on minute onset. Qualitative study was carried out to assess the role of DWI in evaluation of cerebrovascular insult in brain. We searched PubMed and researchgate with relevant title topic and reviewed 40 studies. In which some studies show that DWI has positive result to identify the stroke. This review article provide brief information about the DWI result in the evaluation of stroke. DWI has positive result to identify the stroke, gives useful information help to plan the treatment but DWI fails to show posterior circulation ischemic, this study also shows that MRI modality has better sensitivity than CT. DWI MR has become valuable technique in the field of cerebrovascular insult or to other brain pathologies. DW MRI has ability to detect stroke within minutes after onset, helps to diagnosis the ischemic stroke. DWI allows the pain free evaluation of stroke provides useful information, helps to plan treatment, diagnosis; it is useful in the initial few hours of the ischemic insult helpful in differentiating acute, sub-acute, and chronic infarcts. DWI MRI is a standard protocol for stroke patient.

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INTRODUCTION

MRI is an irreplaceable imaging technique in radiology department. MRI is progressively use because it gives beneficial information by using non- ionizing radiation and also gives best detailed anatomical images in any planes of the patient's body and ability to depict complex (neuroanatomy). (1)

Diffusion weighted MR imaging is a golden technique that works on the diffusion random Brownian motion in tissues while measuring the motion of fluid in DW MR Image (2). DWI with ADC mapping undergo favorable outcomes for differentiating pathologies, identify the initial strokes, helps to assess TIA, infarct and cerebrovascular diseases in brain (3). Two types of motion of fluid occur in brain, isotropic and anisotropic. In anisotropic, fluid moves in any direction (4). Commonly the diffusion weighted technique is obtained by spin echo with diffusion gradients, firstly, 90 degree radio frequency pulse is given, then protons alignment takes place in the transverse zone, after that the signals are read out with the increase or decrease standardized EPI trajectory. The depletion in signal can be associated to the amount of diffusion that is happening in the tissue and how enough diffusion susceptibility the diffusion gradient adds to the spin echo sequence (5) (6).

Frequently EPI DW is mostly used because of faster acquisition time with less motion artifacts. The improvement in gradient technology allows the diffusion sensitivity without affecting the signal to noise ratio, standard and higher b value provides the better image quality. Tissues with restricted diffusion show hypo intense in ADC maps and bright on the trace images (7)

Stroke

Stroke is a cerebrovascular condition and a long term disability in human identify by the sudden onset of symptoms. Stroke is a critical situation in which blood flow stops and stop providing oxygen to brain cells (8). MRI has contributed a worldwide point of view on cerebrovascular pathology at the beginning of stroke and all over subsequent stroke evolution (9). DW MRI Allow for the strong knowledge of stroke pathophysiology, in case of hemorrhagic or ischemic in nature (10). Hemorrhagic stroke occurs because of bleed in surrounding brain tissue common cause of this stroke is hypertension (11) and ischemic is most common type of stroke and occurs because of clot in vessels ischemic stroke is classified into hyper acute, subacute and chronic stroke . Most common symptoms of the stroke are numbness of the face,

Weakness, difficulty in speaking visual disorder, severe headache. Earlier detection and treatment can save the patients (12)(13).

METHODOLOGY

The qualitative study was carried out to assess the role of DWI in evaluation of cerebrovascular insult in brain. We searched PubMed and Scopus, using the some search term “cerebrovascular insult” ‘stroke” “Diffusion weighted imaging” “acute ischemic stroke”.

In review article Data was taken on the basis of age/sex, date and time of symptoms onset and on the basis of clinical history. 40 numbers of articles was taken for this study. 40 out of 30 are mentioned in the result.

Inclusion criteria

- Sudden attack on brain clinically referred patient for MRI of the brain and were detected to have stroke, TIA infarct and ischemic injury.
- The imaging method should include MRI and DWI

RESULT

In this study, 30 out of 28 studies show that DWI has positive result to find the stroke and predict future outcomes. In DWI, voxel with high diffusion appear hypo intense (e.g. cerebrospinal fluid) and voxel with low diffusion appear hyper intense (e.g. acute stroke), shows that DWI is sensitive to hyper acute stroke, other study shows that MRI DWI helps in therapeutic decision algorithms, predictor of clinical outcomes. Two articles have shown that DWI negative in posterior circulation ischemic and fails to show small stroke in brain stem clinicians are using DWI method for stroke evaluation but have possibility of DWI negative in posterior circulation ischemia.

DWI ADC Parameter

Other article shows that DWI ADC can detect ischemic injury within minutes after onset shows the level of restriction in the extracellular compartments, whereas other modalities fail to detect stroke injury after for at least a few hours. Studies show that DWI helps to avoid misdiagnoses, helps to plan treatment, shows hypoxic brain injury, allow one to differentiate cysts from abscesses. DWI detect very small ischemic lesion due to high SNR and can differentiate between acute and chronic lesion.

DW MRI has higher accuracy to identify stroke

Two studies show that clinicians are using DWI MR Technique more than other modalities because it has higher accuracy to predict stroke and other pathophysiological information with less risk with the comparison of CT modality (356) pt. were taken in whom 217 had a final diagnosis of stroke, MRI had 83% accuracy (181 of 217; 78-88%) and CT had 26% accuracy (56 of 217; 20-30%) for the any acute stroke in result MR DWI is more accurate for diagnosis of stroke (14) .

EPI DWI is preferred for stroke

Two studies concluded that EPI DWI is most commonly used technique due to rapid readout acquisition with less motion artifacts provides higher ADC value than other two sequences TSE and RESOLVE both have good spatial resolution but have long acquisition time that's why EPI DWI is more preferable .

Diagnosis of acute ischemic stroke

Four article shows the diagnosis of stroke depends on the clinical imaging. In which MR DWI has ability to differentiate between strokes from stroke mimics. Recent improvement in MR has increased the accuracy to detect ischemic lesion, appear hyper intense on DWI and hypo intense in ADC maps within initial minutes of stroke onset. Early detection of stroke and treatment can save the patient's life.

DISCUSSION

DWI is a standard technique for detection of stroke provides knowledge and gives physiological information about diseases; this technique is sensitive to early ischemic stroke (15). Most of the studies show that DWI has positive result to identify stroke and helps to diagnose the stroke (16). Improvement in MR gradients and field increased the diffusion sensitivity without significant loss of SNR is now practicable. Most of the studies show that High B value DWI offered more detection rate in hyper ischemic stroke (17). Beyond stroke DWI also identifies the brain tumors, epilepsy, trauma and infection, DWI is sensitive for detection of infection (18). There is a technique (TSE) Turbo spin echo DWI and RESOLVE with better spatial resolution than (EPI) Echo planer imaging DWI but both technique have one disadvantage long acquisition time than EPI that's why EPI is still a standard choice for brain imaging because of rapid readout method but have some limitations has low spatial resolution and relatively thick selection . RESOLVE sequence is useful for evaluation of small structure like (spinal cord & orbit). T2 and FLAIR sequence are less sensitive in first few hours (7)(19) (20).

DWI predicts short term stroke risk and also uses to define the ischemic core. MR has higher accuracy to find pathologies, reduce risk and give more information than other modalities. In ischemia (21) DW images clearly show stroke onset area, region of the stroke. Patient with minor stroke usually have small infarct on neuroimaging (9). Stroke is one of the most critical situation in medical field in which imaging plays a major role to identify the stroke .The event of stroke is sudden and incapacitating but with the help of DWI ADC clinicians can see the restriction and plan the treatment (22) (8).DWI has ability to identify quickly moving in the ratio of extracellular to intracellular water content in the brain help to distinguish between strokes from stroke mimics (23).Fast MRI sequence reduces the examination time, provide valuable information in terms of patient care (3).

Furthermore improvement in DWI technique can solve the DWI negative failure in brain. DWI ADC is the most common parameter that detects ischemic injury within minutes after onset, other modality like CT fails to detect stroke in initial hours (24) EPI has high sensitivity. Clinicians are using DWI MR due to its greater sensitivity for stroke diagnosis, identify in the initial hours after onset, shows small lesion (7). Stroke in posterior circulation is more commonly DWI negative than anterior circulation. DWI fails in small stroke in brain stem (25). Two studies compared the imaging modality CT, MRI for the assessment of early stroke in which both study performed with good equipment condition, both study shows that MRI has more ability to detect the acute stroke (26). In one study 356 pts were taken in 164 of 356 detected ischemic acute strokes and in CT 35 of 356 detected early stroke compared with clinical diagnosis MRI is more preferable technique (14).

CONCLUSION

Imaging became the initial step to identify the cause of diseases, in which DWI MR has become valuable technique in the field of cerebrovascular insult or to other brain Pathologies. DW MRI has ability to detect stroke within minutes after onset, helps to diagnosis the ischemic stroke, MRI detect ischemic lesion in acute ischemic stroke patient. DWI allows the pain free evaluation of stroke provides useful information, helps to plan treatment, diagnosis. With this review article a better understanding of DWI MRI in evaluation of cerebrovascular insult. It is useful in the initial few hours of the ischemic insult helpful in differentiating acute, sub-acute, chronic infarcts. DWI MRI is a standard protocol for stroke patient.

REFERENCES

1. Berger A. How does it work?: (2002). Magnetic resonance imaging. *BMJ* [Internet]. 324(7328):35–35. Available from: <http://dx.doi.org/10.1136/bmj.324.7328.35>
2. Scherrer B, Gholipour A, Warfield SK. (2011). Super-Resolution in Diffusion-Weighted Imaging. In: *Lecture Notes in Computer Science*. Berlin, Heidelberg: Springer Berlin Heidelberg; p. 124–32.
3. Baliyan V, Das CJ, Sharma R, Gupta AK. (2016). Diffusion weighted imaging: Technique and applications. *World J Radiol* [Internet]. 8(9):785–98. Available from: <http://dx.doi.org/10.4329/wjr.v8.i9.785>
4. Basser PJ.(1995). Inferring microstructural features and the physiological state of tissues from diffusion-weighted images. *NMR Biomed* [Internet]. 8(7):333–44. Available from: <http://dx.doi.org/10.1002/nbm.1940080707>
5. Holdsworth SJ, Bammer R. (2008). Magnetic resonance imaging techniques: fMRI, DWI, and PWI. *Semin Neurol* [Internet].28(4):395–406. Available from: <http://dx.doi.org/10.1055/s-0028-1083697>
6. Bammer R. (2003). Basic principles of diffusion-weighted imaging. *Eur J Radiol* [Internet]. 45(3):169–84. Available from: [http://dx.doi.org/10.1016/s0720-048x\(02\)00303-0](http://dx.doi.org/10.1016/s0720-048x(02)00303-0)
7. Wu W, Miller KL.(2017). Image formation in diffusion MRI: A review of recent technical developments: Review of Image Formation in dMRI. *J MagnReson Imaging* [Internet]. 46(3):646–62. Available from: <http://dx.doi.org/10.1002/jmri.25664>
8. Boursin P, Paternotte S, Dercy B, Sabben C, Maier B. (2018). Semantics, epidemiology and semiology of cerebrovascular accidents. *Care* [Internet]. 63(828):24–7. Available from: <http://dx.doi.org/10.1016/j.soin.2018.06.008>
9. González RG.(2012). Clinical MRI of acute ischemic stroke. *J MagnReson Imaging* [Internet]. 36(2):259–71. Available from: <http://dx.doi.org/10.1002/jmri.23595>
10. Schaefer PW, Grant PE, Gonzalez RG.(2000). Diffusion-weighted MR imaging of the brain. *Radiology* [Internet]. ;217(2):331–45. Available from: <http://dx.doi.org/10.1148/radiology.217.2.r00nv24331>
11. Hakimi R, Garg A. (2016). Imaging of hemorrhagic stroke. *Continuum (Minneapolis)* [Internet];22(5):1424–50. Available from: <http://dx.doi.org/10.1212/con.0000000000000377>
12. Kloska SP, Wintermark M, Engelhorn T, Fiebich JB. (2010). Acute stroke magnetic resonance imaging: current status and future perspective. *Neuroradiology* [Internet]. 52(3):189–201. Available from: <http://dx.doi.org/10.1007/s00234-009-0637-1>
13. Sarikaya H, Ferro J, Arnold M. (2015). Stroke prevention - medical and lifestyle measures. *Eur Neurol* [Internet]. ;73(3–4):150–7. Available from: <http://dx.doi.org/10.1159/000367652>

14. Chalela JA, Kidwell CS, Nentwich LM, Luby M, Butman JA, Demchuk AM, et al. (2007). Magnetic resonance imaging and computed tomography in emergency assessment of patients with suspected acute stroke: a prospective comparison. *Lancet* [Internet]. ;369(9558):293-8. Available from: [http://dx.doi.org/10.1016/s0140-6736\(07\)60151-2](http://dx.doi.org/10.1016/s0140-6736(07)60151-2)
15. Leiva-Salinas C, Wintermark M. (2010). Imaging of acute ischemic stroke. *Neuroimaging Clin N Am* [Internet]. ;20(4):455-68. Available from: <http://dx.doi.org/10.1016/j.nic.2010.07.002>
16. Lin MP, Liebeskind DS. (2016). Imaging of ischemic stroke. *Continuum (Minneapolis)* [Internet];22(5):1399-423. Available from: <http://dx.doi.org/10.1212/con.0000000000000376>
17. Chilla GS, Tan CH, Xu C, Poh CL. (2015). Diffusion weighted magnetic resonance imaging and its recent trend-a survey. *Quant Imaging Med Surg* [Internet]. 5(3):407-22. Available from: <http://dx.doi.org/10.3978/j.issn.2223-4292.2015.03.01>
18. Gaddamanugu S, Shafaat O, Sotoudeh H, Sarrami AH, Rezaei A, Saadatpour Z, et al. (2022). Clinical applications of diffusion-weighted sequence in brain imaging: beyond stroke. *Neuroradiology* [Internet]. 64(1):15-30. Available from: <http://dx.doi.org/10.1007/s00234-021-02819-3>
19. Drake-Pérez M, Boto J, Fitsiori A, Lovblad K, Vargas MI. (2018). Clinical applications of diffusion weighted imaging in neuroradiology. *Insights Imaging* [Internet]. 9(4):535-47. Available from: <http://dx.doi.org/10.1007/s13244-018-0624-3>
20. Khalil AA, Hohenhaus M, Kunze C, Schmidt W, Brunecker P, Villringer K, et al. (2016). Sensitivity of diffusion-weighted STEAM MRI and EPI-DWI to infratentorial ischemic stroke. *PLoS One* [Internet]. 11(8):e0161416. Available from: <http://dx.doi.org/10.1371/journal.pone.0161416>
21. Duong TQ. (2011). MRI in experimental stroke. In: *Methods in Molecular Biology*. Totowa, NJ: Humana Press; p. 473-85.
22. Guzik A, Bushnell C. (2017). Stroke epidemiology and risk factor management. *Continuum (Minneapolis)* [Internet]. 23(1):15-39. Available from: <http://dx.doi.org/10.1212/con.0000000000000416>
23. Adam G, Ferrier M, Patsoura S, Gramada R, Meluchova Z, Cazzola V, et al. (2018). Magnetic resonance imaging of arterial stroke mimics: a pictorial review. *Insights Imaging* [Internet]. 9(5):815-31. Available from: <http://dx.doi.org/10.1007/s13244-018-0637-y>
24. Arsava EM. (2012). The role of MRI as a prognostic tool in ischemic stroke. *J Neurochem* [Internet]. 123:22-8. Available from: <http://dx.doi.org/10.1111/j.1471-4159.2012.07940.x>
25. Edlow BL, Hurwitz S, Edlow JA. (2017). Diagnosis of DWI-negative acute ischemic stroke: A meta-analysis. *Neurology* [Internet]. 89(3):256-62. Available from: <http://dx.doi.org/10.1212/wnl.00000000000004120>
26. Chaturvedi S, Ofner S, Baye F, Myers LJ, Phipps M, Sico JJ, et al. (2017). Have clinicians adopted the use of brain MRI for patients with TIA and minor stroke? *Neurology* [Internet]. 88(3):237-44. Available from: <http://dx.doi.org/10.1212/wnl.00000000000003503>

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