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A Review On Fungal infection

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Abstract: *Fungal infections remain a major concern for global health, especially in areas with warm and humid environments. The growing resistance to conventional antifungal drugs, along with their adverse effects, has directed attention toward natural alternatives. Plant-derived compounds such as essential oils and bioactive phytochemicals—including alkaloids, terpenoids, flavonoids, tannins, and saponins—have shown strong antifungal properties. These act through multiple mechanisms, such as disrupting the fungal cell wall, altering membrane permeability, and preventing spore germination. Moreover, combining different plant extracts in polyherbal formulations can improve therapeutic outcomes by enhancing synergistic activity while lowering toxicity. This review highlights the promise of medicinal plants as safe, effective, and environmentally friendly antifungal options in comparison to synthetic agents.*

Keywords: Fungal infections, fungal organisms, Aspergillosis, Zygomycotic, Mucormycosis , Cryptococcosis ,Hyalohyphomycotic

I. INTRODUCTION

The recent COVID-19 pandemic has highlighted that even in advanced societies, humanity remains highly vulnerable to infectious diseases. Globally, such diseases continue to rank among the leading causes of mortality. Despite the significant risks posed by microbial threats, their true impact has often been underestimated or overlooked by healthcare systems. Among these, fungal infections (FIs) represent one of the most neglected yet rapidly emerging health concerns, responsible for nearly 1.7 million deaths annually and up to 150 million cases of severe, sometimes fatal, infections each year. In recent years, their incidence has shown a steady rise, with invasive fungal infections being particularly worrisome as they often require specialized care and hospitalization. Fungal infections can manifest in varying degrees of severity, ranging from superficial skin conditions to life-threatening systemic involvement affecting multiple organs. Invasive fungal diseases, in particular, are associated with high morbidity and mortality, thereby placing immense pressure on healthcare infrastructures. The risk is especially heightened in immunocompromised individuals—patients with HIV/AIDS, organ transplant recipients on immunosuppressive drugs, and those undergoing chemotherapy or long-term immunosuppressive therapy for autoimmune disorders.

Currently, four major classes of antifungal drugs are used to manage invasive fungal infections: azoles, echinocandins, polyenes, and allylamines. Azoles function by inhibiting oxidative enzymes responsible for ergosterol synthesis in the fungal cell membrane, leading to defective cell walls and increased permeability. Echinocandins, on the other hand, block the production of β-(1,3)-glucan, a critical polysaccharide in fungal

cell walls. Polyenes act by binding to ergosterol and creating pores in the cell membrane, resulting in leakage of cellular contents and eventual cell death. Allylamines also target ergosterol biosynthesis, but through a different enzymatic pathway. Despite their effectiveness, conventional antifungal drugs are associated with notable drawbacks. Topical formulations may cause irritation, redness, or burning at the site of application, while rapid drug release and limited penetration often reduce therapeutic efficacy. Moreover, antifungal resistance has emerged as a major global challenge, compromising the success of all currently available treatments. Given these limitations, natural alternatives have gained attention as potential therapeutic strategies. Bioactive compounds derived from medicinal plants and essential oils exhibit promising antifungal activity and may serve as effective, safer options to combat resistant fungal pathogens. Several plants such as Vangueria infausta, Bucida buceras, Olinia ventosa, Breonadia salicina, Harpephyllum caffrum, and

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Xylotheca kraussiana have been reported for their antifungal activity. Likewise, essential oils from cinnamon, peppermint, anise, citronella, pepper, clove, and camphor have been widely incorporated in antifungal formulations due to their strong antimycotic potential. However, their clinical application is often restricted because of factors like low solubility, instability, poor bioavailability, and susceptibility to gastric degradation in the gastrointestinal tract. To overcome these drawbacks of herbal extracts, advanced drug delivery strategies have been explored. Encapsulation of bioactive compounds within nanocarriers not only enhances stability and solubility but also helps in bypassing resistance mechanisms. Novel delivery platforms such as nano emulsions, ethosomes, metallic nanoparticles, liposomes, lipid-based nanoparticles, and transferosomes have shown promise in improving the therapeutic efficacy of herbal oils and plant-derived antifungal agents. This review highlights currently available antifungal agents and their properties, mechanisms of fungal resistance, the role of herbal oils and extracts as antifungal candidates, challenges associated with their delivery, and the potential of nanotechnology-based drug delivery systems for effective therapeutic application.

Fungal infection

Fungal infection, also known as mycosis, occurs when fungi grow and reproduce uncontrollably on or within the body. Fungi are tiny organisms naturally found in soil, plants, water, and even inside humans. While most species are harmless, certain types can lead to infections, particularly when they overgrow or when the body's immune defenses are weakened.

Fig no.1

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Fig no.2

Types of Fungal Organisms

Fungi can be divided into four classes

1. Yeasts: Cryptococcus neoformans

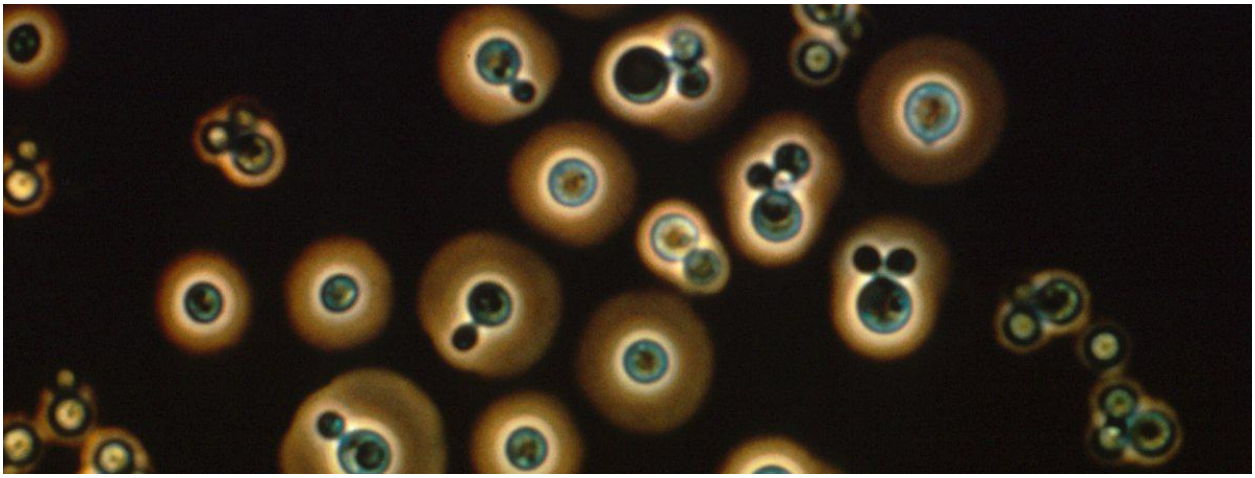

Fig no.3

2. Yeast-like Fungi

These fungi show both yeast-like growth and filamentous (hyphal) forms. They are responsible for infections such as oral thrush, vaginal thrush, and systemic candidiasis.

A common representative of this group is Candida albicans.

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Fig no.4.

3. Dimorphic fungi: These fungi cause histoplasmosis and can grow as filaments or yeast. Coccidiomycosis Blastomycoses sporotrichosis.

Species of fungi included in this category are The capsulatum of Histoplasma Coccidiosis immitis Deramtides of Blastomyces

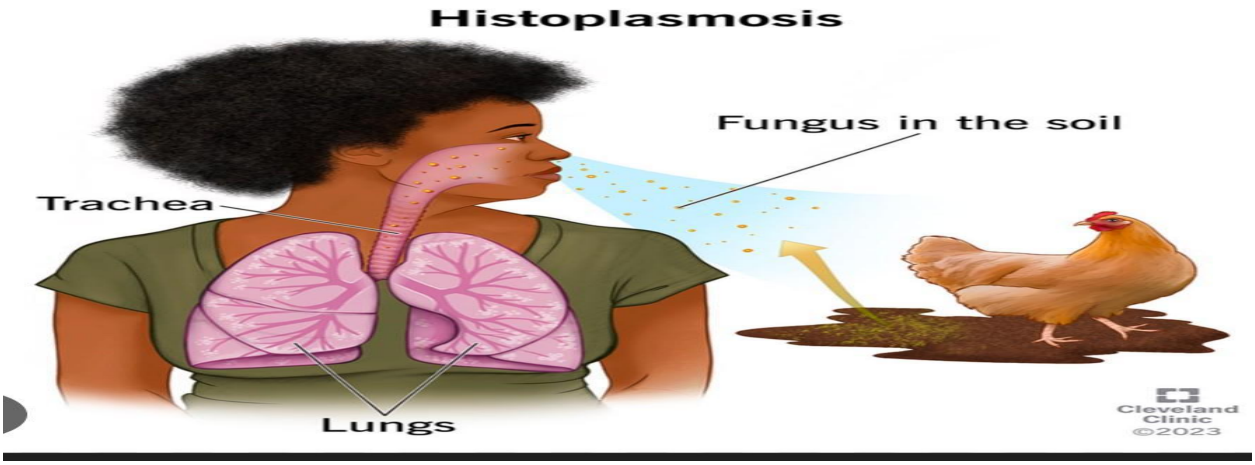

Fig no.5

4. Moulds:

Filamentous fungi reproduce by forming spores. These type of fungal organism caused Skin/ nail infections. Example Trichophyton sp,microsporum sp,epidermophyton sp

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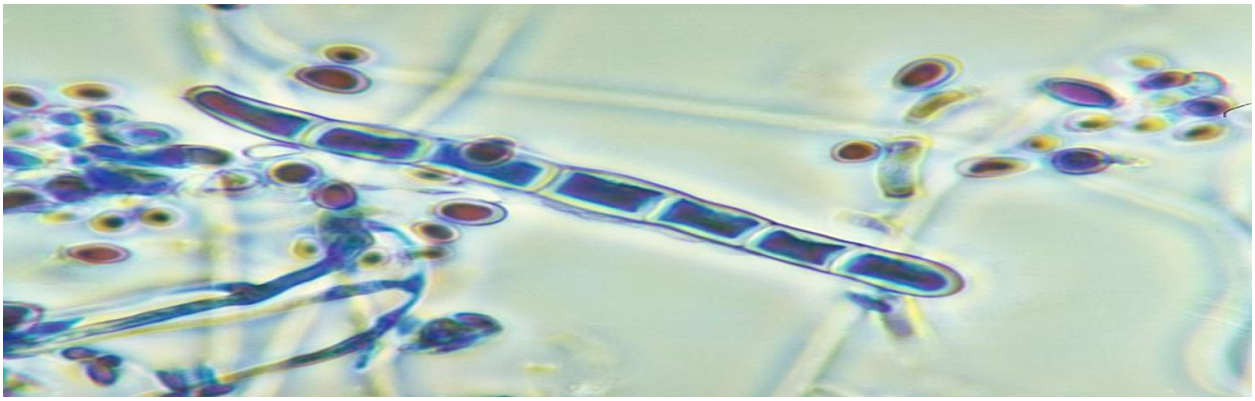

Fig no.6

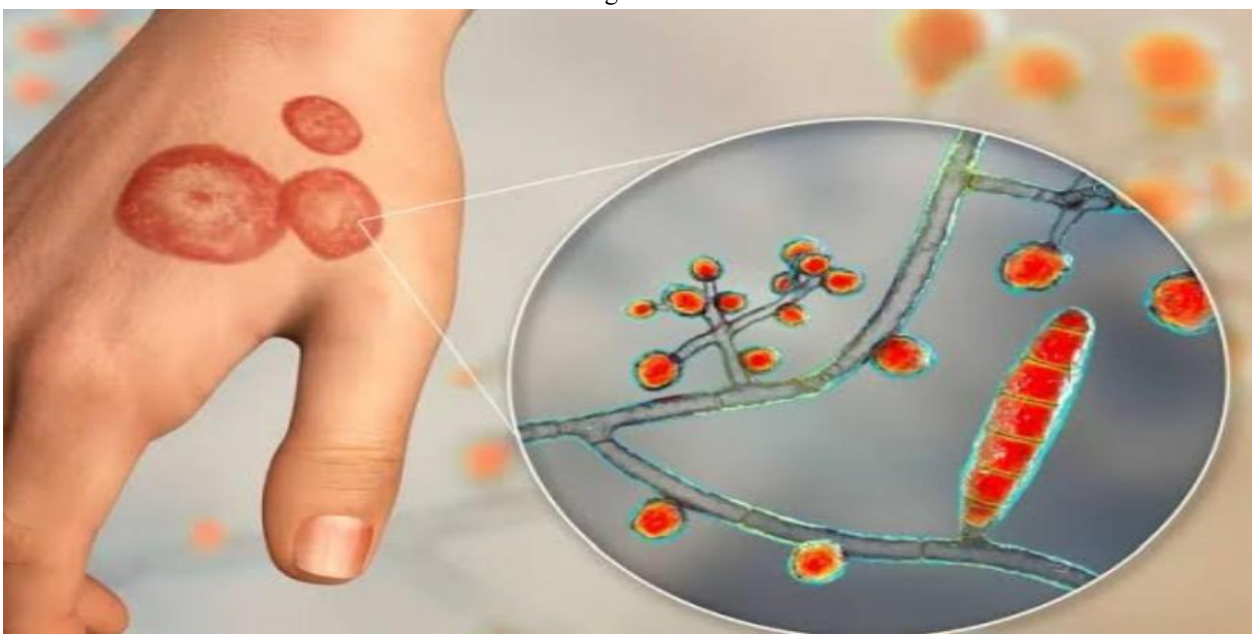

Fig no.7

Classification of Fungal Infections

Mycoses is a fungal infection of animals, including human. Mycoses are classified according to the tissue levels initially colonized. The clinical nomenclatures used for the mycoses are based on the—

1. Classification Based on Site
2. Classification Based on Route of Acquisition
3. Classification based on virulence

1. Classification Based on Site

Mycoses are classified as superficial, cutaneous, subcutaneous, or systemic (deep) infections depending on the type and degree of tissue involvement and the host response to the pathogen.

Superficial mycoses

Superficial mycoses are fungal infections affecting the skin, hair, and nails, caused by fungi like dermatophytes, Candida yeasts, and non dermatophyte molds, often leading to cosmetic changes or minor inflammation, and treated with topical antifungals or, for severe cases, oral medications. Common examples include ringworm (dermatophytosis), pityriasis versicolor, and candidiasis, which may manifest as skin discoloration, itching, or thickened nails.

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Cutaneous mycoses

Cutaneous mycoses extend deeper into the epidermis, and also include invasive hair and nail diseases. These diseases are restricted to the keratinized layers of the skin, hair, and nails. The organisms that cause these diseases are called dermatophytes, the resulting diseases
are often called ringworm, dermatophytosis or tinea.

Fig no.8

Subcutaneous mycoses

Muscle, fascia, subcutaneous tissues, and the dermis are all affected by subcutaneous mycoses. These infections are long-lasting and can be caused by skin piercings that let the fungi in. These infections are challenging to treatment and might necessitate surgical interventions like debridement.

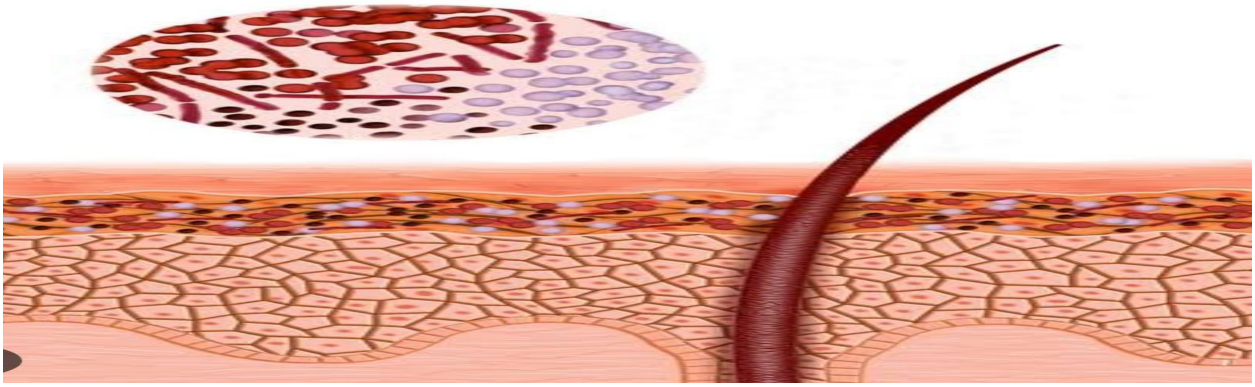

Fig no.9

2. Categorization by Acquisition Route Fungi that cause infection can be exogenous or internal.

Exogenous fungi can enter the body through the air, the skin, or the skin. internal infection. entails reactivation of an earlier infection or colonization by a member of the normal flora.

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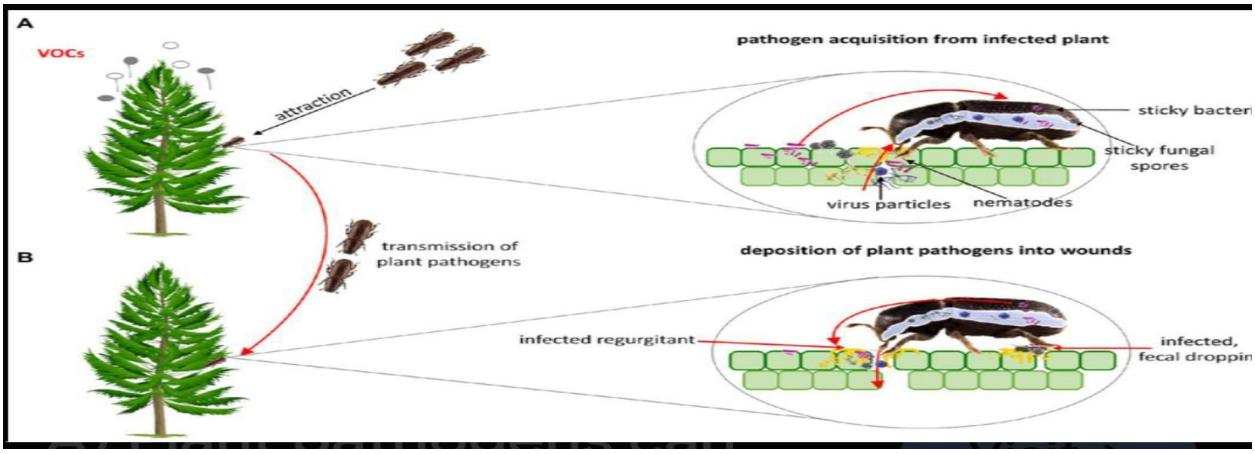

Fig no.10

3. Classification Based on Virulence primary pathogens can establish infections in normal hosts.

Grouping Primary pathogens can infect healthy hosts based on their virulence. In people with weakened host defenses, opportunistic pathogens cause illness.

I. Primary pathogen-induced systemic mycoses start mostly in the lungs and can spread to various organ systems. Systemic mycoses are caused by virulent organisms. Systemic mycoses are typically caused by dimorphic primary pathogens.

Fig no.11

II. Systemic mycoses brought on by opportunistic infections Patients with immune deficiencies who would not otherwise get infected can develop systemic mycoses as a result of opportunistic pathogen infections. AIDS, antibiotic-induced changes to normal flora, immunosuppressive therapy, and metastatic cancer are a few examples of conditions that are not compromised. Illustrations of opportunistic. Aspergillosis, cryptococcosis, and candidiasis are examples of mycoses. Mycosal opportunistic disease .The disease Candidiasis The most prevalent opportunistic fungal infection is candidiasis, which is caused by Candida albicans and other species of Candida. The most frequent cause of candidiasis is Candida albicans. There are two types of candidiasis: superficial and deep.

Aspergillosis

Most often, invasive aspergillosis affects the paranasal sinuses and lungs. From the lungs, this fungus may spread to the brain, kidneys, liver, heart, and bones. Although the respiratory system is the primary entry point for aspergillosis, skin injuries may also transfer the organism to hosts that are vulnerable. Defects in circulation that are both quantitative and functional One of the main risk factors for invasive aspergillosis development is neutrophils. For instance, systemic corticosteroids and neutropenia brought on by cytotoxic chemotherapy are frequent risk factors for invasive aspergillosis.

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Zygomycosis

The most general term for infections brought on by bread mold fungi is Zygomycosis.

phylum Zygomycota. However, the diseases that Zygomycosis can refer to are better known by their specific names because Zygomycota has been found to be polyphyletic and is not included in contemporary fungal classification systems: After Mucorales, mucormycosis basidiobolomycosis (after Basidiobolus) and phycomycosis (after Phycomycetes). Zygomycosis

Invasive sinopulmonary infections can also be brought on by Rhizopus, Rhizomucor, Absidia, Mucor species, or other Zygomycetes. The rhinocerebral syndrome is a particularly dangerous type of Zygomycosis, also referred to as mucormycosis .Which happens to people with diabetes who have ketoacidosis.

Along with diabetic ketoacidosis, conditions such as neutropenia and prolonged corticosteroid use are considered important risk factors for Zygomycosis. Both Aspergillus species and Zygomycetes exhibit a marked tendency to invade blood vessels.

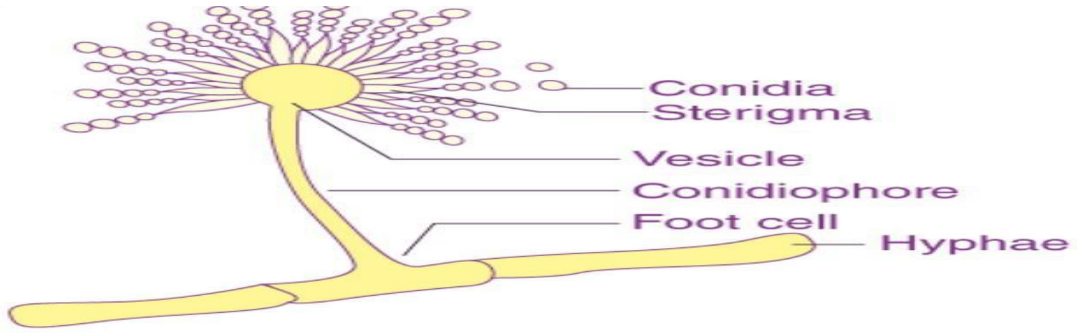

Fig no.12

Mucormycosis:

Mucormycosis (Black Fungus):

Mucormycosis is an uncommon yet serious fungal infection caused by molds belonging to the order Mucorales. These fungi are widely distributed in nature, particularly in soil, decaying organic matter, compost, and even in the nasal passages of healthy individuals. The infection typically involves the sinuses, lungs, and brain, and can become fatal in people with uncontrolled diabetes or in those with weakened immune systems, such as cancer patients or individuals living with HIV/AIDS.

The infection gained significant attention during the COVID-19 pandemic. Experts observed that its incidence may be associated with the use of corticosteroids—drugs that are crucial for managing severe COVID-19 cases by reducing lung inflammation and preventing immune overreaction. However, steroids can also suppress the immune response and elevate blood glucose levels in both diabetic and non-diabetic patients. This combination of reduced immunity and high blood sugar appears to create favorable conditions for the development of mucormycosis, which has a high overall mortality rate of around 50%.

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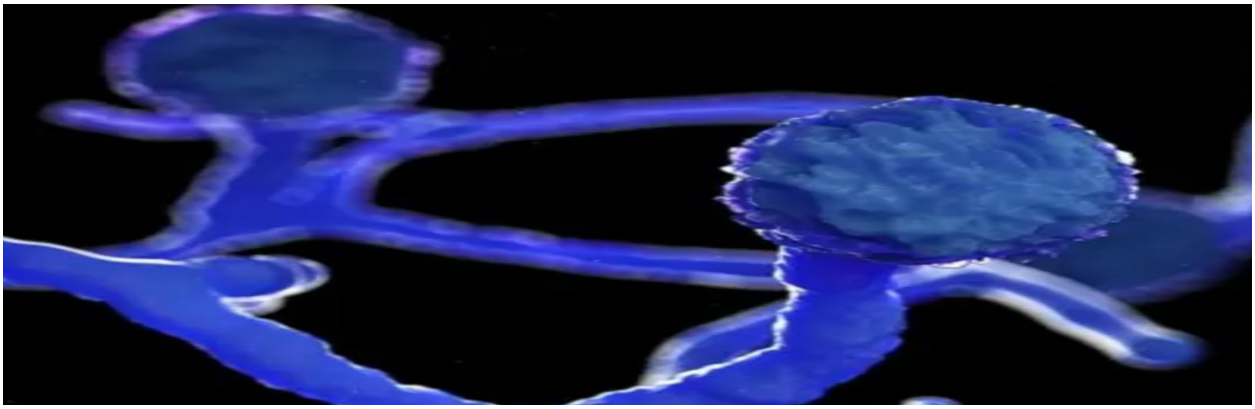


Fig no.13

Cryptococcosis:

Cryptococcosis is a common opportunistic fungal infection that often manifests as pneumonia or meningitis. The condition is most frequently associated with impaired cellular immunity, particularly in individuals with acquired immunodeficiency syndrome (AIDS), making them highly vulnerable to this infection

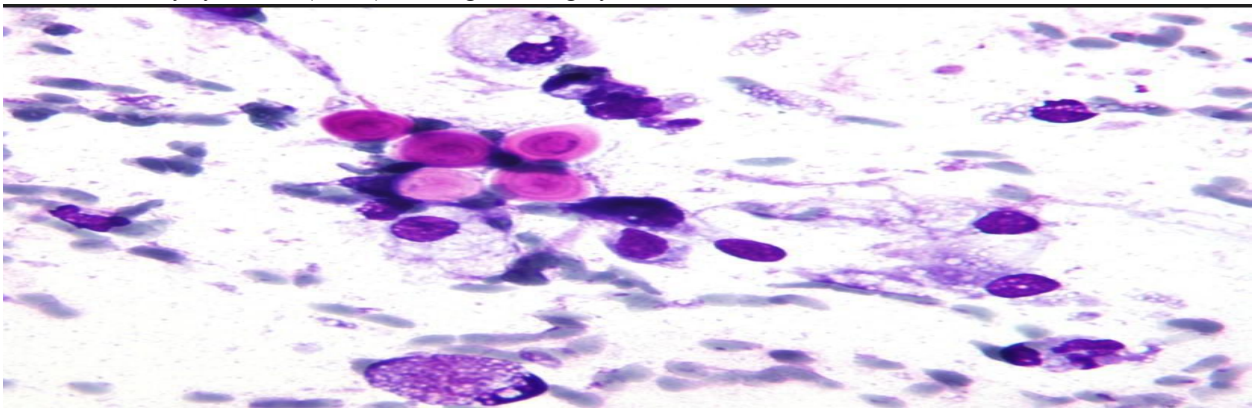
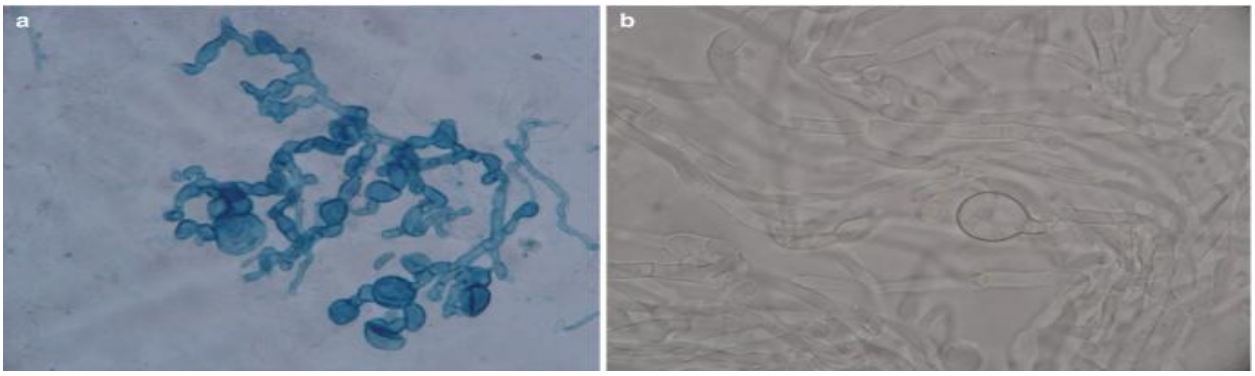


Fig no.14

Hyalohyphomycosis

Hyalohyphomycosis refers to infections caused by various saprophytic fungi that produce transparent (hyaline) hyphae. These organisms, such as Fusarium species, can invade immunocompromised hosts, especially those with neutropenia, leading to severe conditions including pneumonia, bloodstream infections, and disseminated disease with skin involvement.



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II. CONCLUSION

Fungal infections continue to be a major health challenge worldwide, with clinical manifestations ranging from mild surface infections to life-threatening systemic diseases. Their growing incidence is linked to factors like immune suppression, excessive antibiotic usage, and environmental changes. Although advances in diagnostics and antifungal therapies have improved patient survival, issues such as antifungal resistance, toxicity, limited treatment availability, and frequent relapses persist. To address these challenges, deeper insights into fungal pathogenesis, the development of safer and more potent antifungal drugs, and preventive healthcare measures are vital. Ongoing research and greater global awareness are necessary to lessen the impact of fungal diseases and enhance patient outcomes.

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