

DIAGNOSTIC ACCURACY OF FLUID-ATTENUATED INVERSION-RECOVERY MAGNETIC RESONANCE IMAGING IN DETECTION OF ACUTE SUBARACHNOID HEMORRHAGE KEEPING LUMBER PUNCTURE AS GOLD STANDARD

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ABSTRACT

Objective: To determine the diagnostic accuracy of FLAIR MRI in identifying acute Subarachnoid Hemorrhage (SAH) using Lumber puncture (LP) as a gold standard.

Materials and Methods: This was a validation study conducted from 3rd September 2020 to 3rd February 2021 at the Department of Radiology, Khyber Teaching Hospital, Peshawar. The sample size was 266. A non-probability consecutive sampling technique was used. All alert patients aged 20-70 years with sudden acute headache, other signs of SAH (nausea, vomiting, blurring of vision, sensitivity to light, and neck stiffness), and GCS > 13 were included in this study. SAH on FLAIR-MRI was determined based on high signals in the subarachnoid space on FLAIR. Diagnostic accuracy was calculated regarding sensitivity, specificity, and positive and negative predictive values. SPSS version 22 was used to perform statistical analysis of the data.

Results: Mean age ranged from 20 to 70 years (46.3 + 14.1 years), with 58.6% male, and 41.4% female subjects. On FLAIR-MRI, SAH was observed in 65.4% of patients while SAH was recorded in 57.5% of patients on follow-up LP. Sensitivity of FLAIR-MRI was found to be 91.5% and specificity 69.9%. FLAIR-MRI had 80.5% positive predictive value and 85.8% negative predictive value.

Conclusion: FLAIR-MRI is effective in accurately identifying SAH with high sensitivity and fair specificity. As such, it is a useful radiological tool for diagnosis of SAH in adults and further studies are recommended to confirm its usefulness.

Keywords: Magnetic resonance imaging, lumber puncture, subarachnoid hemorrhage, headache

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INTRODUCTION

Non-traumatic subarachnoid hemorrhage (SAH) accounts for 3% of all strokes.^{1,2} Classical symptoms are sudden, explosive "Thunderclap" headaches, including neck stiffness, vomiting, confusion, and loss of consciousness.^{3,4} In 75%-80% of cases, rupture of an intracranial aneurysm is the primary cause of non-traumatic SAH.⁵ SAH yearly incidence is about 10 per 100,000 persons with high fatality (40%-50%). Incidence of SAH is 40.6%, 46.2%, 14.0%, and 59.1% in Europe, Asia, North America,

and Japan respectively.⁷ Incidence is 5% in Pakistan as well as in India.⁸ Early accurate diagnosis of SAH is crucial for better patient outcome as misdiagnosis can lead to poor prognosis.⁹

To detect SAH, the diagnostic algorithm involves non-contrast computed tomography (NCCT) brain followed by LP if NCCT is negative.¹ CT has a sensitivity of 98% to detect blood up to 5 days and 100% within 6 hours of symptom onset. LP has 98% sensitivity, 95% specificity, a negative predictive value of 99%, and a positive predictive value of 72% for aneurysmal SAH.⁹ CT shows high sensitivity and specificity, but LP is the gold standard for ruling out SAH when NCCT is negative.^{3,9} CT sensitivity for subacute or chronic SAH is lower and produces artifacts⁹, while LP is invasive and can cause postural headaches.¹

Magnetic resonance fluid-attenuated inversion-recovery (FLAIR) has high sensitivity in detecting SAH and is superior to CT for subacute and chronic SAH.^{2,10} Recent

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studies report FLAIR's sensitivity for detecting acute SAH as 78.57%, specificity as 96.53%, positive predictive value (PPV) as 57.89%, negative predictive value (NPV) as 98.67%, and accuracy rate as 95.29%.¹²

There is no international consensus on SAH diagnosis, and published data on FLAIR imaging in SAH is limited and this area of study has not been much of a focus in Pakistan. Our research aimed to determine the diagnostic accuracy of FLAIR-MRI in acute SAH using lumbar puncture as the gold standard, so that FLAIR MRI, if found to be accurate, may replace the invasive procedure of lumbar puncture.

MATERIALS AND METHODS

This descriptive cross-sectional study was conducted from 3rd September 2020 to 3rd February 2021 at the Department of Radiology, Khyber Teaching Hospital, Peshawar. A sample size of 266 was calculated using a sample size calculator for sensitivity and specificity by Lin-Naing taking sensitivity and specificity of FLAIR of 78.57% and 96.53% respectively, the prevalence of SAH of 46.2%, 95% confidence level, and 10% precision.^{7, 12} Non-probability consecutive sampling technique was used. All alert patients aged 20-70 years with sudden acute headache, other signs of SAH (nausea, vomiting, blurring of vision, sensitivity to light, and neck stiffness), and GCS > 13 were included in this study while patients who had previous surgery for the source of SAH and those with a history of head trauma, toxic causes, or unconscious presentation were excluded.

Subarachnoid hemorrhage is defined as extra-axial hemorrhage in subarachnoid spaces of the brain.¹³ SAH on LP was confirmed based on all the following features¹⁴, like visual examination of CSF for xanthochromia, CSF cytology for increased red blood cell counts, increased proteins and measurement on Spectrophotometry for oxyhemoglobin or bilirubin determination. SAH on FLAIR-MRI was determined based on high signals in the subarachnoid space on FLAIR.¹⁵ Diagnostic accuracy was calculated in terms of sensitivity, specificity, and positive and negative predictive values.

This study was conducted after ethical committee approval and informed consent from patients presenting to the accident and emergency department with severe headaches and other signs of SAH. FLAIR-MRI was conducted within 6 hours of symptom onset, followed by LP for CSF analysis after 8-12 hours for confirmation of SAH. Imaging was performed with a 1.5T machine (Achieva, Phillips) and included routine sequences with FLAIR (2200ms inversion time (TI) with axial cuts). MRI findings and CSF results were reported and compared by an expert radiologist and pathologist. On a pre-made proforma, all data was entered.

SPSS version 22 was used to perform statistical analysis of the data. The study variable was FLAIR-MRI findings and LP CSF analysis report. Sensitivity, specificity, PPV, NPV, and diagnostic accuracy were determined by taking LP as the gold standard.

RESULTS

The study was conducted on 266 patients with headaches and suspected SAH. The sample's mean age ranged from 20 to 70 years (46.3 + 14.1 years). In our study, 58.6% of the sample were male and 41.4% were female gender. 42.1% had a history of nausea, 33.5% had vomiting and 3.5% had blurring of vision.

On FLAIR, SAH was observed in 65.4% of patients while on follow-up LP, SAH was recorded in 57.5% of patients.

Sensitivity of FLAIR-MRI was found to be 91.5% and specificity 69.9%. FLAIR-MRI has 80.5% PPV and 85.8% NPV. (Table 1)

DISCUSSION

Detecting acute SAH with MR imaging is controversial due to fresh blood's minimal effect on CSF signal intensity. However, some studies have reported reliable detection of acute SAH with MRI using appropriate parameters.¹⁶ The role of MRI in the identification of SAH relies on different T1 and T2 times in SAH, cerebrospinal fluid (CSF), and brain tissue.¹⁵ According to Ogawa et al. patients with acute SAH revealed significantly reduced T1

Table 1: FLAIR-MRI AND LP 2x2 TABLE (n = 266)

		SAH on LP		Total
		Yes	No	
SAH on FLAIR-MRI	Yes	140	34	174
	No	13	79	92
Total		153	113	266

Sensitivity of FLAIR-MRI: TP/TP + FN = 91.5%

Specificity of FLAIR-MRI: TN/TN + FP = 69.9%

Positive Predictive Value FLAIR-MRI: TP/TP + FP = 80.5%

Negative Predictive Value FLAIR-MRI: TN/TN + FN = 85.8%

Accuracy: TP + TN / n = 82.3%

time and moderately reduced T2 time than in normal CSF while these values were of long duration in SAH than in grey matter.¹⁷ PD images and T2W images adequately revealed acute SAH in their research. FLAIR is an inversion recovery sequence with a long echo time (TE) and strong T2 weighting, nullifying CSF signals that appear hypo-intense. However, due to the short T1 time of blood products in subarachnoid space, the bloody CSF appears hyperintense relative to brain tissue.¹⁸ Noguchi et al. have demonstrated that FLAIR is more sensitive compared to CT in identifying diluted acute SAH.¹⁹

Given conflicting results from previous research, we did this research to determine the diagnostic efficacy of FLAIR MRI in detecting acute SAH. We found that FLAIR had a diagnostic accuracy rate of 85.8% in detecting acute SAH, with a sensitivity of 91.5%, specificity of 69.9%, PPV of 80.5%, and NPV of 85.8%, using LP as the gold standard.

Prior research showed a sensitivity of FLAIR in detecting acute SAH at 97.6%, a specificity as 66.7%, and NPV of SAH at 85.7%, which is comparable to our findings for sensitivity, specificity, and NPV.¹⁵

Another study by Burtscher M and co-workers found that FLAIR had a sensitivity of 89%, similar to our findings, and suggested that it has higher sensitivity than CT for detecting SAH, especially in cases where SAH has a significant load.²⁰

According to one research, FLAIR had 89.4% specificity, and 58.3% sensitivity for identifying SAH, which is in some contrast with our study's lower specificity and higher sensitivity.²¹

Verma RK and colleagues evaluated the effectiveness of susceptibility-weighted imaging (SWI), CT and FLAIR MRI in detecting SAH.¹⁰ They also evaluated whether the combined data from SWI/FLAIR MRI was more accurate than CT in detecting SAH. This study found SAH in 146 areas. FLAIR MRI detected 127 (87%) regions, SWI identified 129 (88.4%), and CT detected 110 (75.3%) regions. SWI and FLAIR together detected 146 regions (100%). Research has found that combining SWI and FLAIR increases detection rate for SAH compared to CT scans.

FLAIR is good for detecting SAH in temporal-occipital, frontal-parietal and Sylvian cistern areas, whereas SWI is better for detecting it in interhemispheric and intraventricular areas. Together, these two techniques provide complementary detection capabilities across different anatomical regions, making MRI a more effective tool for SAH detection. SWI is effective in the central brain regions, while FLAIR's strength is high in periphery. Even while FLAIR and SWI worked well together to produce promising results, FLAIR alone had a high sensitivity of 87%. This shows that FLAIR alone can function as a useful

diagnostic tool.¹⁰

Our study, conducted on a large number of subjects, provided valid outcomes and supported the implementation of FLAIR as a replacement for CT, which emits harmful radiation. These findings can improve guidelines and prevent delays in the diagnosis.

FLAIR MRI is a valid non-invasive method for SAH detection, the future of MRI in the diagnosis of SAH is likely to see a significant boost in sensitivity and specificity through the incorporation of the Susceptibility-weighted imaging (SWI) sequence, as prior research has found that combining SWI and FLAIR increases detection rate for SAH.¹⁰

CONCLUSION

FLAIR-MRI is effective in accurately identifying SAH with high sensitivity and fair specificity. As such, it is a useful radiological tool for diagnosis of SAH in adults and further studies are recommended to confirm its usefulness.

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AUTHOR'S CONTRIBUTION

Following authors have made substantial contributions to the manuscript as under

Iftikhar S: Concept, Critical appraisal, and Discussion Writing

Anjum H: Data collection, compilation of results, formatting of the article

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.



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