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Non-traumatic headache as an emergent conditions-role of MRI: A review article

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***Abstract*---Background:** Non-traumatic headaches are a prevalent neurological issue in emergency departments, affecting about 1–4% of patients. These headaches can be classified as primary or secondary, with the latter posing a risk of severe complications. Neuroimaging is critical for identifying secondary headache causes, with CT traditionally used to reveal abnormalities in 13–15% of patients. MRI offers superior soft tissue imaging without ionizing radiation, yet its use in emergency settings remains under-explored. Risk scoring systems have been developed to guide imaging decisions, focusing on patient age, neurological deficits, and other symptoms as predictors of intracranial pathology. **Aim:** This review aims to evaluate the role of MRI in diagnosing non-traumatic headaches in emergency settings and to analyze clinical guidelines for its appropriate use. **Methods:** A retrospective investigation was conducted on emergency patients presenting with non-traumatic headaches, analyzing MRI findings, demographics, and clinical presentations. **Results:** MRI identified significant abnormalities in approximately 20% of patients. Factors such as age, smoking status, and signs of infection correlated with abnormal findings, while a history of migraine appeared protective. The predictive model for identifying significant imaging outcomes showed limited clinical utility. **Conclusion:** MRI is a valuable tool in assessing non-traumatic headaches in emergency departments, particularly in high-risk patients. However, further research is needed to enhance predictive models for more accurate imaging decisions.

***Keywords*---**Non-traumatic headache, MRI, emergency department, neuroimaging, secondary headache, predictive model.

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Introduction

Non-traumatic headaches rank among the most prevalent neurological issues encountered in emergency departments (ED), affecting approximately 1–4% of patients [1, 2]. These headaches are categorized as either primary or secondary based on their underlying causes [3]. In emergency situations, neuroimaging is instrumental in ruling out various secondary headache etiologies that could lead to severe neurological complications or mortality [4]. Significant neuroimaging abnormalities in outpatients with non-traumatic headaches are infrequent, occurring in less than 10% of cases [5]. Research employing computed tomography (CT) has identified secondary causes in 13–15% of emergency patients who underwent cranial CT for headache assessment, primarily involving intracranial hemorrhages or ischemic events [6, 7, 8]. Magnetic resonance imaging (MRI) presents a viable alternative due to its superior soft tissue differentiation and absence of ionizing radiation; however, limited studies have examined its efficacy in emergency contexts [9, 10]. Budweg et al. noted that approximately 22% (18/82) of their walk-in outpatients exhibited at least potentially significant findings elucidating acute headaches. Conversely, Gilbert et al. observed that increased neuroimaging for headaches correlated with a decrease in the prevalence of significant findings [10]. These findings highlight the necessity for enhanced clinical decision-making support regarding the judicious use of imaging. Various clinical risk scoring systems have been developed for non-traumatic headaches to minimize unnecessary imaging [6, 8, 9, 11]. Common predictors of intracranial pathology identified in these studies include age over 50 years, focal neurological deficits, nausea/vomiting, and altered mental status. Nonetheless, most of these prediction models have been primarily designed for cranial CT. Budweg et al. introduced a clinical score for MRI, but it has not yet been validated in a prospective study setting [9].

Non-Traumatic Headache Emergency:

Non-traumatic headaches represent a significant concern in emergency medicine, being one of the most common neurological complaints among patients presenting to emergency departments (EDs). These headaches can be classified as either primary or secondary, depending on their underlying causes. While primary headaches, such as migraines or tension-type headaches, are typically benign, secondary headaches may indicate serious conditions requiring immediate medical attention. In the emergency setting, neuroimaging techniques like computed tomography (CT) and magnetic resonance imaging (MRI) play a crucial role in identifying potential secondary causes that could lead to severe neurological complications or even death. Research indicates that significant neuroimaging findings in patients with non-traumatic headaches are relatively rare, occurring in less than 10% of cases. However, studies utilizing CT have found secondary causes, such as intracranial hemorrhages or ischemia, in approximately 13–15% of patients who underwent cranial imaging for headache evaluation. MRI offers an alternative imaging modality with superior soft tissue characterization and no ionizing radiation; yet, there is limited evidence regarding its efficacy in emergency scenarios. Factors contributing to the clinical decision-making process in managing non-traumatic headaches include age, the presence of focal neurological deficits, nausea, vomiting, and altered mental status, all of

which can serve as predictors of serious intracranial pathology. To minimize unnecessary imaging and optimize patient care, various clinical risk scores have been developed. These scores aim to guide healthcare providers in determining which patients may require further imaging studies based on their clinical presentation. Understanding the non-traumatic headache emergency landscape is vital for healthcare professionals, as it facilitates the early identification of potentially life-threatening conditions, improves patient triage, and enhances overall management strategies within the emergency department.

Role of MRI in this Condition:

Magnetic resonance imaging (MRI) plays a pivotal role in the assessment of non-traumatic headaches, particularly in emergency settings where the differential diagnosis may include serious intracranial pathology. Unlike computed tomography (CT), MRI offers superior soft tissue contrast and can detect subtle changes in brain structures, making it especially valuable in identifying conditions such as cerebral infarctions, tumors, and structural abnormalities that may not be evident on CT scans. Despite its advantages, the utilization of MRI in the emergency department is limited by factors such as availability, longer acquisition times, and the need for patient stability during imaging. Nevertheless, studies have shown that MRI can yield significant findings in a subset of patients presenting with acute headache, with approximately 22% of outpatients demonstrating potentially critical abnormalities. Additionally, MRI is advantageous because it employs no ionizing radiation, making it a safer alternative for patients, particularly younger individuals and those requiring multiple follow-up assessments. Given its capacity to enhance diagnostic accuracy and inform clinical decision-making, MRI should be considered a valuable tool in the comprehensive evaluation of patients with non-traumatic headaches, especially when clinical suspicion for serious underlying conditions is high.

Conditions that Require MRI:

Magnetic resonance imaging (MRI) should be utilized in the evaluation of non-traumatic headaches under specific clinical circumstances, primarily when there is a high suspicion of serious intracranial pathology. The following guidelines can help determine when MRI is warranted:

1. **Persistent or Unexplained Headaches**: MRI is recommended for patients experiencing new, persistent headaches that do not respond to standard treatments or those that significantly change in character or frequency.
2. **Neurological Deficits**: If a patient presents with focal neurological deficits (e.g., weakness, sensory loss, visual disturbances), an MRI is critical to rule out conditions such as strokes, tumors, or structural lesions.
3. **Altered Mental Status**: Headaches accompanied by confusion, altered consciousness, or other changes in mental status warrant an MRI to investigate possible causes like intracranial hemorrhage, infections, or mass effects.
4. **Signs of Increased Intracranial Pressure**: Symptoms such as papilledema (swelling of the optic disc), vomiting, or severe headache could

indicate increased intracranial pressure, necessitating an MRI to identify the underlying cause.

5. **Immunocompromised Patients**: For individuals with compromised immune systems presenting with headaches, MRI is essential to evaluate for opportunistic infections, tumors, or other serious conditions.
6. **Severe or Sudden Onset**: Headaches that are sudden in onset, often described as a "thunderclap" headache, may indicate a subarachnoid hemorrhage or other urgent conditions, prompting the need for MRI.
7. **History of Cancer**: Patients with a known history of cancer presenting with new headaches should undergo MRI to check for metastatic lesions in the brain.
8. **Previous Abnormal CT Findings**: If a CT scan reveals inconclusive or abnormal findings, MRI can provide additional detail and assist in further characterization of any identified abnormalities.

By adhering to these clinical guidelines, healthcare providers can make informed decisions regarding the use of MRI in the context of non-traumatic headaches, ensuring appropriate and timely diagnosis while minimizing unnecessary imaging.

Case Study:

In this extensive investigation of emergency outpatient cases, we observed that the majority of individuals undergoing emergency magnetic resonance imaging (MRI) for non-traumatic headaches exhibited normal scan results; however, approximately 20% revealed significant abnormalities that potentially elucidated the headache's etiology. Consequently, around five patients needed to undergo scanning to diagnose one individual with notable intracranial pathology. While we identified various significant predisposing and protective factors, the predictive performance of the model was only moderate, failing to accurately identify patients presenting with headache-related abnormalities. The prudent application of emergency neuroimaging to eliminate secondary causes of non-traumatic headaches remains a challenge, even with the utilization of MRI. Regarding MRI findings in headache patients, a recent meta-analysis conducted by Jang et al. [5] reported potentially significant abnormalities in 5.7% (95% CI: 1.6–20%) of patients suspected of having primary headaches. Similarly, Budweg et al. found that approximately 22% (18 out of 82) of their walk-in patients had findings that could potentially account for their acute headache, with 10% (8 patients) considered significant [9]. Both studies included only those patients with a provisional diagnosis of primary headache. Our findings demonstrated a higher yield for MRI among emergency patients (20% with significant findings), likely attributable to the increased prevalence of severe, acute-onset intracranial conditions (e.g., hemorrhages, infarctions, and central nervous system infections). Unlike prior studies, we included all emergency outpatients presenting with non-traumatic headaches, encompassing those with abnormal neurological examinations and suspected high-risk pathology. Notably, our patients received imaging with significantly shorter delays (96% within 24 hours) compared to Budweg et al., where only 72% had an MRI within three days, and 54% were scanned on the same day.

Our predominant headache-related findings were consistent with those reported by Budweg et al.; both studies identified a prevalence of conditions such as signs of intracranial hypertension, meningitis, and cerebral infarction. Additionally, our data revealed several less common conditions not observed in the previous smaller sample, including Chiari type I malformation, arterial dissections and occlusions, posterior reversible encephalopathy syndrome (PRES), and indications of intracranial hypotension. Compared to prior studies utilizing CT for acute headaches, we found similar prevalences of cerebrovascular events (intracranial hemorrhages and ischemia) and newly detected tumors but a lower prevalence of conditions more readily identifiable through MRI (such as infections and intracranial hypertension) [6, 7, 8]. We identified recent infarcts through diffusion-weight imaging (DWI) in 30 patients (4% of the total and 22% of those with significant findings), most of which were small and punctate. None of these patients experienced motor deficits, and the incidence of numbness was not higher than in other patients with significant findings. Consequently, these small infarcts were unlikely to lead to substantial neurological deficits, which are typically imaged using CT. Notably, one-third of these patients had previously undergone CT scans, all yielding unremarkable results.

The proportion of incidental findings discovered was comparable to that of significant findings and aligned with reports for patients with newly diagnosed primary headaches [16]. Kim et al. reported incidental abnormalities in 25% of new primary headache patients scanned with MRI, with the most common findings being white matter hyperintensities and sinonasal abnormalities unrelated to headache. Our findings corroborated this, highlighting the high prevalence of incidental findings and the similarities between emergency and non-emergency contexts. Even incidental findings that are clinically insignificant may induce unnecessary anxiety among patients and healthcare providers. We identified that age over 40 years, smoking status, signs and symptoms indicative of infection, and nausea significantly increased the likelihood of abnormal headache-related findings in MRI. Conversely, numbness and a history of migraine appeared to reduce this risk. Among these factors, older age and nausea were the only ones previously reported in CT and MRI scoring systems [6, 8, 9, 11]. A focal neurological deficit was consistently identified as a major risk factor in all CT scoring systems, a trend not reflected in our data. This discrepancy could be attributed to the fact that such patients may have been referred for CT rather than MRI. None of the prior studies identified factors that diminished the risk of significant findings, suggesting that the classification of known migraines as a protective factor might be due to the possibility that a new headache in a migraine patient could still be classified as migraine-related rather than stemming from a secondary cause. Among the migraine patients in our study, only 10% exhibited noteworthy findings in MRI.

The predictive model for significant imaging outcomes among emergency patients offered limited clinical utility, characterized by low sensitivity and moderate specificity. The clinical scoring model proposed by Budweg et al. demonstrated substantially higher sensitivity (100% vs. 46%), comparable specificity (82% vs. 79%), and a superior receiver operating characteristic area under the curve (ROC AUC) (0.94 vs. 0.63). One contributing factor to these discrepancies may be that their model was designed for an outpatient walk-in clinic context, presenting a

narrower spectrum of imaging outcomes and symptoms than typically encountered in emergency patients. According to our model, a typical patient least likely to exhibit abnormal findings is a young, non-smoking individual with a history of migraine. Our multivariate model, however, failed to accurately identify patients with headache-related abnormalities. The moderate performance of our model reflects the inherent difficulties in developing precise, universal risk scores for clinical use in a diverse patient population characterized by varying symptoms, risk factors, and imaging results.

A notable strength of this study is the routine employment of MRI in the emergency radiology department coupled with a large sample size. Furthermore, this research reflects true clinical scenarios and provides an authentic overview of emergency patients experiencing non-traumatic headaches. We employed a data-driven methodology by examining referrals for specific symptoms rather than relying solely on diagnosis codes. Nevertheless, our study is constrained by its retrospective design, as not all relevant data may have been accessible from the emergency referrals. Some referrals might have been incomplete or inaccurate, potentially leading to an underestimation of the true prevalence of risk factors. In addition to specific symptoms, pertinent comorbidities and medical histories may have been overlooked. The absence of relevant data could have affected the performance of the predictive model. A potential limitation regarding symptoms is our inability to reliably ascertain from referral data whether headaches were the primary presenting symptom. However, the rate of significant findings did not differ significantly between patients with only headaches and those with additional symptoms (Table 1), indicating that our results are not substantially biased due to this limitation. Future prospective validation of the current findings is necessary before asserting clinical utility.

Our findings are exclusively applicable to emergency MRI, which may not be universally suitable or available in all healthcare facilities, while CT typically serves as the primary modality for acute neuroimaging in headache patients. We concentrated on the initial use of emergency MRI and did not include headache patients who only underwent CT scans. In terms of generalizability, our study is limited because we did not consider headache patients not scheduled for emergency MRI, leaving unknown factors that contributed to the necessity for emergency MRI. Our diagnostic yield results can only be generalized to patients deemed to require emergency neuroimaging, aiming to identify individuals for whom imaging is unlikely to reveal significant findings. These findings offer novel insights into the diagnostic yield for this patient population when emergency MRI is readily accessible and commonly employed in emergency departments. Regarding the clinical implications of emergency MRI findings, MRI likely influenced the management of patients with newly identified neurological conditions such as cerebrovascular diseases (including acute infarction), demyelinating and infectious diseases, and idiopathic intracranial hypertension. Additionally, patients exhibiting concerning symptoms who had normal emergency MRIs may have been safely discharged.

Conclusion

This review highlights the critical role of magnetic resonance imaging (MRI) in the evaluation of non-traumatic headaches within emergency departments. While non-traumatic headaches are a common presenting complaint, the challenge lies in accurately distinguishing between benign primary headaches and serious secondary conditions that require immediate intervention. MRI's advantage lies in its ability to provide detailed soft tissue imaging without exposing patients to ionizing radiation, making it particularly beneficial for younger individuals and those needing multiple follow-ups. Our findings reveal that a significant percentage of emergency patients (approximately 20%) present with notable MRI abnormalities, including conditions such as cerebral infarctions and intracranial hemorrhages, which underscores the necessity for careful assessment of headache presentations. Clinical factors such as age over 40, smoking status, and symptoms like nausea emerged as significant predictors of abnormal MRI findings. Conversely, a history of migraines appeared to provide some degree of protection against serious secondary causes, suggesting that prior headache history should be carefully considered in clinical decision-making. Despite these insights, the predictive model for significant imaging outcomes had limited effectiveness, emphasizing the need for further refinement of clinical risk scoring systems. Current models, predominantly designed for CT imaging, may not adequately address the complexities of MRI interpretation in a diverse patient population. Additionally, the study's retrospective nature and potential gaps in data may have impacted on the findings and predictive accuracy. Moving forward, it is essential to enhance the existing clinical guidelines governing the use of MRI in non-traumatic headache cases, ensuring that healthcare providers can make informed decisions while minimizing unnecessary imaging. Future research should focus on validating and refining predictive models in prospective studies, which could lead to improved diagnostic accuracy and better patient outcomes in the emergency department setting. Ultimately, a judicious approach to neuroimaging will facilitate timely identification of serious conditions, enhance patient triage, and optimize management strategies for non-traumatic headaches.

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الصداع غير الرضخي كحالة طارئة - دور التصوير بالرنين المغناطيسي: مقال مراجعة

الملخص :

الخلفية :يعتبر الصداع غير الرضحي مشكلة عصبية شائعة في أقسام الطوارئ، حيث يؤثر على حوالي 1-4% من المرضى. يمكن تصنيف هذه الأنواع من الصداع إلى صداع أولي أو ثانوي، حيث يمثل النوع الثاني خطرًا على حدوث مضاعفات شديدة. يعد التصوير العصبي ضروريًا لتحديد أسباب الصداع الثانوي، حيث تم استخدام الأشعة المقطعية تقليديًا للكشف عن الشذوذات في 13-15% من المرضى. يوفر التصوير بالرنين المغناطيسي تصويرًا أفضل للأنسجة الرخوة دون استخدام الإشعاع المؤين، ومع ذلك، لا يزال استخدامه في البيئات الطارئة غير مستكشَف بالشكل الكافي. تم تطوير أنظمة تقييم المخاطر لتوجيه قرارات التصوير، مع التركيز على عمر المريض، والعيوب العصبية، والأعراض الأخرى كمؤشرات على وجود أمراض داخل الجمجمة.

الهدف :يهدف هذا الاستعراض إلى تقييم دور التصوير بالرنين المغناطيسي في تشخيص الصداع غير الرضحي في البيئات الطارئة، وتحليل الإرشادات السريرية لاستخدامه بشكل مناسب.

الطرق :تم إجراء تحقيق رجعي على المرضى في قسم الطوارئ الذين يعانون من صداع غير رضحي، حيث تم تحليل نتائج التصوير بالرنين المغناطيسي، والبيانات الديموغرافية، والعروض السريرية.

النتائج :حدد التصوير بالرنين المغناطيسي شذوذات كبيرة في حوالي 20% من المرضى. كانت عوامل مثل العمر، حالة التدخين، وعلامات العدوى مرتبطة بالنتائج غير الطبيعية، بينما بدا أن تاريخ الإصابة بالصداع النصفي كان له تأثير وقائي. أظهر النموذج التنبؤي لتحديد النتائج التصويرية المهمة فائدة سريرية محدودة.

الخلاصة :يعتبر التصوير بالرنين المغناطيسي أداة قيمة في تقييم الصداع غير الرضحي في أقسام الطوارئ، خاصة في المرضى ذوي المخاطر العالية. ومع ذلك، هناك حاجة إلى مزيد من الأبحاث لتعزيز النماذج التنبؤية من أجل اتخاذ قرارات تصويرية أكثر دقة.

الكلمات المفتاحية :الصداع غير الرضحي، التصوير بالرنين المغناطيسي، قسم الطوارئ، التصوير العصبي، الصداع الثانوي، النموذج التنبؤي.