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Etiology, diagnosis, and therapeutic strategies in migraine management

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ABSTRACT

Migraine is a condition that affects many people and is more common in women. It can be categorized into migraines with or without aura. The course and occurrence of the disease are determined by various factors, such as environmental, genetic, and hormonal, which contribute to its complexity. CGRP (calcitonin gene-related peptide) also plays an essential role. This disease progresses in distinct phases, most often as follows: Prodromal phase, aura, headache phase itself, and postdromal phase, which occurs after the headache has ended. Migraine diagnosis is based on the International Classification of Headache Disorders criteria. There are pharmacological and non-pharmacological ways of dealing with this disease. Acute migraine is most commonly treated with NSAIDs and triptans, while preventive treatment is managed with beta-blockers, antiepileptic drugs, and CGRP inhibitors. Non-pharmacological methods, such as habit changes, stress management, acupuncture, and dietary changes, bring additional benefits. New therapies targeting neuroinflammation and hormonal regulation are showing promising results. This article presents the etiology, diagnosis, and therapeutic strategies associated with migraine treatment. The article also shows the importance of a multidisciplinary approach to migraine treatment. Therapy should include both pharmacological and non-pharmacological methods.

Keywords: Migraines, neuroinflammation, preventive treatments, CGRP antagonists

1. INTRODUCTION

Migraine can occur episodically or chronically. Headaches usually last 4 to 72 hours. They are divided into four phases: remonitory (non-painful symptoms like fatigue and neck stiffness), aura (transient neurological symptoms in one-third of patients, primarily visual), headache (throbbing pain) with nausea, photophobia, and phonophobia, and postdrome ("migraine hangover") with fatigue and

sensitivity. Migraine can be classified as either episodic or chronic. In episodic migraine, the number of days with migraine pain is 15 or fewer per month, while in chronic migraine, it is 15 or more days per month. A diagnosis of migraine requires the occurrence of five attacks.

During each, at least two of the four primary traits of the headache must be present, along with at least one associated symptom. Migraine is dynamic, meaning it depends on risk and protective factors. It can then transition from an episodic form to a chronic one. (Aguilar-Shea et al., 2022). In the pathophysiology of migraine, the trigeminovascular system plays a key role by connecting the trigeminal ganglions to the brainstem and thalamus. CGRP and PACAP are neuropeptides that mediate pain by sensitizing trigeminal and central neurons. Areas affected by migraine in the brainstem, such as the periaqueductal gray (PAG) and locus coeruleus, modulate trigeminovascular pain.

Treatments like triptans and CGRP antagonists target these areas. The hypothalamus regulates stress-induced trigeminal sensitization and premonitory symptoms. The thalamus contributes to central sensitization and photophobia by integrating nociceptive signals. The cortex, associated with aura and cortical spreading depression, shows structural and functional changes in migraine, influencing pain processing and sensory dysrhythmia (Puledda et al., 2023). In this article, we will present the causes of migraine by analyzing underlying neurobiological processes and risk factors that may lead to this condition.

We will also explore current treatment options, including pharmacological and non-pharmacological approaches, like lifestyle changes. We will discuss new methods to understand better how to manage and relieve migraine symptoms more efficiently. The main goal is to highlight the best strategies for treating migraines and to increase the quality of care for patients who struggle with them. We will present the best options for treating migraines, and ways to improve the quality of care for patients who struggle with migraines.

2. METHODOLOGY

Publicly available sources of medical knowledge, such as PubMed, were used to collect the data needed to prepare the article. We focused on studies published between January 2009 and August 2024. The phrases used to search for information were "migraine" or "CGRP inhibitors". Our goal was to collect the most important information on the etiology and treatment of migraine, including pharmacological and non-pharmacological methods. Special attention was given to the multifactorial nature of migraines and the use of CGRP inhibitors, which help prevent migraines. The interpretation of the information allows for a summary of the collected data. Discrepancies may occur due to possible inaccuracies in the source materials.

3. RESULTS AND DISCUSSION

This article has summarized the most important information about the etiology, symptoms, and treatment methods for migraine. There are many theories explaining the pathophysiology of migraine. These include vascular, hormonal, and genetic theories. An important aspect of migraine treatment is the pharmacological and non-pharmacological approach. In the pharmacological approach, NSAIDs, acetaminophen, and triptans. NSAIDs and acetaminophen are effective for managing mild to moderate migraine pain, while triptans, which act on serotonin receptors, work well for more severe attacks. The use of opioids is discouraged due to the risk of addiction. Migraine treatment also includes prophylactic pharmacotherapy, which aims to reduce the frequency and severity of attacks.

For this purpose, beta-blockers, antiepileptic drugs, and antidepressants are used. Erenumab and fremanezumab are calcitonin gene-related peptide (CGRP) inhibitors. This is a recently discovered group of drugs. They are an important factor in migraine treatment by specifically targeting CGRP, which plays a significant role in the pathophysiology of migraine. Magnesium and vitamin B2 supplementation supports migraine prevention. Non-pharmacological approaches to treating migraine include improving sleep hygiene, reducing stress, and avoiding migraine-triggering foods. Over the years, migraine treatment has made significant progress. However, migraine still poses a considerable challenge to doctors. This requires continued research to understand the causes of the disease better and develop more effective treatments. Key findings are presented in (Table 1).

Table 1 Key findings in migraine research

Aspect	Key findings
Etiology of Migraine	Vascular theory, neuronal theory, neuroinflammation, biochemical theory, genetic factors, hormonal factors, structural CNS abnormalities
CGRP inhibitors	Reduce the severity of attacks
Non-Pharmacological Treatments	Acupuncture, massage therapy, lifestyle changes
Pharmacological Treatments	Triptans, beta-blockers, antiepileptics, antidepressants, CGRP inhibitors
Impact on Quality of Life	Significantly lower quality of life

Epidemiology of migraine

Migraine is a common worldwide problem, affecting around 15% of people. It occurs more frequently in women than in men, almost three times as often. It typically begins before the age of 35, most often during adolescence, and rarely after 50. The prevalence peaks between ages 35–39 and decreases with age, dropping to 7.9% in individuals over 65 (Onan et al., 2023). In contrast, tension-type headache (TTH) has a higher prevalence of 26.8% with a more balanced gender distribution (female-to-male ratio of 1.2:1). TTH commonly starts before the age of 30, peaks at 35–39 years, and increases further in older adults, reaching 32.2% in those over 65 (Onan et al., 2023).

Patients suffering from chronic or episodic migraine have a significantly reduced quality of life. Severe pain and prolonged attacks can last even longer than 31 hours. Due to such episodes, patients often have reduced productivity at work or school and frequently have trouble developing their careers. The negative impact of migraine attacks is also evident in personal relationships. Furthermore, the stress associated with these challenges can further trigger migraines, as stress is a known trigger for the condition. Stigmatization is also a problem for people with migraines. As many as 54% of patients worry that they may be perceived as lazy, and 40% are told to simply "get over it". These struggles deepen the physical and emotional burden of the condition (Peters, 2019).

Etiology of migraine

Migraine is a neurological disorder with a complex and not fully understood pathomechanism. Over the years, many theories have been developed to explain its origin. We will present some of the most important below:

Vascular Theory

In this theory, the intracranial vessels play a key role. According to it, these vessels narrow, causing migraine symptoms, then dilate. During visual aura, vasoconstriction in the occipital region is particularly significant. This process leads to hyperperfusion and perivascular edema. Pain receptors can be activated by these changes, which causes severe headaches (Goadsby et al., 2017).

Neuronal Theory

According to this theory, bioelectric brain disorders, such as cortical spreading depression (CSD), can cause migraines. Such effects lead to brain enlargement, swelling, and excitability of nerve fibers, which is the cause of pain (He et al., 2021).

Neuroinflammation

Neuroinflammation is associated with migraines and related conditions. NLRP1, NLRP2, AIM2, and NLRP3 are inflammasome complexes that play a key role. These pathways could be the treatment targets and biomarkers, though more research is needed, especially on NLRP3-targeting therapies (Kursun et al., 2021).

Biochemical Theory

Disturbances in serotonergic transmission play a key role in the pathogenesis of migraine. Serotonin levels increase during attacks and decrease between attacks. Increased susceptibility to migraine may be associated with genetic polymorphism in the serotonin transporter gene (5-HTT) (Wachowska et al., 2023).

Genetic Factors

Migraine may have a genetic basis, including polygenic hereditary susceptibility. To the development of migraine may also contribute polymorphism in genes related to neurotransmission (e.g., serotonin transporter or dopamine receptor) and homocysteine metabolism (Wachowska et al., 2023).

Hormonal Factors

Fluctuations significantly influence migraines in progesterone and estrogen. Progesterone deficiency and its withdrawal during the luteal phase can trigger migraines, but evidence for this is limited. Estrogen levels that vary throughout the menstrual cycle, especially elevated estrogen levels, have been associated with the onset of migraine with aura. However, estrogen therapy after menopause may even worsen symptoms in some individuals (Kalarani et al., 2022). Estrogen in oral contraceptives can often worsen migraines, especially during the placebo week. The precipitous declines in plasma estrogen cause this. Progesterone-only contraception is much less likely to worsen symptoms. The effects and actions of ovarian hormones on neurochemical pathways in the brain vary depending on location and interactions, which may contribute to migraine patterns (Kalarani et al., 2022).

Structural CNS Abnormalities

Recent studies (especially with an emphasis on neuroimaging studies) have shown that significant structural abnormalities are present in those who suffer from migraines. The key changes detected are as follows:

White Matter Abnormalities (WMAs): These common, minor changes may result from microvascular damage. They are more common in migraine sufferers, especially those with aura.

Silent Infarct-Like Lesions (ILLs): These non-mass defects in brain parenchyma occur more often in posterior circulation areas.

Volumetric Changes: Decreased gray matter in the insula, anterior cingulate cortex, and cerebellum is linked to migraines, while the periaqueductal gray shows increased density in migraines with aura.

These structural changes reflect basic pathophysiological mechanisms, which may help us better understand the impact of migraine on the brain. Then, targeted therapies could be used more effectively and efficiently (Ashina et al., 2021). The complexity of migraines is due to complicated interactions between vascular, neuronal, inflammatory, biochemical, hormonal, and genetic factors. Further research into its treatment and mechanisms is required to control its symptoms effectively (Wachowska et al., 2023).

Migraine symptoms

Migraine is a chronic neurological disorder characterized by recurring headaches. It often occurs in distinct phases. The premonitory phase usually appears first and includes symptoms such as yawning, fatigue, mood changes, and neck stiffness. These symptoms occur several hours or days before the headache begins. Some people experience an aura with transient neurological symptoms such as visual disturbances (e.g., flashing objects or blinding spots), sensory tingling, or difficulty speaking (Aguilar-Shea et al., 2022). The headache phase consists of a throbbing pain, often unilateral (which worsens with movement), accompanied by nausea, vomiting, and sensitivity to light, sound, touch, or smell.

The postdrome phase comes last. It is also called a "migraine hangover". It manifests with fatigue, sleepiness, and difficulty concentrating (Aguilar-Shea et al., 2022). Migraines are classified by frequency and the presence of aura. Chronic migraines are experienced more than 15 days a month, while episodic migraines happen less frequently. To be diagnosed as migraines, a diagnosis

must include at least five attacks with throbbing pain, moderate/severe intensity, and nausea or hypersensitivity. These symptoms should last between 4 and 72 hours without treatment. Genetics and lifestyle influence the progression of chronic migraines (Aguilar-Shea et al., 2022).

Studies have shown that anxiety has a stronger association with migraine than depression. Key symptoms of anxiety associated with migraine include difficulty coping with anxiety and difficulty relaxing. Symptoms of depression associated with migraine were mainly physical, such as fatigue, appetite disturbances, and sleep disturbances. Emotional symptoms played a smaller role. Focusing on specific migraine symptoms can lead to better treatment outcomes. This way, therapies target specific symptoms, allowing for better disease control (Peres et al., 2017).

Diagnostics

Diagnosis of Migraine and its Types

Migraine diagnosis is based on the criteria set by the International Classification of Headache Disorders (ICHD-3) (Headache Classification Committee of the International Headache Society, 2018). The types of migraine are classified as follows:

Migraine Without Aura

Description: Headache lasting from 4 to 72 h, with characteristics as such:
Recurring,
One-sided location (initially),
Pulsating pain,
Pain varies from mild to intense
Pain intensifies during physical activity.
Sensitivity to sound and light, nausea/vomiting (associated symptoms)
Diagnostic Criteria:
At least five migraine-like headache attacks with the characteristics mentioned above.
Exclusion of other diagnoses described in ICHD-3.

Migraine With Aura

Description: Neurological symptoms preceding the headache, including:
Visual disturbances (most common),
Unilateral sensory disturbances,
Speech disturbances and other neurological symptoms.
Diagnostic Criteria:
At least two attacks with aura.
One or more aura symptoms developing over 5 minutes and lasting between 5 and 60 minutes.
Headache occurs within 60 minutes after the aura ends.

Chronic Migraine

Description: Headaches appearing at least 15 days per month for longer than 3 months, with migraine-like symptoms at least 8 days per month.
Diagnostic Criteria:
A history of no fewer than five migraine episodes that meet the criteria for migraine with or without aura.

Migraine Treatment Approaches

Pharmacological Treatment of Migraine

Analgesics and Non-Steroidal Anti-Inflammatory Drugs (NSAIDs)

NSAIDs

Non-steroidal anti-inflammatory drugs (NSAIDs), such as ibuprofen, are the first line of treatment for mild to moderate migraines. They cause reduced production of prostaglandins by blocking the cyclooxygenase enzyme (COX). Prostaglandins are involved in inflammation and pain. Because ibuprofen is an over-the-counter (OTC) medication, it is commonly used to relieve headaches. However, it may be less effective in more severe migraine attacks or when the patient experiences nausea and vomiting (Rabbie et al., 2013).

Paracetamol (Acetaminophen)

Paracetamol can be used for mild migraines. It is considered a safer choice than NSAIDs, especially in patients with gastrointestinal problems, such as stomach ulcers. However, it is less effective than NSAIDs in more severe migraine cases (Derry and Moore, 2013).

Opioids

Opioids such as codeine and tramadol are sometimes prescribed for severe migraine pain. However, their use is not recommended due to the risk of addiction and medication overuse headaches (Levin, 2014).

Triptans: Mechanism of Action and Efficacy

Triptans are a class of drugs that target serotonin receptors, particularly 5-HT1B and 5-HT1D. They can be used to alleviate migraine symptoms. Their mechanism of action is to constrict dilated cranial blood vessels. They also work by reducing neurogenic inflammation. As serotonin receptor agonists, triptans also inhibit the secretion of CGRP, a neuropeptide involved in the pathogenesis of migraine. In addition, triptans prevent the transmission of pain signals within the trigeminovascular system (Edvinsson et al., 2012).

Efficacy

Studies have shown that triptans, including sumatriptan, rizatriptan, and zolmitriptan, effectively reduce the severity and duration of acute migraine attacks. Many patients who suffered from those attacks experienced significant relief within 2 hours of taking the drug. Studies also indicate that triptans combined with aspirin or acetaminophen provide slightly more effective pain relief than standard oral triptans (Cameron et al., 2015).

Preventive Medications

Preventive treatment is used to reduce the frequency and intensity of migraine attacks, especially in patients who experience frequent attacks or suffer from chronic migraines. Patients may use pain relievers and other medications used to treat migraines less often. The quality of life of patients improves. Several classes of medications are used for preventive purposes. These include beta-blockers, antiepileptic drugs, and antidepressants.

Beta-blockers

Propranolol and metoprolol are frequently chosen options for migraine prevention. These medications block beta-adrenergic receptors and reduce the frequency of migraines by adjusting neuronal excitability (Danesh and Gottschalk, 2019). Propranolol and metoprolol are common choices for migraine prevention. These drugs are effective in reducing both the frequency and severity of migraines in many patients (Jackson et al., 2019).

Antiepileptic Drugs

Topiramate and valproate are antiepileptic drugs frequently used to prevent migraines. These medications work by stabilizing neuronal activity. They can also prevent the occurrence of cortical spreading depression (CSD) which is believed to trigger migraines. However, these drugs may have side effects like cognitive disturbances and weight gain (Rollo et al., 2023).

Antidepressants

Tricyclic antidepressants (TCAs) like amitriptyline help prevent migraines, specifically in patients with comorbid mood disorders or tension-type headaches (Smitherman et al., 2011).

New therapeutic approaches: CGRP Inhibitors

CGRP (calcitonin gene-related peptide) plays a key role in the onset and progression of migraines, making it an essential target for treatment. CGRP inhibitors are a new class of drugs that block its activity.

Mechanism of Action

During a migraine, CGRP is released, leading to blood vessel expansion and pain. CGRP inhibitors work by blocking either the CGRP peptide or its receptors (Wrobel and Silberstein, 2015).

Efficacy

CGRP inhibitors, for example, fremanezumab, erenumab, and galcanezumab reduce the number of migraine episodes in individuals with episodic and chronic migraines. These inhibitors are an important option for those who do not react to traditional preventive therapies (Muddam et al., 2023).

Non-Pharmacological Treatments for Migraine

Physical Therapies: Acupuncture, Massage

Acupuncture

Acupuncture works by inserting a thin needle into specific body points, which helps in reducing muscle tension. Combining acupuncture with medication enhances the effectiveness of migraine treatment, offering better results than using drugs alone (Liu et al. 2024).

Massage

Proper massage of the neck and shoulder area has a relaxing effect by reducing muscle tension which can reduce the number of migraine attacks (Chaibi et al., 2011).

Lifestyle Changes: Sleep Hygiene, Stress Reduction, and Trigger Avoidance

Sleep Hygiene

Lack of sleep and interrupted sleep can trigger migraine attacks. Improving these factors will reduce their frequency (Vgontzas and Pavlović, 2018).

Stress Reduction

Stress is the most important and well-known trigger for migraine attacks. Methods such as relaxation training and cognitive behavioral therapy (CBT) help to cope with stress, which reduces the number of migraine attacks (Sauro and Becker, 2009).

Trigger Avoidance

Recognizing and avoiding known triggers for migraines—such as certain foods and stress—can help reduce both the frequency and intensity of migraine attacks (Hindiyeh et al., 2020). Keeping a migraine diary seems to be an effective way to monitor and eliminate these triggers (Lipton et al., 2022).

Diet and Supplements: Magnesium, Vitamins, and Food Elimination

Magnesium

People with low magnesium levels are more likely to experience migraine attacks. Additional supplementation is recommended (Von-Luckner and Riederer, 2018).

Vitamins

Vitamin B2 (riboflavin) and coenzyme Q10 effectively prevent migraines. They can improve mitochondrial function and reduce the frequency of attacks (Markley, 2012).

Food Elimination

A proper diet helps in dealing with migraines. Giving up coffee, chocolate, alcohol, cheese, and processed meat will reduce the frequency of attacks (Hindiyeh et al., 2020).

4. CONCLUSIONS

This research shows that migraine is a condition with a complex etiology that requires appropriate treatment. Over many years, treatments have changed significantly. Today, they include pharmacological actions using new drugs and non-pharmacological methods. Particularly important drugs are CGRP inhibitors. The combination of pharmacological and non-pharmacological strategies can be beneficial. The primary goals of treatment should be pain control, relief of associated symptoms, and prevention of relapse. Migraine care should include both appropriate therapy and lifestyle changes, which will significantly improve the patient's quality of life. Every person's body is different, so therapy must be modified to meet their special needs. The future of migraine treatment lies in personalizing care.

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Conflict of interest

The authors declare that there is no conflict of interests.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

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