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Dr. Antony Stephen Raj
Associate Professor, Department of Kriya Sharira, Sri Sairam Ayurveda Medical College and Research Centre, Chennai, Tamil Nadu, India

Dr. Faiz Mohammed
Associate Professor, Department of Rachana Sharira, Sri Sairam Ayurveda Medical College and Research Centre, Chennai, Tamil Nadu, India

Dr. Govardhan Sahani
Associate Professor, Department of Shalya Tantra, Sri Sairam Ayurveda Medical College and Research Centre, Chennai, Tamil Nadu, India

Dr. Arun Prakash
Associate Professor, Department of Roga Nidana, Sri Sairam Ayurveda Medical College and Research Centre, Chennai, Tamil Nadu, India

Dr. Mydeen Sadik
Associate Professor, Department of Samhita Siddhanta, Sri Sairam Ayurveda Medical College and Research Centre, Chennai, Tamil Nadu, India

Corresponding Author:
Dr. Antony Stephen Raj
Associate Professor, Department of Kriya Sharira, Sri Sairam Ayurveda Medical College and Research Centre, Chennai, Tamil Nadu, India

Ayurvedic approach towards the management of malaria

Dr. Antony Stephen Raj, Dr. Faiz Mohammed, Dr. Govardhan Sahani, Dr. Arun Prakash and Dr. Mydeen Sadik

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Abstract
Malaria stands as a highly transmissible and potentially life-threatening illness caused by the *Plasmodium* parasite group. These parasites infiltrate red blood cells, instigating symptoms like fever, chills, sweating and severe discomfort. Transmission occurs through the bites of female Anopheles mosquitoes carrying the *Plasmodium* parasite. Despite notable medical advancements, malaria persists as a leading global cause of mortality, particularly in Asia. Timely diagnosis and immediate treatment are pivotal in averting severe complications and preserving lives. Within the realm of Ayurveda, an ancient medicinal system, numerous medications, hold efficacy in treating malaria fever. These medications assist in mitigating malarial symptoms and halting the progression of the disease to critical stages. The World Health Organization (WHO) has initiated various malaria control initiatives centered on reinforcing primary healthcare facilities, ensuring timely diagnosis and treatment and local disease prevention. These initiatives have significantly decreased malaria prevalence in numerous regions globally. This research aims to furnish an extensive overview of Ayurvedic drugs employed in managing malaria and its associated complexities. Through an assessment of these drugs effectiveness, the study endeavours to contribute to the advancement of novel and enhanced malaria treatments.

Keywords: Malaria, *Plasmodium* parasite, Ayurveda

Introduction
Malaria manifests symptoms akin to various febrile illnesses like typhoid fever, dengue fever, common flu, respiratory infections, and pneumonia. Accurate diagnosis is achieved through parasitological tests, such as microscopic and rapid diagnostic test yet in areas lacking these tests, diagnosing malaria can be intricate, leading to misidentification and inappropriate treatment. This life-threatening disease, caused by the *Plasmodium* species parasite, spreads to humans via bites from infected female Anopheles mosquitoes. The mosquito, carrying the parasite in its sporozoite phase, transmits it during the bite. Upon entering the human body, the sporozoites travel to the liver, invading cells and multiplying into merozoites. After a few days, infected liver cells burst, releasing merozoites into the bloodstream. These invade red blood cells, initiating the symptomatic, asexual reproductive stage marked by fever, chills, headaches and muscle pains. Symptoms typically arise 4-8 days post-initial invasion. Merozoites replicate within red blood cells for 36-72 hours (from invasion to haemolysis). In synchronous infections, fever recurs every 36-72 hours as infected cells rupture, releasing endotoxins. Importantly, not all *Plasmodium* species induce the same symptoms, with some being more severe. Timely diagnosis and treatment are pivotal in averting severe illness and fatalities [1, 2].

Different Species of Malaria
The *Plasmodium* genus, a blood parasite, infects various vertebrate species. About 156 identified *Plasmodium* species infect different animals, but only four primarily parasitize humans: *P. falciparum*, *P. vivax*, *P. ovale*, and *P. malariae*. These species almost exclusively rely on humans as their natural intermediate hosts. *P. falciparum*, the deadliest of the four, leads to the majority of global malaria-related deaths.

P. vivax, the most widespread, causes recurring infections by remaining dormant in the liver. *P. ovale*, akin to *P. vivax*, has a more limited geographical presence. *P. malariae* is less prevalent and typically induces a milder form of malaria. Additionally, *Plasmodium* knowlesi, a malaria strain found in parts of Southeast Asia, affects both monkeys and humans [3].

Signs and Symptoms of Malaria

1. **Fever:** Often cyclical, with spikes and remissions occurring every few days. It might start as mild and then become more pronounced.
2. **Chills:** Accompanying the fever, intense cold sensations and shivering can be experienced.
3. **Headaches:** Persistent and often severe, sometimes accompanied by nausea or vomiting.
4. **Muscle and Joint Pain:** Aches and discomfort in muscles and joints, which can be generalized or localized.
5. **Fatigue:** A feeling of extreme tiredness or weakness that may persist even after rest.
6. **Sweating:** Profuse sweating, especially during fever episodes.
7. **Anaemia:** In some cases, malaria can lead to a decrease in red blood cells, resulting in anaemia.
8. **Nausea and Vomiting:** Gastrointestinal symptoms like nausea and vomiting can occur, especially during fever episodes.
9. **Jaundice:** Yellowing of the skin and eyes might occur in severe cases due to the destruction of red blood cells.
10. Seizures and Neurological Symptoms: In severe cases, particularly in cerebral malaria, seizures, confusion, and neurological symptoms might manifest.
11. **Respiratory Distress:** Breathing difficulties can occur in severe cases.

The severity and combination of symptoms can vary depending on the type of the malarial parasite, patient's immunity and whether it's a first infection or a recurring case. Some patients exhibit other symptoms such as cough, tachycardia and diarrhoea. Early diagnosis and prompt treatment are crucial in managing malaria effectively. Typically, these symptoms emerge a few weeks following a mosquito bite carrying the infection, yet specific strains of malaria parasites can lie dormant in the body for as long as a year [4].

Pathogenesis of Malaria

Malarial infection begins with the bite of an infected female Anopheles mosquito, introducing sporozoites into the bloodstream. These sporozoites journey to the liver, where they multiply without causing symptoms for about 7-10 days. Upon multiplying, they transition into merozoites and traverse to the lungs via the heart. After the vesicles burst, merozoites enter the bloodstream, invade erythrocytes, and replicate within them. The subsequent rupture of these cells leads to the clinical symptoms. Some infected blood cells transform into sexual forms known as gametocytes instead of replicating further, continuing the cycle when ingested by mosquitoes during bites.

The onset of pathological symptoms begin from the rupture of infected erythrocytes, releasing potential malaria toxins that activate peripheral blood mononuclear cells and trigger cytokine release. Disease severity is believed to hinge on the balance between pro-inflammatory and anti-inflammatory cytokines, chemokine and growth factors. Studies have indicated elevated levels of IL-1B, IL-6, IL-8 and TNF-alpha in late-onset severe disease, along with a low IL-10: TNF-alpha ratio (5).

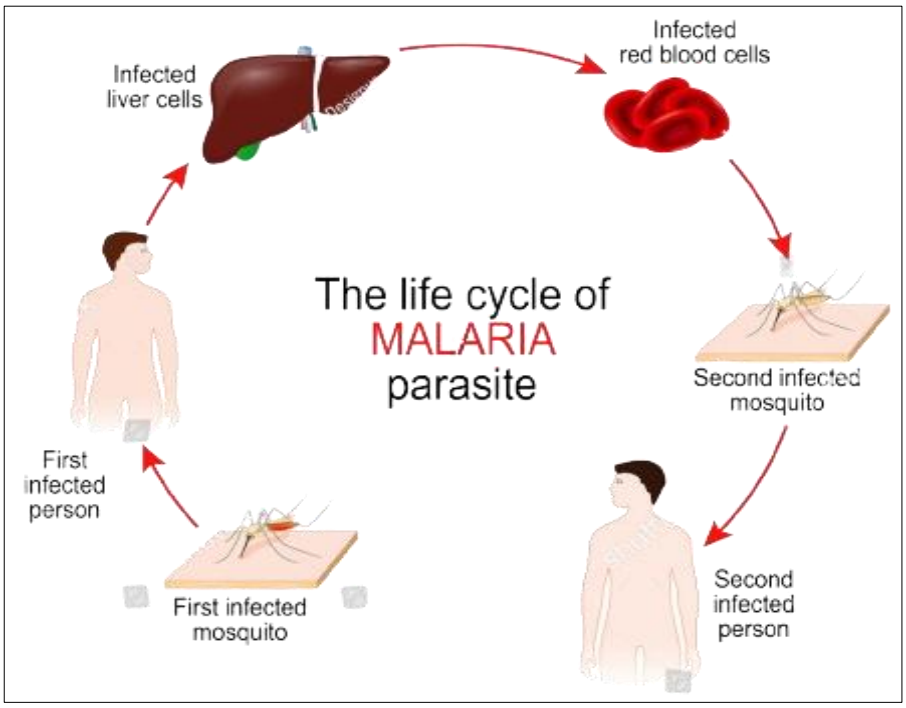

Fig 1: Malaria transmission cycle

Other methods of transmission of malaria

- Mother to unborn child.
- Blood transfusions.
- By sharing a needle.

Investigations for Malaria

1. Peripheral Blood Smears (PBS). Microscopic examination of stained blood films using Giemsa or Wright's, or Field's stains.

2. The Quantitative Buffy Coat (QBC) technique identifies malaria parasites in peripheral blood by staining their DNA with acridine orange. This method has demonstrated the capability to detect malaria even in samples with a low number of parasites, as few as 5 parasites per microliter of blood [6, 7].

Herbal Remedies for Malaria and its complications

Physalis angulate

Physalis angulata, a member of the SOLANACEAE family, has historical uses in treating conditions like malaria fever accompanied by fever and chills. Research indicates that the leaf extract of this plant possesses anti-malarial properties along with immunomodulatory, anti-inflammatory and antioxidant characteristics. Through phytochemical screening, substantial amounts of phenolic compounds, including alkaloids, terpenoids, tannins, flavonoids and glycosides, have been identified in the ethanolic extracts of *P. angulata*. These phytochemicals derived from *P. angulata* play a role in hindering merozoite transmission into the bloodstream and preventing erythrocyte invasion, aiding in the management of malaria symptoms [8].

Acanthospermum hispidum

Acanthospermum hispidum, found in tropical and subtropical regions like India, is renowned for its therapeutic properties in addressing various ailments such as fever, respiratory issues, and gastrointestinal disorders. Rich in active phytochemicals like alkaloids, flavonoids, hydrolyzable tannins, terpenes and steroids, this plant's extracts and isolated compounds have displayed diverse biological activities, including hepato-protective, antioxidant, antimicrobial and antiparasitic effects. Studies have highlighted the notable anti-malarial attributes of phytochemicals derived from *A. hispidum*. These compounds function by impeding the transmission of merozoites, the disease-causing infectious agents, into the host's bloodstream, thereby preventing their invasion of erythrocytes (red blood cells). This mechanism aids in controlling malaria symptoms. Consequently, harnessing phytochemicals from *A. hispidum* holds significant promise for developing effective anti-malarial medications and other therapeutic strategies [9].

Azadirachta indica

Azadirachta indica, commonly known as Neem, holds a prominent place in traditional Indian medicine owing to its diverse medicinal properties. Abundant in chemical compounds and phytochemicals like limonoids, flavonoids, phenols, catechins, gallic acid, polyphenols and nimbins, Neem exhibits a range of therapeutic actions, including antiviral, antifeedant, antibacterial and antimalarial effects. Utilizing extracts from *A. indica* can impede the transmission of *Plasmodium* within the host, preventing its infiltration into the lungs and erythrocytes, where it propagates and exacerbates the disease [10].

Acorus calamus

Acorus calamus, commonly referred to as sweet flag, contains various phytochemical groups like glycosides, phenolic compounds, alkaloids, flavonoids, saponins and triterpenoids. Within the ethanolic extract of its robust rhizome, an active compound called Tatanan A exhibits promising antimalarial and antiparasitic effects. Research indicates that Tatanan A effectively inhibits the initial phase of parasitic replication, thereby curtailing its dissemination within the host's body. *A. calamus* boasts multiple medicinal properties, encompassing activities against parasites, bacteria, viruses and specifically, antiplasmodic properties [11].

Uraria lagopodioides

Uraria lagopodioides, a perennial herb growing close to the ground, is a member of the Papilionaceae family and thrives in various regions across India-such as Bihar, Orissa and West Bengal-as well as in Nepal, China and Northern Australia. Also known as Prisniparni, this plant boasts numerous medicinal properties encompassing antiparasitic, antibacterial and anti-inflammatory effects. Phytochemical studies conducted on the ethanolic extract of *U. lagopoides* have unveiled the presence of flavonoids, glycosides, proteins and phytosterols. These compounds offer diverse health benefits, aiding in the management of various health conditions like fever, cough and inflammation [12, 13].

Vitex negundo

Vitex negundo, known as *Nirgundi*, holds significance in traditional medicine for its medicinal attributes. Various Vitex species contain distinct chemical compositions, yielding a diverse array of phytochemicals. Within this plant's leaves, seeds and roots, multiple bioactive compounds are found, including volatile oils, flavonoids, lignans, iridoids, terpenes and steroids. These compounds demonstrate antiparasitic, anti-inflammatory, antioxidant and antimicrobial properties. The plant comprises alkaloids, flavonoids, tannins, terpenoids, glycosides, phenolic compounds and steroids. Notably, the chloroform extract of *V. negundo* contains carbohydrates, alkaloids, flavonoids, terpenoids, glycosides and steroids, lacking tannins and phenolic compounds. The diverse phytochemical composition of this plant aids in averting the entry and reproduction of parasites in the lungs and erythrocytes, thereby thwarting the onset of malaria and its associated symptoms [14].

Fig 2: *Physalis angulata*

Fig 3: *Acanthospermum hispidum*

Fig 4: *Azadirachta indica*

Fig 5: *Acorus calamus*

Fig 6: *Uraria lagopodioides*

Fig 7: *Vitex negundo*

Conclusion

Malaria is a highly transmissible parasitic infection transmitted by Anopheles mosquitoes. It manifests symptoms that can vary in severity, potentially leading to life-threatening complications like shock. Swift diagnosis is imperative to avert further health issues. While malaria fever is usually self-limiting, it has emerged as a significant public health concern in tropical and subtropical regions. In Ayurveda, diverse single drugs and formulations are detailed for managing various types of fever comprehensively. For instance, *Azadirachta indica* demonstrates antimalarial, anti-inflammatory and immunomodulatory effects. Similarly, *Acorus calamus* showcases antiparasitic and antimalarial properties, while *Acanthospermum hispidum* presents antimicrobial, antioxidant and anti-inflammatory attributes. *Uraria lagopodioides* exhibits both antimalarial and antibacterial effects. These traditional remedies are employed to address malaria fever and its potential complications, aiming to sustain positive health outcomes. Their multifaceted properties contribute to controlling the symptoms and preventing the progression of malaria, emphasizing the

significance of incorporating these natural remedies into holistic health management.

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