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Mini Review

Appropriateness of Neuroimaging to Screen for Secondary Causes in Patients with Established Primary Headache: A Mini-Review

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Abstract

Headaches are among the most prevalent neurologic conditions worldwide, and are a frequent reason for neuroimaging, particularly when accompanied by clinical features that raise concern for secondary etiologies. In patients with established primary headache disorders and normal neurologic examination, the diagnostic yield of routine neuroimaging is low. Modern clinical evidence supports a selective, risk-stratified approach to neuroimaging, rather than indiscriminate imaging. This mini-review evaluates the diagnostic yield and clinical utility of neuroimaging to screen for secondary causes in patients with established primary headache disorders without focal neurologic deficits, seizures, and other red flag features. Current evidence demonstrates very low prevalence of clinically significant intracranial pathology in those diagnosed with a primary headache disorder and who underwent neuroimaging. Professional societies do not recommend routine neuroimaging in the absence of concerning clinical features. To this end, validated clinical frameworks, including the SNNOOP10 mnemonic, provide structured guidance for identifying patients at higher risk of secondary headache etiologies who may benefit from neuroimaging. The decision to perform imaging studies should remain symptom-guided and individualized, in order to balance diagnostic benefit against potential harms such as patient anxiety, unnecessary testing, and financial burden.

Keywords: Primary Headache; Neuroimaging; Magnetic Resonance Imaging (MRI)

Introduction

Primary headache disorders such as tension-type, migraine, and cluster headaches remain among the most prevalent neurologic conditions worldwide, and rank among the top causes of years lived with disability, according to Global Burden of Disease analyses [1]. Primary and secondary headaches contribute substantially to global health and socioeconomic burden [2]. They comprise a substantial proportion of outpatient neurology visits, and frequently prompt consideration for neuroimaging, particularly when accompanied by atypical features or neurologic abnormalities [3,4]. Despite well-established diagnostic criteria for primary headache disorders, neuroimaging remains utilized even in patients with stable headache phenotypes and normal neurologic examination [3]. This practice is often influenced by patient and physician anxiety, including medicolegal concerns such as the fear of missing a significant lesion and subsequent litigation risk [14]. Modern evidence and guidelines emphasize that neuroimaging in patients with established primary headache disorders should be guided by individualized risk assessment rather than routine screening [4,9,10]. This mini-review focuses on the diagnostic yield, clinical utility, and established algorithms related to neuroimaging to screen for secondary causes in patients with established primary headache disorders.

Primary headaches

Tension-type

Tension-type headache is the most common primary headache disorder, characterized by bilateral, band-like pressing or tightening pain of mild to moderate intensity. Episodes generally last from 30 minutes to several days and are not exacerbated by routine physical exertion. Associated symptoms are minimal, with absence of nausea or vomiting and at most one of photophobia or phonophobia [11]. Neurologic examination is typically normal, and the clinical course is often chronic or episodic and stable.

Migraine

Migraine is characterized by recurrent attacks of a unilateral, pulsatile headache lasting hours to days. It is frequently accompanied by nausea, vomiting, photophobia, and phonophobia. Episodes may occur with or without aura, which consists of transient focal neurologic symptoms such as visual or sensory disturbances preceding or accompanying headache onset [11]. Neurologic examination is usually normal between attacks.

Cluster

Cluster headache is a primary trigeminal autonomic cephalalgia characterized by recurrent episodes of severe, unilateral orbital, supraorbital, or temporal pain. Episodes last between 15 and 180 minutes, and are associated with prominent ipsilateral cranial autonomic symptoms such as lacrimation, conjunctival injection, nasal congestion, ptosis, or miosis, with patients often appearing restless or agitated during attacks [11,19]. Although cluster headache is primarily a clinical diagnosis, neuroimaging is commonly performed at initial presentation to exclude secondary causes that may mimic this syndrome. In patients with a classic presentation, stable course, and normal neurologic examination, repeat or routine imaging is not recommended in the absence of new or atypical features [10].

Secondary causes of headache

Secondary headaches arise from underlying structural, vascular, infectious, inflammatory, or systemic pathologies. Causes include ischemic and hemorrhagic stroke, brain tumors, central nervous system (CNS) infections, idiopathic intracranial hypertension, venous sinus thrombosis, and giant cell arteritis [11]. Although headache may be a presenting symptom of these conditions, secondary headaches are typically accompanied by additional features such as focal neurologic deficits, altered mental status, or a change in headache pattern over time. In contrast, isolated primary headaches with stable phenotype and normal neurologic examination are rarely associated with serious intracranial pathology [5, 6].

Diagnostic yield of neuroimaging in primary headache disorders

A clinical framework proposed in 1994 remains a cornerstone of headache algorithms today. The study demonstrated that patients with headache and normal neurologic examination have a very low likelihood of clinically significant intracranial pathology. This has served as foundational evidence supporting selective rather than routine imaging in these populations [5]. Subsequent studies have consistently validated this principle in outpatient settings, with low prevalence (1 - 2%) of clinically significant intracranial abnormalities in patients diagnosed with a primary headache disorder [3,6,8].

From a clinical standpoint, patients and providers often conceptualize imaging yield in terms of specific feared diagnoses such as brain tumors and arteriovenous malformations (AVMs). Pathology-specific prevalence rates vary across studies due to differences in patient populations, clinical settings, and imaging modalities [6,8,13]. Nonetheless, available evidence consistently demonstrates that rates of intracranial mass lesions and vascular malformations among headache patients without focal deficits are less than 1%. A systematic review of headache patients with normal neurologic examination reported low pooled prevalence rates for conditions such as meningioma, glioma, and hydrocephalus, while also highlighting relatively higher frequency of unexpected or incidental magnetic resonance imaging (MRI) findings [18]. Furthermore, a review of neuroimaging in headache reported incidence rates of approximately 0.3% for brain tumors, and 0.7% each for AVMs and saccular aneurysms, in patients with established primary headache, with a greater proportion of cases reporting incidental lesions [14]. In a multicenter cohort of 927 patients diagnosed with primary headache disorders who underwent MRI or computed tomography (CT), 170 (18.3%) had neuroimaging abnormalities, while only 34 (3.6%) were found to have serious pathology, underscoring that incidental findings are much more common than urgent disease in typical primary headache presentations [17]. A similar diagnostic yield was reported in a 2020 systematic review of neuroimaging in headache patients with normal neurologic examination, detailed in the table below [13]. Incidental neuroimaging findings are common in asymptomatic patients, and are frequently associated with needlessly complicated downstream follow-up, patient anxiety, and increased healthcare utilization [15,16].

Imaging Finding/Diagnosis Category	Pooled Prevalence (% Yield)
Unexpected/incidental findings and normal anatomic variants	17.5%
Vascular findings	6.6%
Neoplastic findings	1.4%
Non-neoplastic findings	9.6%
Stroke	2.0%
Unruptured intracranial aneurysm	1.8%
Subdural hematoma	0.8%
Hydrocephalus	0.7%
Glioma	0.2%
Meningioma	0.1%

Table 1: Pathology-specific diagnostic yield of neuroimaging in headache patients with normal neurologic examination.

Risk-stratified assessment and SNNOOP10 mnemonic

To assist clinicians in identifying patients who may warrant neuroimaging for headache, several clinical decision frameworks have been proposed. Among these, the SNNOOP10 mnemonic is widely used to highlight key red flag features suggestive of secondary headache etiologies [4,9,12]. Presence of any of these features substantially increases the likelihood of secondary headache and supports the use of neuroimaging. Diagnostic yield of neuroimaging is highest when guided by these clinical risk factors rather than applied indiscriminately to all patients with headache.

Signs/Symptoms	Related Secondary Headache Etiologies
Systemic symptoms (e.g. fever, fatigue, myalgia)	Headache attributed to infection or non-vascular intracranial disorders, carcinoid or pheochromocytoma
Neoplasm in history	Neoplasms or secondary metastasis
Neurologic deficit/ dysfunction (including decreased consciousness)	Headaches attributed to vascular and non-vascular intracranial disorders, brain abscess, and other infections
Onset of headache is sudden/abrupt.	Subarachnoid hemorrhage, other headaches attributed to cranial or cervical vascular disorders
Older age > 50 years	Giant cell arteritis and other headaches attributed to cranial or cervical vascular disorders, neoplasms, and other non-vascular intracranial disorders
Pattern change or recent onset of headache	Neoplasms, headaches attributed to vascular and non- vascular intracranial disorders
Positional headache	Intracranial hypertension or hypotension
Precipitated by sneezing, coughing, or exercise	Posterior fossa malformations, Chari malformation
Papilledema	Neoplasms and other non-vascular intracranial disorders, intracranial hypertension
Progressive headache and atypical presentations	Neoplasms and other non-vascular intracranial disorders
Pregnancy/puerperium	Headaches attributed to cranial or cervical vascular disorders, post-dural puncture headache, hypertension- related disorders (e.g. preeclampsia), cerebral sinus thrombosis, hypothyroidism, anemia, diabetes

Painful eye with autonomic features	Pathology in posterior fossa/pituitary region, or cavernous sinus, Tolosa-Hunt, ophthalmic causes
Post-traumatic onset of headache	Acute and chronic post-traumatic headache, subdural hematoma and other headache attributed to vascular disorders
Pathology of the immune system (e.g. HIV)	Opportunistic infections
Painkiller overuse or new drug at onset of headache	Medication overuse headache, drug incompatibility

Table 2: SNNOOP10 red flag features for secondary headache.

Professional Society Recommendations

Evidence-based guidelines from the American Academy of Neurology and American Headache Society recommend against routine neuroimaging in patients who meet diagnostic criteria for primary headache disorders, including normal neurologic examination and absence of red flag features [4, 5]. Guidelines of the American College of Radiology Appropriateness Criteria and the European Headache Federation similarly state that neuroimaging is usually not appropriate for such clinical presentations [7, 10]. These recommendations align with risk-stratified frameworks that prioritize clinical assessment and targeted imaging.

Conclusion

Primary headache disorders are highly prevalent, whereas secondary headache is less common in individuals with established headache phenotypes and normal neurologic examination. Diagnostic yield of routine neuroimaging is low in these populations. Current evidence and professional guidelines do not support routine neuroimaging in patients with uncomplicated primary headache disorders. Instead, imaging decisions should remain symptom-guided and individualized, incorporating structured clinical frameworks such as SNNOOP10 to identify patients at higher risk for secondary headache etiologies. This approach balances diagnostic benefit against the potential harms of over-imaging, including incidental findings, unnecessary testing, patient anxiety, and increased healthcare utilization.

Author Contributions

PB conceptualized the study. The original draft of this manuscript was written by MO, YTL, and PB. Review and additional editing of the manuscript was conducted by YM.

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