REVIEW ARTICLE

REVIEW OF FUNGAL SKIN INFECTIONS AND THEIR INVASION

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ABSTRACT

Fungi have major roles in microbial community stability, human health, and disease (Peleg et al., 2010). Genomic methodologies to identify fungal species and communities have been limited compared with those that are available for bacteria (Dollive et al., 2012). Superficial mycoses infections are prevalent worldwide. They affect around 20% of the world's population, and this percentage continues to increase (Ameen, 2010).

Keywords: Skin infection, fungi, invasion, folicule

INTRODUCTION

Fungi have major roles in microbial community stability, human health, and disease (Peleg et al., 2010). Genomic methodologies to identify fungal species and communities have been limited compared with those that are available for bacteria (Dollive et al., 2012). Superficial mycoses infections are prevalent worldwide. They affect around 20% of the world's population, and this percentage continues to increase (Ameen, 2010).

SKIN INFECTIONS

The skin is the largest organ of the human body, which comprises about 15% of the total adult body weight. It has many important functions, such as preventing excess water loss from the body and protecting the body against external physical, biological and chemical assailants, (Kanitakis, 2002). Globally, the skin infection is ranked fourth among the top ten most common skin diseases (Hay et al., 2014). The skin infection has a high prevalence rate which reaches up to 80 % in developing countries (Ramamuthie et al., 2015). Lack of awareness and understanding of risk factors for skin infection is a major reason for the development of skin infections (Goonmatte and Rajesh, 2013). The skin works as a mechanical barrier which limits the invasion and growth of pathogenic fungi (Harder et al., 1997). Skin protection established by keratinocytes and skin-resident T-cells is compromised in chronic skin disease and it has been suggested that the disturbance of the normal skin homeostasis causes an increased risk of infection (Di Meglio et al., 2011). Intact skin protects from the external environment by maintaining a normal flora that is not conducive to the growth of pathogenic organisms. Primary skin and soft tissue infections (SSTIs) occur when pathogenic microorganisms invade the healthy skin, while secondary SSTIs occur when microorganisms infect the damaged skin. In both situations, the pathogenic microorganisms lead to damage the surrounding tissues, which cause an inflammatory response characterized by warmth, pain, and erythema (Chahine et al., 2015).

TABLE 1 Gap analysis of the most common fungal skin infections

<table>
<thead>
<tr>
<th>Fungal skin infection</th>
<th>Fungal species</th>
<th>Area infected</th>
<th>Symptoms</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tinea pedis</td>
<td>Trichophyton, Epidermophyton or Microsporum.</td>
<td>It infects the foot.</td>
<td>It causes peeling, redness, itching, burning, and sometimes blisters and sores.</td>
<td>Terbinafine fluconazole or itraconazole</td>
</tr>
<tr>
<td>Tinea corporis</td>
<td>Trichophyton, Microsporum, or Epidermophyton</td>
<td>It can appear anywhere on the body.</td>
<td>It is often accompanied by scaly skin.</td>
<td>Itraconazole or terbinafine</td>
</tr>
<tr>
<td>Cutaneous candidiasis</td>
<td>Candida albicans</td>
<td>Yeast infections may affect nearly any skin surface on the body, but are most likely to occur in warm, moist, creased areas including the armpits and the groin.</td>
<td>It causes rash, patches that ooze clear fluid, pimple-like bumps and itching or burning Candida can cause diaper rash in infants and can cause infections of the nail. Oral thrush is a form of candida infection that is found in the mouth. Candida also causes vaginal yeast infections.</td>
<td>Clotrimazole, nystatin, fluconazole, voriconazole, amphotericin B, or echinocandins</td>
</tr>
</tbody>
</table>

FUNGAL SKIN INFECTION

Superficial fungal infections of the skin are among the most common diseases. It affects the outer layers of the skin, hair, and nails. The fungi may cause dermatological infections without involving tissue systemic invasion. The main groups of fungi leading to superficial fungal infections are dermatophytes, moulds, and yeasts. The dermatophytes that cause only superficial localised infections of the skin are grouped into three genera: Microsporum, Epidermophyton, and Trichophyton. Dermatophytes infect keratin and therefore cause diseases in body sites wherein keratin is present including the skin surface, hair, and nails. Trichophyton rubrum is the most prevalent cause worldwide for superficial dermatophytosis. Yeasts are not pathogenic, but an alteration in normal flora and colonisation then disease can occur. Candida normal inhabitant in the oropharynx, gastrointestinal tract, and vagina in some people, but in moist and wet conditions, Candida will overgrowth which can lead to superficial infections of the skin. Candida albicans can cause diseases in the skin, nails, viscera and mucous membranes (Ho and Cheng, 2010). Many human infections with environmental fungi reports describe infections caused by traditional and new agents with new mechanisms of infection. Fungal diseases remain a serious cause of illness and death. Much can be done to avoid the consequences of these infections, although environmental exposure to these agents may not be preventable in the society. Future research is needed to develop novel diagnostics, treatments, and vaccines against fungal infections (Brandt and Park, 2013).
Fungal infections are more prone to emerge after antibiotic treatment caused by the loss of the body’s own bacterial flora (Noterman and Nurmin, 2016). Tinea capitis which was also known as herpes tonsurans, ringworm of the hair (James et al., 2006) and tinea tonsurans. It is mainly caused by dermatophytes in the Trichophyton and Microsporum genera which invade the hair shaft. The clinical feature is typically single or multiple patches of hair loss. Ectothrix hair invasion is usually caused by Microsporum gypseum, M. canis, M. distortum, M. ferrugineum, M. audouinii, M. naum, and T. verrucosum. Hyphae invade the hair shaft at the mid of the follicle, then it grows out of the follicle and covers the hair surface. The hyphae destroy the hair cuticle and cause tinea capitis infection including seborrheic dermatitis, “black dot” which refers to the breakage of hair follicles and inflammation. Inflammatory lesions of tinea capitis may develop abscesses, pustules or kerions which are edematous nodules with or without pustules (Rapini et al., 2007).

**Fungi Invasion**

![Image 1](476x313)

Figure 1 Histological features of rat skin tissue show a cross section of the skin layers (H&E, × 4). (Image captured by Ayah Rebhi Hilles).

**Fungi Invasions the Hair Follicle**

Tinea capitis is a superficial fungal infection of the scalp caused by Trichophyton and Microsporum genera that invade the hair shaft which formed of three layers (medulla, cortex, and cuticle). The clinical features include patches of hair loss, sometimes accompanied by a ‘black dot’ pattern, inflammation, pustules, and itching. It is more common in pre-pubertal children, more often in boys than girls (Baker et al., 2012).

![Image 2](476x313)

Figure 2 Histological features of the hair follicle in the rat skin tissue show a longitudinal section of the hair follicle (H&E, × 40). (Image captured by Ayah Rebhi Hilles).

**Fungi invade the Hair Follicle because of the Sebaceous Gland**

Malassezia is a genus of fungi which naturally found on the skin surfaces. The fungus is more common in areas with many sebaceous glands as it requires fat to grow but if the fungus grows rapidly, the natural renewal of cells will be disturbed, and dandruff will appear with itching (Guého et al., 1996).

Dermatophytes are aerobic fungi which invade the superficial keratinized layers of skin, hair, and nails. Three genera of fungi responsible for most dermatophytic infections i.e Trichophyton, Microsporum, and Epidermophyton.

**Fungi invade the skin**

Dermatophytes infect only the keratinized stratum corneum of the epithelial skin layers. Dermatophytes consider as the causative agents of dermatophytosis (tinea). They are parasitizing filamentous fungi that can infect the keratinized tissues which include the stratum corneum of the epidermis skin layers, nails and hairs. Dermatophytes induce a dermal inflammatory response which causes erythema and intense itching. The pathogenesis of tinea includes four steps, starting with the contact of infective spores with the skin then adherence to the superficial cells, after that the fungi invade to the keratin layers by secretion of keratinases which degrade the hard keratin into low molecular weight components and the last step is induction of inflammation (Tyring et al., 2016).

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CONCLUSION

Superficial fungal infections occur in the outermost layers of the skin, nails, and hair. In recent years, the prevalence of these infections has risen steadily due to many factors, such as low socioeconomic status, poor skin health, low level of hygiene, personal hygiene, climatic conditions and level of awareness.

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