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*Review Article*

# Advanced Magnetic Resonance Imaging Sequences in Differentiating Various Intracranial Space Occupying Lesions

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## ABSTRACT

Intracranial space occupying lesions (ICSOL) represent one of the most commonly encountered abnormalities in brain. The availability of computed tomography (CT) and conventional magnetic resonance imaging (MRI) have revolutionised the approach towards diagnosis and management of intracranial lesions. Majority of intracranial lesions can be reliably diagnosed on conventional MRI. However many times it is difficult to differentiate brain pathologies on the basis of CT scan or conventional MRI. In such cases, advanced MRI sequences such as diffusion weighted imaging (DWI), perfusion weighted imaging (PWI) and proton magnetic resonance spectroscopy (MRS) can be helpful in making a reliable and accurate diagnosis. Herein, we describe importance of advanced MRI sequences in diagnosing various ICSOLs which were extremely hard and confusing to differentiate on conventional MRI.

***Keywords:*** Computed Tomography; Magnetic Resonance Imaging; Neoplastic; Tumour

## INTRODUCTION

Morphological assessment using CT or MRI is still the workhorse of tumor detection and diagnosis. In particular, MRI provides detailed information about cerebral tumor anatomy, cellular metabolism and hemodynamic features, making it a fundamental tool for a correct diagnosis, treatment and monitoring of the disease. [1]

Differentiation of neoplastic from non-neoplastic brain masses by using conventional CT or MRI is frequently difficult, and many cases require biopsy or follow-up imaging. Today a number of newer MRI techniques are in clinical use and focus of research. These advanced MRI techniques, such as diffusion-weighted imaging, MRS, and perfusion MRI, can further improve the diagnostic accuracy of conventional CT and MRI. [2] In this article, we provide an insight into the clinical applications of these newer techniques in differentiating various ICSOLs correctly.

**Pyogenic abscess and Tuberculoma:**

Pyogenic abscess and Tuberculoma may appear as well defined ring enhancing lesions on conventional MRI and differentiating them becomes a diagnostic challenge. In such cases, advanced MRI sequences have a definite role.

On DWI, both tuberculomas and pyogenic abscesses show restricted diffusion (Figure 1A & Figure 2A). This is similar to the observations of Luthra G et al [3] who observed diffusion restriction with low ADC value in both tubercular and pyogenic abscesses. Trivedi R et al [4] also stated that diffusion restriction is seen in tuberculomas with liquid necrosis. However on MRS, tuberculomas show lipid peak at

1.3 ppm and sometimes in both 1.3 and 0.9 ppm (Figure 1B) of the spectrum.

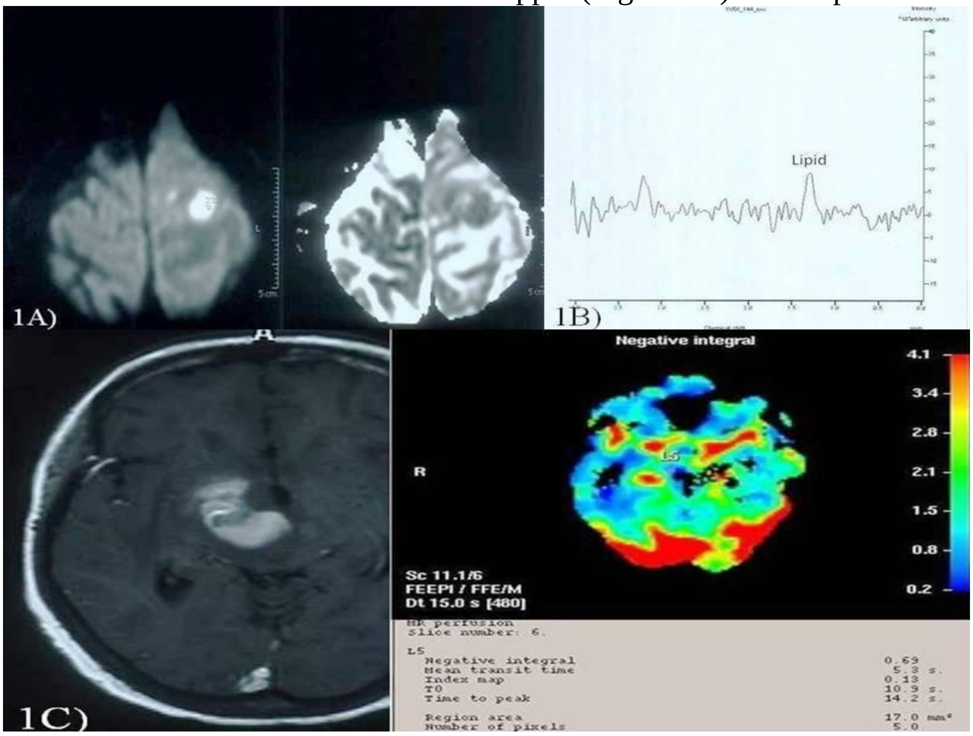


**Figure 1: Tuberculoma**
1A) Axial DWI and corresponding ADC map showing restricted diffusion. 1B) MRS image showing Lipid peak at 1.3ppm of spectrum. 1C) MR perfusion image in a case of tuberculoma showing reduced rCBV of 0.69ml/100gm.

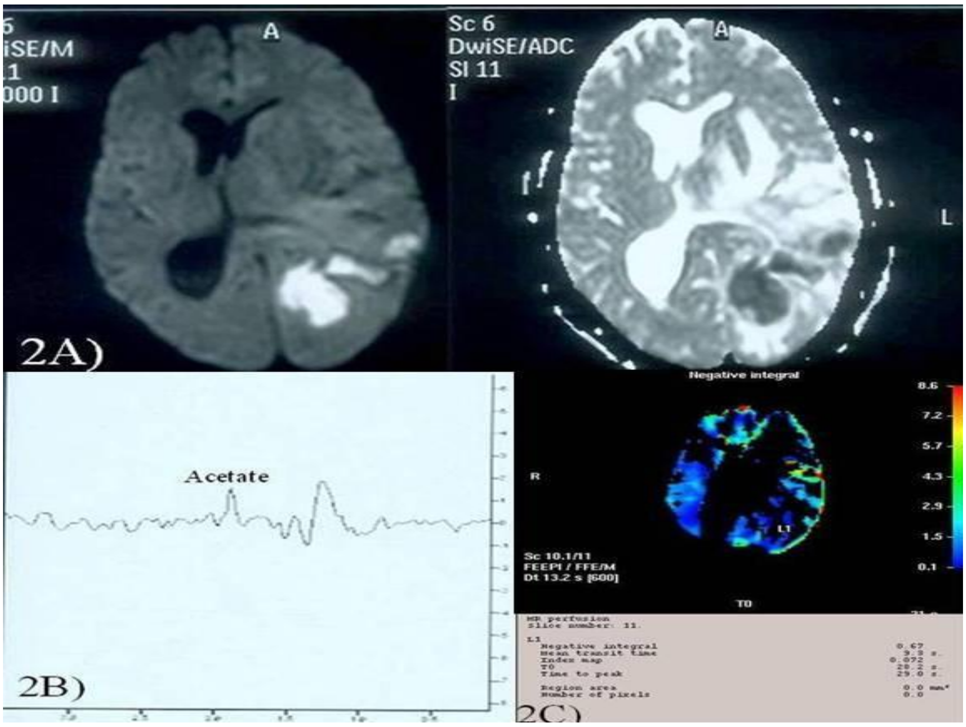


**Figure 2: Pyogenic Abscess**
2A) Axial DWI and corresponding ADC map showing restricted diffusion. 2B) MRS image showing Acetate peak at 1.9 ppm of spectrum. 2C) MR perfusion image showing reduced rCBV of 0.67ml/100gm.

Mukherjee S et al [5] observed a characteristic lipid peak at 1.3ppm on MRS in cases of tuberculomas. Luthra G et al [3] also observed similar lipid peak at 1.3ppm in all patients with tubercular abscess. Sometimes lactate peak can also be seen in tuberculomas. Instead in pyogenic abscess, amino acid peaks are seen, particularly at low TE with or without additional resonances of lipids, lactate, acetate, and succinate (Figure 2B). Luthra G et al [3] observed the presence of amino acids in 89 of 91 abscesses along with lipid and lactate, and acetate and succinate. Similar results were also seen in study by Garg M et al. [6]

On PWI, no significant difference exists between pyogenic abscess and tuberculomas as both show low relative cerebral blood volume (rCBV) (Figure 3A & 3B). Mean rCBV of 0.76 was seen in cases of abscess in a study by Hakyemez B et al. [7] Similarly Chatterjee S et al [8] observed low mean rCBV of 0.9 in tuberculomas in their study.

**Necrotic Metastasis & Tuberculoma:**

Intracranial tuberculosis has been a major problem in developing countries. It may manifest in diffuse form such as exudative leptomeningitis or in localized form such as focal tubercular lesions such as tuberculoma and tubercular abscess. Conventional MRI can help to distinguish infective and neoplastic ring-enhancing lesions. However differentiation of intracranial metastasis from tuberculomas may sometimes become difficult on conventional MR imaging. In such cases, advanced MRI sequences may contribute substantially in making correct diagnosis.

On DWI, tuberculomas show restricted diffusion (Figure 1A) as stated by Trivedi R et al. [4] Necrotic metastases however show diffusion facilitation in majority of cases (Figure 3A). On MRS, tuberculomas show lipid peak at 1.3 ppm and sometimes in both 1.3 and 0.9 ppm (Figure 1B). However metastasis in majority of cases show lipid peaks at 1.3ppm (L1) and 0.9 ppm (L2) with L1/L2 > 4 (Figure 3B). This was also demonstrated by Opstad KS et al [9] who observed that metastases had a high L1/L2 ratio on MRS.

On PWI, mean rCBV in cases of tuberculous lesions (Figure 1C) is lower as compared to brain metastasis (Figure 3C). Chatterjee S et al [8] also observed that perfusion imaging is very reliable in distinguishing necrotic metastasis from Tuberculoma and in their study all cases of tuberculomas had lower rCBVs as compared to metastasis.

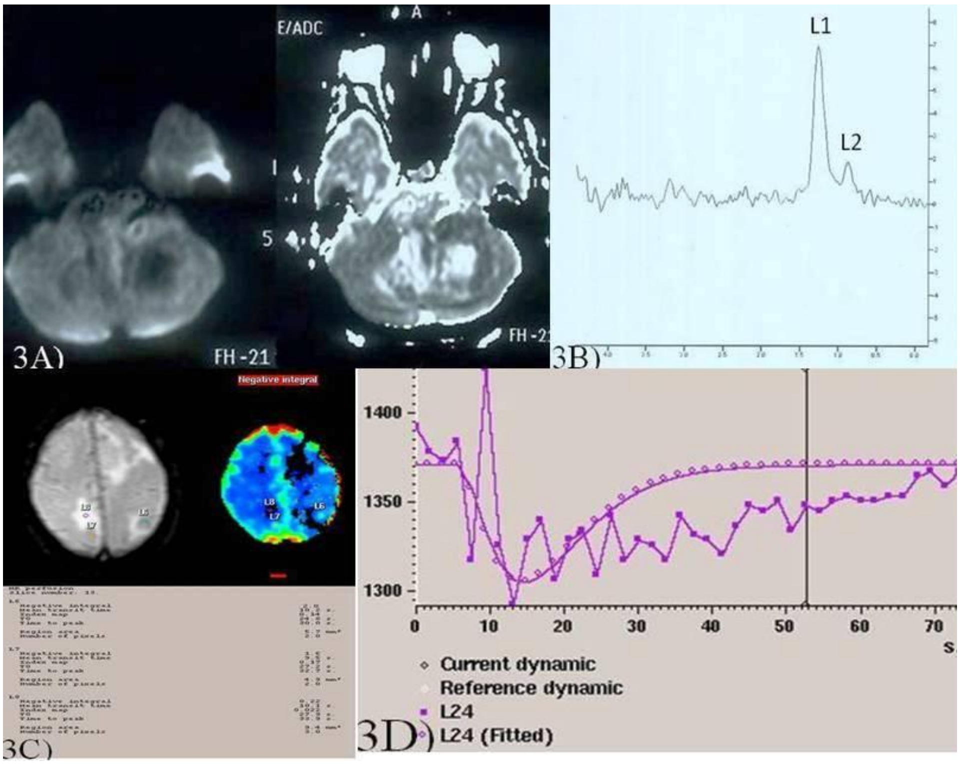


**Figure 3: Necrotic Metastasis**

3A) Axial DWI and corresponding ADC map showing diffusion facilitation. 3B) MRS image showing lipid peaks at 1.3ppm (L1) and 0.9 ppm (L2) with L1/L2 > 4. 3C) MR perfusion map showing high rCBV of 2.0 ml/100gm within the tumour with significantly reduced rCBV (0.22 ml/100gm) within peritumoral edema. 3D) Perfusion curve showing recovery significantly less than baseline.

**Pyogenic abscess, Necrotic metastasis and Glioblastoma Multiforme:**

Pyogenic abscess, Necrotic metastasis and Glioblastoma Multiforme (GBM) mimic each other on morphological MR imaging. In such cases, DWI, MRS and PWI can be used to make a correct diagnosis.

In pyogenic abscess, diffusion restriction with reduced ADC value is seen in abscess cavity (Figure 2A) while no diffusion restriction is seen in cavity of necrotic metastasis (Figure 3A). In GBM, no or patchy diffusion restriction (Figure 4A) is seen in majority of cases.

ON MRS, necrotic metastasis in majority of cases show lipid peaks at 1.3ppm (L1) and 0.9 ppm (L2) with L1/L2 > 4 (Figure 3B) while pyogenic brain abscesses are characterized by demonstration of amino acid peaks, particularly at low TE with or without additional resonances of lipids, lactate, acetate, and succinate (Figure 2B). MRS in cases of GBM shows significantly reduced NAA with markedly increased Cho/NAA and Cho/Cr ratio (Figure 4B).

On PWI, metastasis show high rCBV in tumour with significantly reduced rCBV in peritumoral edema (Figure 3C) while GBM show high rCBV in tumour (Figure 4C) as well as in peritumoral edema (Figure 4D). Also recovery curve in metastasis is well below baseline (Figure 3D) while in GBM, recovery curve is 80-100 % of baseline (Figure 4E). In contrast, pyogenic abscess show low rCBV on PWI thus making its differentiation easy (Figure 2C).

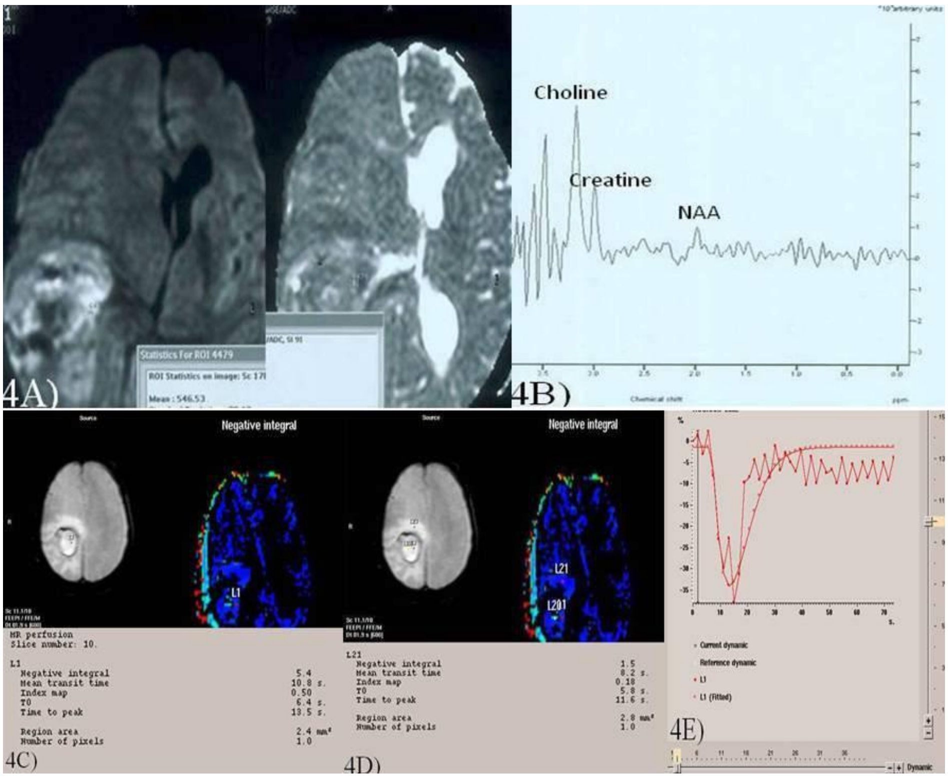


**Figure 4: Glioblastoma Multiforme**
4A) Axial DWI and corresponding ADC map showing patchy diffusion restriction. 4B) MRS image showing significantly reduced NAA with markedly increased Cho/NAA and Cho/Cr ratio. 4C) MR perfusion map showing high rCBV of 5.4 ml/100gm within the tumour. 4D) MR perfusion map showing high rCBV of 1.6 ml/100gm within peritumoral edema. 4E) MR perfusion curve showing recovery 80-100 % of baseline.

**Lymphoma and Butterfly gliomas:**

CNS lymphoma and butterfly Gliomas may have same appearance on conventional imaging as both cross corpus callosum into the contralateral hemisphere. So it may be very difficult to distinguish these two entities. DWI, MRS and PWI can be used in differentiating these lesions accurately.

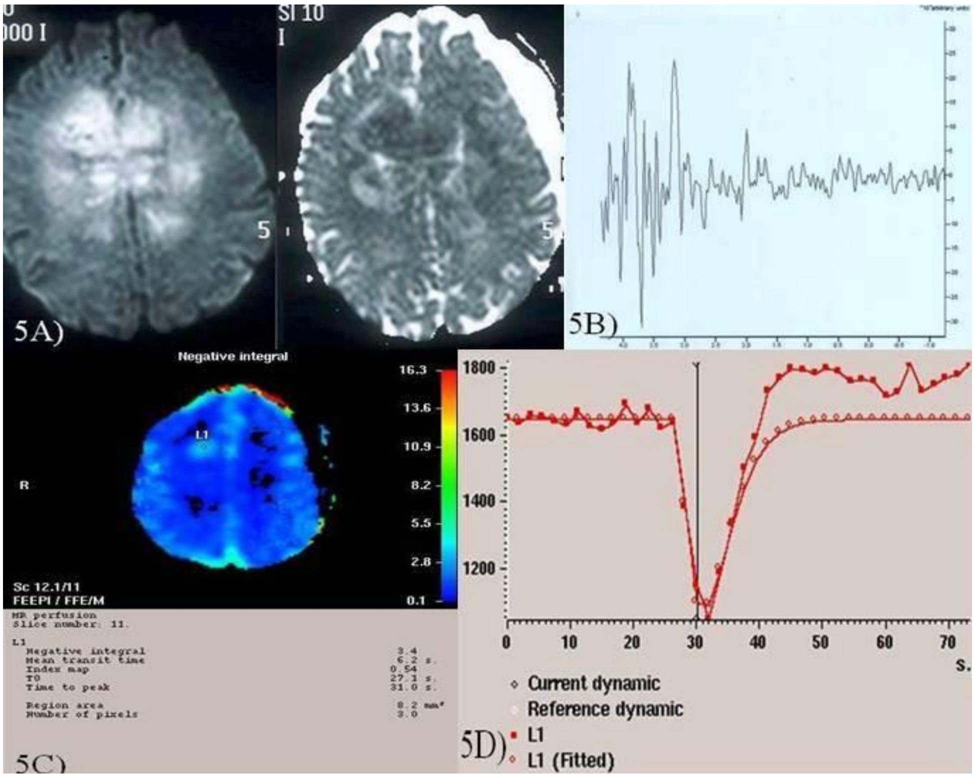


**Figure 5: Lymphoma**
5A) Axial DWI and corresponding ADC map showing diffusion restriction. 5B) MRS image showing no specific spectroscopic pattern. 5C) MR perfusion map showing high rCBV of 3.4 ml/100gm within the tumour. 5D) MR Perfusion curve showing signal recovery more than baseline (over shooting).

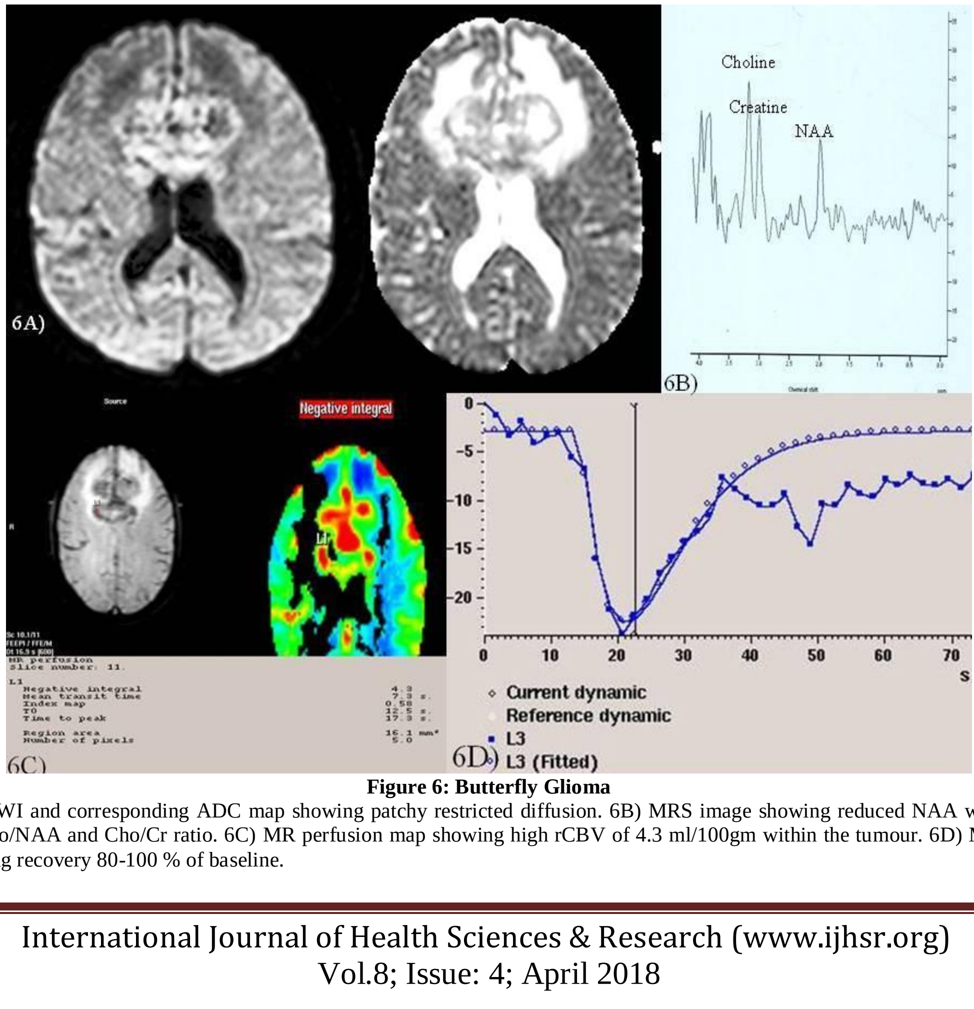


**Figure 6: Butterfly Glioma**
6A) Axial DWI and corresponding ADC map showing patchy restricted diffusion. 6B) MRS image showing reduced NAA with markedly increased Cho/NAA and Cho/Cr ratio. 6C) MR perfusion map showing high rCBV of 4.3 ml/100gm within the tumour. 6D) MR perfusion curve showing recovery 80-100 % of baseline.

On DWI, lymphomas show restricted diffusion with low intensity on ADC maps [10] (Figure 5A). In contrast, butterfly gliomas show no or patchy restricted diffusion in majority of cases as depicted in (Figure 6A). Toh Ch et al [11] also reported that lymphomas were hyperintense to gray matter on DWI and isointense to hypointense on Apparent Diffusion Coefficient (ADC) maps because of water restriction.

On MRS, no specific MR spectroscopic pattern is seen (Figure 5B) while in high butterfly gliomas significantly reduced NAA with markedly increased Cho/NAA and Cho/Cr ratio is seen (Figure 6B).

On PWI, lymphomas show reduced rCBV as compared to butterfly gliomas [(Figure 5C & 6C), with signal recovery more than baseline (overshooting) (Figure 5D) while in butterfly gliomas, recovery curve 80-100% of baseline is seen (Figure 6D).

## SUMMARY AND CONCLUSION

Advanced MRI sequences like DWI, MRS and PWI are extremely helpful and reliable in differentiating various intracranial lesions which usually remain inconspicuous and undiagnosed on conventional imaging. Thus importance of these advanced sequences need to be further highlighted so as to make appropriate and reliable diagnosis.

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