
بسم الله الرحمن الرحيم

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Fungal Diseases and COVID-19

https://www.cdc.gov/fungal/covid-fungal.html

Overview

Symptoms of some fungal diseases can be similar to those of COVID-19, including fever, cough, and shortness of breath.[1]

Laboratory testing is necessary to determine if a person has a fungal infection or COVID-19. Some patients can have COVID-19 and a fungal infection at the same time.

Overview

People with severe COVID-19, such as those in an intensive care unit (ICU), are particularly vulnerable to bacterial and fungal infections. The most common fungal infections in patients with COVID-19 include Mucormycosid, Aspergillosis, Invasive Candidiasis.[1–6]

These fungal co-infections are reported with increasing frequency and can be associated with severe illness and death.[1,3,4,7,8] Awareness of the possibility of fungal co-infection is essential to reduce delays in diagnosis and treatment in order to help prevent severe illness and death from these infections.

AIRBORNE FUNGI IN TABRIZ, COMPARING AIRBORNE AND CLINICAL SAMPLES OF A. FUMIGATUS (2011), SURVEY AND LITERATURE REVIEW

KAZEMI ABDOLHASSAN, AHMADPOUR EHSSAN, NAGHILI BEHROZ, ZAREI MAHMOUDABADI ALI, JAFARI ABBASALI*, MOUSAVI AYATOLLAHI AMIN * JUNDISHAPUR JOURNAL OF MICROBIOLOGY (JJM) 2013 , Volume 6 , Number 4 (S.N. 22); Page(s) 1 To 5. Paper

DEPARTMENT OF MEDICAL MYCOLOGY, SCHOOL OF MEDICINE, SHAHID SADOUGHI UNIVERSITY OF MEDICAL SCIENCES, YAZD, IR IRAN

Abstract: Background: Air contamination with fungal spores and the presence of these spores on respiratory tract, especially in industrialized cities with contaminated air, can play an important role on the occurrence of respiratory and coetaneous mycoses, asthma and allergic reactions. This survey was carried out to determine the prevalence of different fungal spores in the atmosphere of Tabriz district.

Objectives: The present study aimed to detect fungal air spores in Tabriz environments, and to compare the environmental samples of Aspergillus fumigatus with the clinical isolated samples of this fungus, due to the importance of the dangers of A.fumigatus for public health, particularly for the immunocompromised patients.

Materials and Methods: During this survey, the presence of air fungal spores was analyzed using settle plate and prepared culture in Sabouraud's dextrose agar. Prior identifications were performed using macroscopic characters, and direct microscopy. 262 samples were collected from different areas of the atmosphere of Tabriz district within all four seasons of the year. Fungal colonies were isolated from all air samples and identified using macroscopic and microscopic characters, and slid culture.

Results: The main isolated fungal spores from the atmosphere of Tabriz district were Penicillium Sp. (36.6%), Cladosporidium Sp. (26.8%) and Aspergillus Sp. (23.6%).

Conclusions: The presence of fungal spores in the atmosphere as a part of air pollution can cause significant problems for human health, particularly in the respiratory tracts.

Keyword(s): FUNGI, SPORES, FUNGAL, TABRIZ, ASPERGILLUS FUMIGATUS

PCR reaction produced a single product of ca. 1500 bp

Figure 2. Gel Electrophoresis of PCR Products Using Degenerate Primers

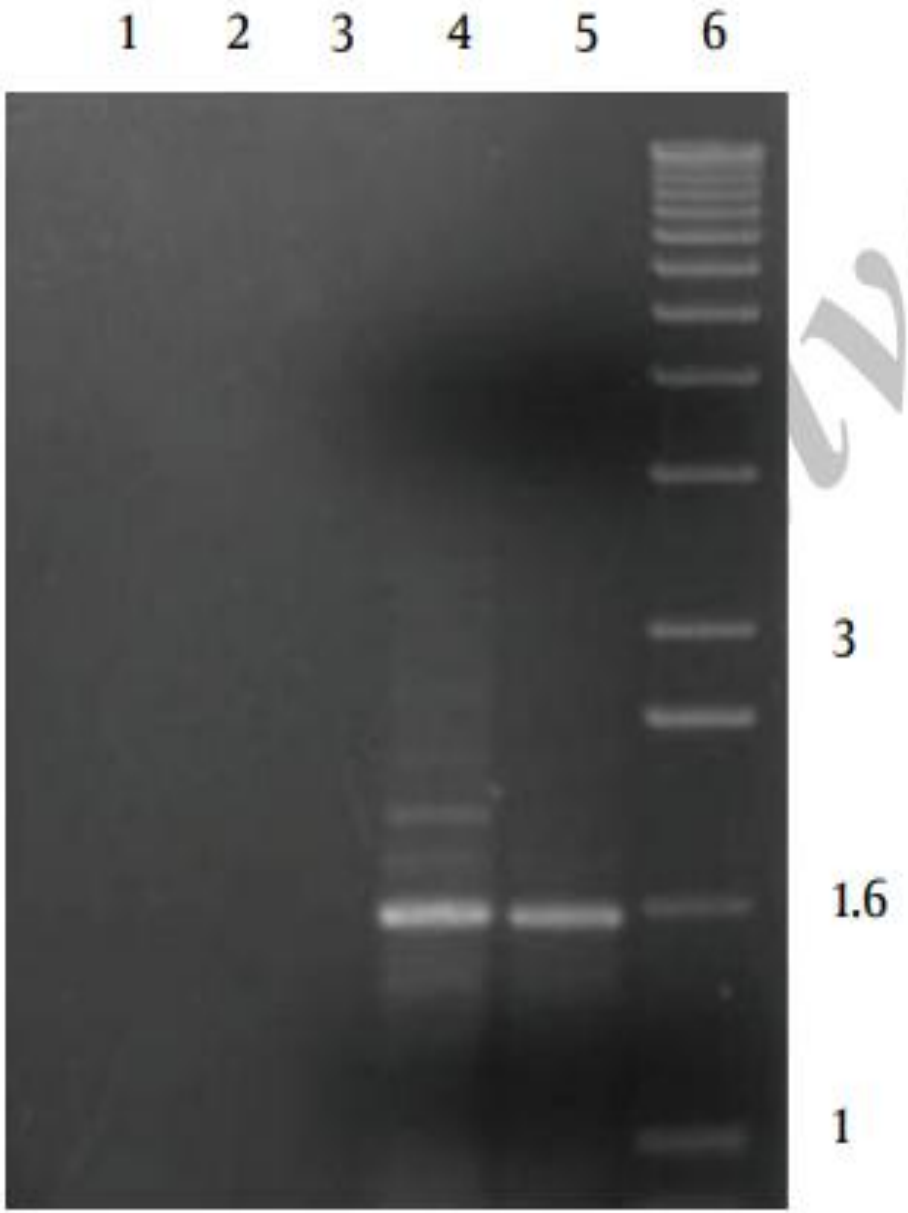


Table 1. Colony Count and Percentage of the Identified Fungi

Fungi	Percentage	Colony Count
Penicillium Sp.	39.6	104
Cladosporidium Sp.	26.8	70
Aspergillus Sp.	23.6	62
Tichoderma Sp.	5.1	14
Yeast	2.8	4
Chrysosporium Sp.	0.7	2
Fusarium Sp.	0.7	2
Alternaria Sp.	0.7	2
Acremonium Sp.	0.7	2
Total	100	262

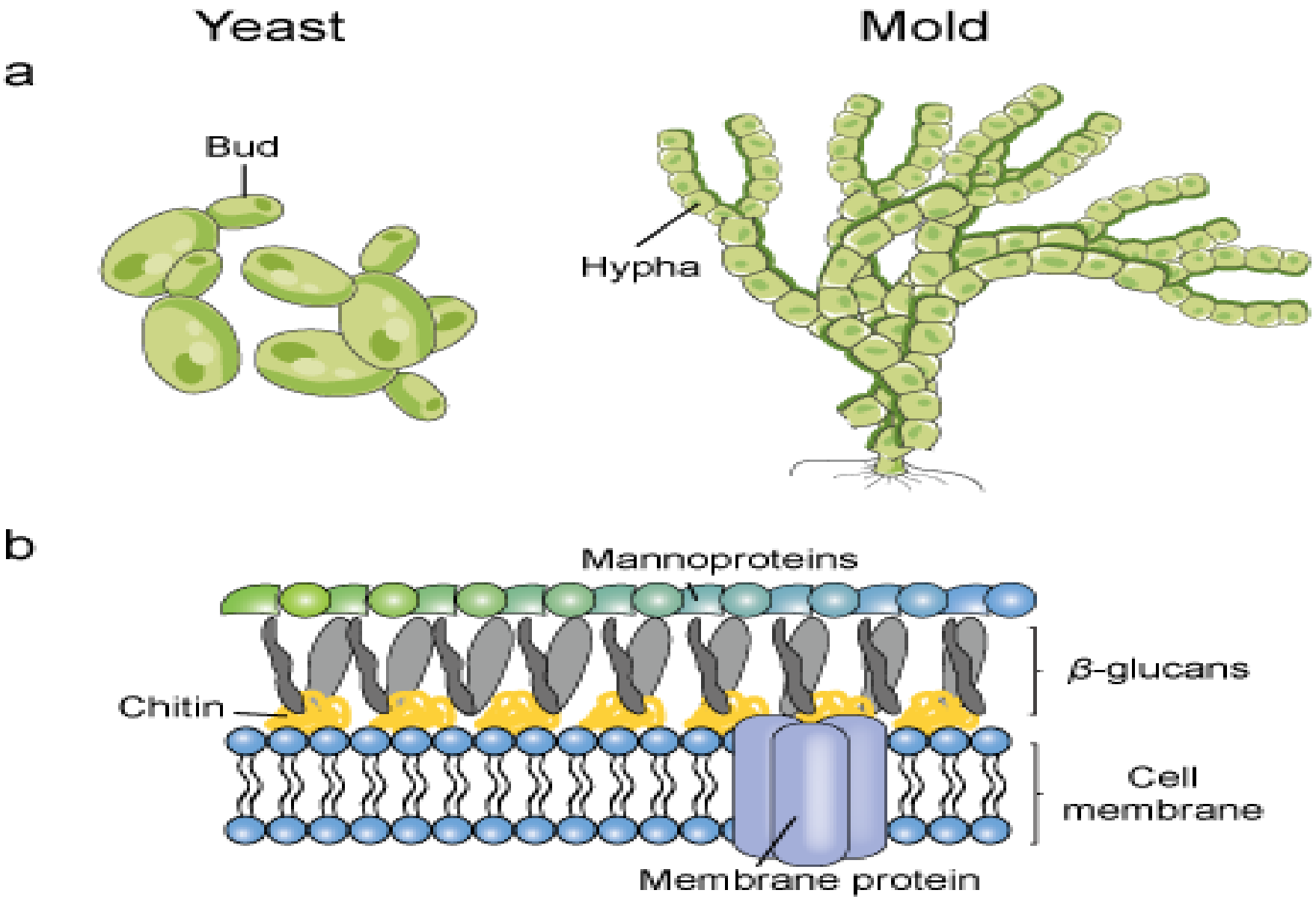
5. Discussion

Fungi can both degrade the organic materials and structures of their colonies, and contribute to the appearance of symptoms and diseases in the inhabitants of contaminated homes, hospitals, factories, etc. (8, 9). Citizens in city environments are not only at risk of harm to their health through environmental degradation as a result of the worsening air pollution problems such as fungal spores, but are also constantly threatened by emerging and recurring asthma, rhinitis, bronchopulmonary disorders, mycoses and hypersensitivity pneumonitis epi-

COVID-19-associated pulmonary aspergillosis

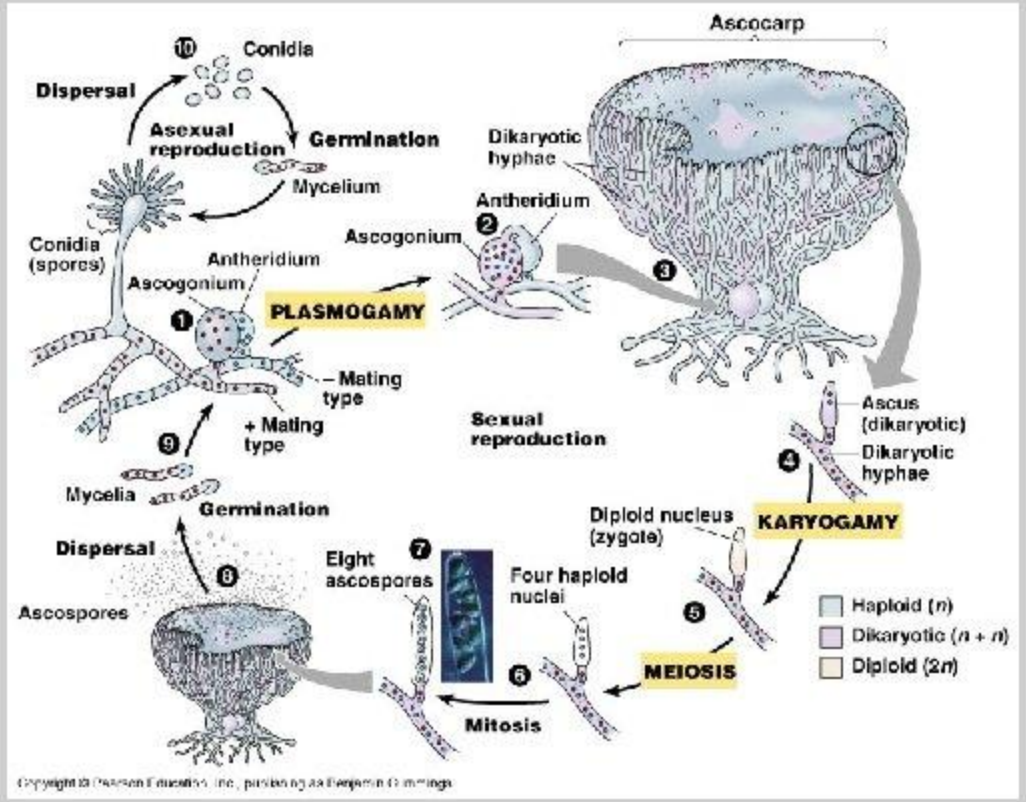
Scientists are still learning about aspergillosis (infections caused by the fungus *Aspergillus*) in people with severe COVID-19. In the past, scientists thought aspergillosis occurred almost entirely in people with severely weakened immune systems. However, aspergillosis has been increasingly reported in patients without weakened immune systems but who have severe respiratory infections caused by viruses, including influenza. Several recent reports describe COVID-19-associated pulmonary aspergillosis (CAPA).[1,3,6,9,10-14]

Structure of Fungi



C. Ascomycota - Life cycle

1. Dikaryotic growth
2. Fruiting body: ascocarp
3. Fertile layer with asci
4. Eight ascospores per ascus (sac)
5. Asexual reproduction via conidia



COVID-19-associated pulmonary aspergillosis

Available information indicates that CAPA:

usually occurs in patients with severe COVID-19 (e.g., patients on ventilators in ICUs)[1,6,11-14]

can be difficult to diagnose because patients often have non-specific symptoms and testing typically requires a specimen from deep in the lungs[11, 14]

can cause severe illness and death[8,9,11-14]

COVID-19-associated pulmonary aspergillosis

Clinicians should consider the possibility of aspergillosis in patients with severe COVID-19 who have worsening respiratory function or sepsis, even if they do not have classical risk factors for aspergillosis.[16]

Testing for CAPA usually involves obtaining specimens from patients' lower respiratory tract, which are tested for *Aspergillus* galactomannan antigen and fungal culture.

Invasive aspergillosis[1]

Usually occurs in people who are already sick from other medical conditions, so it can be difficult to know which symptoms are related to an *Aspergillus* infection. However, the symptoms of invasive aspergillosis in the lungs include:

Fever

Chest pain

Cough

Coughing up blood

Shortness of breath

Other symptoms can develop if the infection spreads from the lungs to other parts of the body.

Treatment

First-line treatment for invasive aspergillosis is voriconazole. Alternative treatments include lipid amphotericin formulations, posaconazole, isavuconazole, itraconazole, caspofungin, and micafungin. Prophylaxis against aspergillosis is recommended during prolonged neutropenia for patients who are at high risk for aspergillosis, allogeneic stem cell transplant patients with graft versus host disease, lung transplant recipients, and certain other solid organ transplant recipients under certain conditions.

For more detailed recommendations on treatment and prophylaxis, please refer to the Infectious Diseases Society of America's Practice Guidelines for the Diagnosis and Management of Aspergillosisexternal icon.

Antifungal resistance

Even with antifungal treatment, aspergillosis can cause death in more than half of infected patients with weakened immune systems. *Aspergillus fumigatus* (*A. fumigatus*) that is resistant to all azole antifungal medications, including voriconazole, itraconazole, and posaconazole, is emerging in the U.S. [1, 2, 3]making infections with this strain even harder to treat.

Some *A. fumigatus* strains carry resistance markers that have been associated with environmental fungicide use rather than a patient's previous exposure to antifungals. Healthcare professionals and public health officials should be aware that resistant infections are possible even in patients not previously treated with these medications. Most U.S. laboratories do not have the capability to test for antifungal-resistance in *A. fumigatus*.

If resistant aspergillosis is suspected in a hospital that lacks immediate access to testing, clinicians should consult their local health department to inquire how to access testing. Further research is needed to determine the prevalence of this resistance.

Select regional labs in the AR Lab Network perform screening to monitor and track the emergence of azole-resistant *A. fumigatus* in the United States. Testing is available to all states. For more information on antifungal resistance, please see CDC Antifungal Resistance page.

KAZEMI ABD ALHASAN*, ROBSON G.D., DENNING D.W., ASGHARZADEH M.

IDENTIFICATION, ISOLATION, CLONING AND SEQUENCING OF FLUCONAZOLE RESISTANCE GENE IN ASPERGILLUS FUMIGATUS.

PHARMACEUTICAL SCIENCES SUMMER 2008 , Volume - , Number 2; Page(s): 27 - 35.

Abstract: Objectives: Development of azole resistance in opportunistic fungi is the most problematic reason in immunocompromised patients and at present time, there is an increased awareness of the morbidity and mortality associated with fungal infections caused by resistant fungi to imidazole. This research was carried out for cloning and sequencing of Fluconazole resistance gene.
Methods: Using genomic DNA of Aspergilus fumigatus (ATCC strain 90254) a primary 800 bp PCR product and then a secondary 1750 bp inverse PCR product were obtained. The 1750 bp PCR product was gel purified and cloned into E. coli using the suitable plasmid. Plasmid was extracted from transformed E. coli and the presence of expected insert into plasmid, was confirmed by digestion of plasmid using Eco R1 restriction enzyme. Also southern analysis using standard protocol was carried out for investigation of gene expression.
Results: Gel purified 1750 bp band was sequenced and after deletion of extra nucleotides from both side of residue a 1703 bp motif submitted at NCBI gene bank with accession No.: AY848856.
Conclusion: In conclusion considering (resistant to fluconazole) A. fumigatus resistance gene to this compound was cloned and sequenced successfully in our lab. Since A. fumigatus is increasingly resistant to the widely used fluconazole, we emphasize for future additional studies for expression of this gene and its mRNA transcription to understand the effective and inhibitor factors for expression of gene.

Keyword(s): FLUCONAZOLE RESISTANCE, GENE, SEQUENCING, ASPERGILLUS FUMIGATUS

Aspergillosis Statistics

How common is aspergillosis?

Because aspergillosis is not a reportable infection in the United States, the exact number of cases is difficult to determine. Milder, allergic forms of aspergillosis are more common than the invasive form of the infection. Allergic bronchopulmonary aspergillosis (ABPA) likely affects between 1 and 15% of cystic fibrosis patients.[1] One study calculated that **2.5% of adults who have asthma also have ABPA, which is approximately 4.8 million people worldwide.[2]** Of these **4.8 million people who have ABPA, an estimated 400,000 also have chronic pulmonary aspergillosis (CPA).[2] Another 1.2 million people are estimated to have CPA after having tuberculosis,[3]** and over 70,000 people are estimated to have CPA as a complication of sarcoidosis.[4]

Invasive aspergillosis is uncommon and occurs primarily in immunocompromised people. The first population-based incidence estimates for invasive aspergillosis were obtained from laboratory surveillance conducted in the San Francisco Bay Area during 1992-1993 and suggested a yearly rate of 1 to 2 cases of aspergillosis per 100,000 population.[5] However, the epidemiology of invasive *Aspergillus* infections has likely shifted since this time due to the increasing number of solid organ and stem cell transplant recipients and newer immunosuppressive agents. The number of hospitalizations related to invasive aspergillosis in the United States increased an average of 3% per year during 2000- 2013. [6] Nearly 15,000 aspergillosis-associated hospitalizations occurred in the United States in 2014, at an estimated cost of $1.2 billion.[7]

Prospective surveillance among transplant recipients performed during 2001-2006 found that invasive aspergillosis was the most common type of fungal infection among stem cell transplant recipients[8] and was the second-most common type of fungal infection among solid organ transplant recipients.[9] In a broad US healthcare network of intensive care unit autopsy studies, aspergillosis was one of the top four most common diagnoses that likely lead to death.[10]

Aspergillosis outbreaks: Although most cases of aspergillosis are sporadic (not part of an outbreak), outbreaks of invasive aspergillosis occasionally occur in hospitalized patients. Invasive aspergillosis outbreaks are often found to be associated with hospital construction or renovation, which can increase the amount of airborne *Aspergillus*, resulting in respiratory infections or surgical site infections in high-risk patients.[12,13] Outbreaks of primary cutaneous aspergillosis and central nervous system aspergillosis in association with the use of contaminated medical devices have also been described.[14, 15] The incubation period for aspergillosis is unclear and likely varies depending on the dose of *Aspergillus* and the host immune response.

Deaths due to aspergillosis

Allergic forms of aspergillosis such as allergic bronchopulmonary aspergillosis (ABPA) and allergic *Aspergillus* sinusitis are generally not life-threatening.

In contrast, although invasive aspergillosis is uncommon, it is a serious infection and can be a major cause of mortality in immunocompromised patients.

For example, a large prospective study found that the one-year survival for people who had **invasive aspergillosis was 59% among solid organ transplant recipients[10] and 25% among stem cell transplant recipients.**[8] In a systematic review of intensive care unit autopsy studies, aspergillosis was one of the top four most common diagnoses that likely lead to death.[11]

Mucormycosis

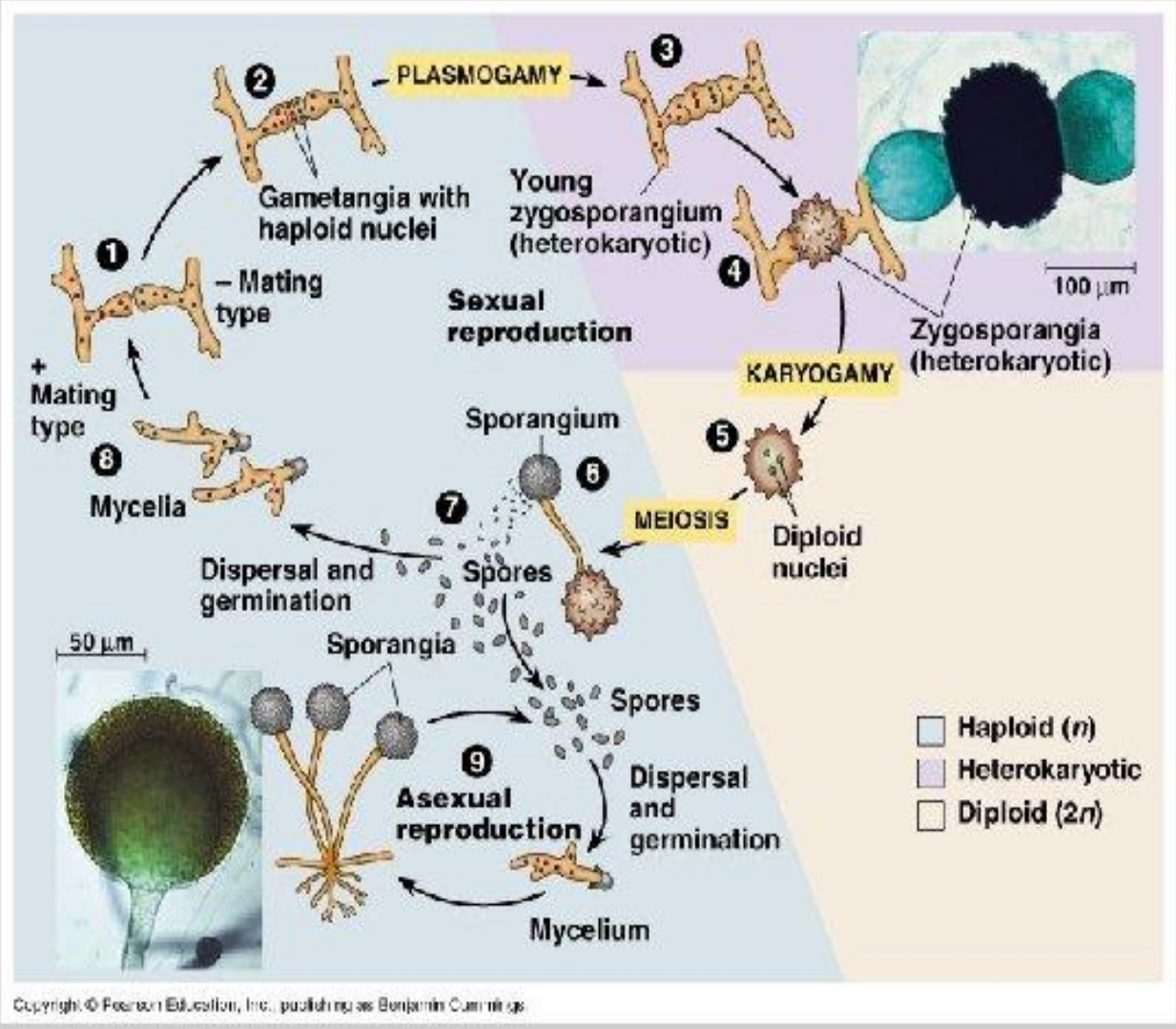
Mucormycosis (previously called zygomycosis) is a serious but rare fungal infection caused by a group of molds called mucormycetes. These molds live throughout the environment.

Mucormycosis mainly affects people who have health problems or take medicines that lower the body's ability to fight germs and sickness.

It most commonly affects the sinuses or the lungs after inhaling fungal spores from the air. It can also occur on the skin after a cut, burn, or other type of skin injury.

B. Zygomycota

1. No dikaryotic growth
2. Both sexual and asexual sporangia



Why Deadly ‘Black Fungus’ Is Ravaging COVID Patients in India

Standard treatments such as steroids, as well as illnesses such as diabetes, make the fungal infection worse@Scientific American

COVID-19-associated mucormycosis

COVID-19–associated mucormycosis is less common than other COVID-19–associated fungal infections[24], but emerging reports from India highlight the importance of considering this infection. Some medications used to treat severe COVID-19, including high-dose corticosteroids and tocilizumab, might predispose patients with COVID-19 to mucormycosis.

Mucormycosis has been reported in patients with severe COVID-19 infection who lacked other classical mucormycosis risk factors, such as diabetes, conditions or medications that weaken the immune system, and cancer.[25, 26]

Early diagnosis and treatment are key to improving outcomes for patients with COVID-19–associated mucormycosis. Clinicians should consider the possibility of mucormycosis in patients with severe COVID-19 even when patients lack classical risk factors for this disease.

Biomarkers for diagnosing invasive aspergillosis, such as beta-d-glucan and galactomannan, are typically negative in patients with mucormycosis. The treatment for mucormycosis frequently involves aggressive surgical intervention and treatment with antifungals, including amphotericin B, posaconazole, or isavuconazole.

Voriconazole is not recommended for treating mucormycosis.[27]

Symptoms of Mucormycosis

The symptoms of mucormycosis depend on where in the body the fungus is growing. [1,4]

Symptoms of **rhinocerebral (sinus and brain) mucormycosis** include:

One-sided facial swelling

Headache

Nasal or sinus congestion

Black lesions on nasal bridge or upper inside of mouth that quickly become more severe Fever

Disseminated mucormycosis typically occurs in people who are already sick from other medical conditions, so it can be difficult to know which symptoms are related to mucormycosis.

Patients with disseminated infection in the brain can develop mental status changes or coma.

Treatment

Early recognition, diagnosis, and prompt administration of appropriate antifungal treatment are important for improving outcomes for patients with mucormycosis. [2]

Amphotericin B, posaconazole, and isavuconazole are active against most mucormycetes.

Lipid formulations of amphotericin B are often used as first-line treatment.

Medications active against *Aspergillus* such as voriconazole are not active against mucormycetes, and there is some evidence to suggest that pre-exposure to voriconazole may be associated with increased incidence of mucormycosis in some patients. [26,27]

In addition, surgical debridement or resection of infected tissue is often necessary, particularly for rhinocerebral, cutaneous, and gastrointestinal infections. [2,4] Control of the underlying immunocompromising condition should be attempted when possible. [2] The efficacy of other treatments such as hyperbaric oxygen therapy is uncertain but have been useful in certain situations. [28]

How common is mucormycosis?

Mucormycosis is rare, but the exact number of cases is difficult to determine because no national surveillance exists in the United States. Population-based incidence estimates for mucormycosis were obtained from laboratory surveillance in the San Francisco Bay Area during 1992–1993 and suggested a yearly rate of **1.7 cases per 1 million** population.[1]

Prospective surveillance among 16,808 transplant recipients performed in 23 institutions during 2001–2006 found that mucormycosis was the third most common type of invasive fungal infection in **stem cell transplant recipients** and accounted **for 8% of all invasive fungal infections** (77 mucormycete cases occurred among 983 stem cell transplant recipients who developed any fungal infection).[2,3] Among solid organ transplant recipients, **mucormycosis accounted for 2% of all invasive fungal infections** (28 mucormycete cases occurred among 1,208 solid organ transplant recipients who developed any fungal infection).[3,4]

The number of cases varied widely across participating institutions.

Mucormycosis outbreaks

Healthcare providers who are concerned about an unusual number of new cases should contact their state or local public health agency.

Although most cases of mucormycosis are sporadic (not part of an outbreak), outbreaks of mucormycosis have occured. In healthcare settings, it can be difficult to determine whether mucormycosis is healthcare-associated or whether the infections were acquired somewhere else.

Some examples of sources implicated in healthcare-associated mucormycosis outbreaks include adhesive bandages, wooden tongue depressors, **hospital linens**, negative pressure rooms, water leaks, **poor air filtration, non-sterile medical devices, and building construction**. [7-14]

Community-onset outbreaks have been associated with trauma sustained during natural disasters. [15]

Deaths due to mucormycosis

Mucormycosis is frequently a life-threatening infection. A review of published mucormycosis cases found an overall all-cause mortality rate of 54%. [8]

The mortality rate varied depending on underlying patient condition, type of fungus, and body site affected (for example, the mortality rate was 46% among people with sinus infections, 76% for pulmonary infections, and 96% for disseminated mucormycosis). [8]

The perfect storm

COVID-19 Resource Center

Breaking news and emerging research on the COVID-19 pandemic.

The combination of COVID-19, corticosteroid therapy and diabetes creates the perfect storm in which mucormycosis takes roots and thrives. Corticosteroids are a life-saving treatment used to reduce the dysregulated immune response observed in patients with COVID-19. However, **they increase the blood sugar level, and fungi enjoy the sugar,** Natarajan said. Hyperglycemia in patients with diabetes creates an even more favorable environment.

“Diabetes affects many people in India and, due to the weakened immune system, predisposes to more severe COVID-19 infection, which is typically treated with corticosteroids. With this combination of dysfunctional immune system — that is, a common denominator of COVID-19 and **diabetes — plus the use of corticosteroids, the risk of mucormycosis increases exponentially**,” Natarajan said.

In addition, COVID-19 damages and weakens the superior respiratory tract and the eye, increasing susceptibility to fungal infection. Another contributing factor is the use of antibiotics, also commonly prescribed in patients with COVID-19 to fight secondary infections, he said.

Increased spread of *Candida auris* during COVID-19 pandemic

Candida auris is an emerging fungus that can cause outbreaks of severe infections in healthcare facilities. In the United States, it has most commonly spread in long-term care facilities caring for people with severe medical conditions. However, since the start of the COVID-19 pandemic, outbreaks of *C. auris* have been reported in COVID-19 units of acute care hospitals.

These outbreaks may be related to changes in routine infection control practices during the COVID-19 pandemic, including limited availability of gloves and gowns, or reuse of these items, and changes in cleaning and disinfection practices.

New *C. auris* cases without links to known cases or healthcare abroad have been identified recently in multiple states, suggesting an increase in undetected transmission. Screening for *C. auris* colonization, an important part of containment efforts, has been more limited as resources of healthcare facilities and health departments have been diverted to respond to COVID-19.

Invasive candidiasis in patients with COVID-19

Invasive candidiasis in patients with COVID-19

Patients hospitalized for COVID-19 are at risk for healthcare-associated infections (HAIs), including candidemia, or bloodstream infections caused by *Candida*.[7,17–19] Fungal infections resistant to antifungal treatment have also been described in patients with severe COVID-19.[19,20] Early diagnosis and monitoring for *Candida* infections and antifungal resistant infections (e.g., *C. auris,* azole-resistant *Aspergillus*) are key to reducing death from COVID-19 in patients with severe COVID-19 fungal co-infections.

Fungal pneumonias can resemble COVID-19

Other fungal diseases, such as histoplasmosis, Valley fever (coccidioidomycosis), and blastomycosis, can cause fever, cough, and shortness of breath, similar to COVID-19 and bacterial pneumonias.[21]

These fungi live in soil. People become infected by breathing in fungi present in the air. Clinicians should consider fungal pneumonias as a possible cause of respiratory illness, particularly if COVID-19 testing is negative. It is important to note that these fungal diseases can occur at the same time as COVID-19.[22,23]

Miscellaneous

Invasive pulmonary fusariosis in an immunocompetent critically ill patient with **severe COVID-19**.

Poignon C, Blaize M, Vezinet C, Lampros A, Monsel A, Fekkar A.

Clin Microbiol Infect. 2020 Nov;26(11):1582-1584. doi: 10.1016/j.cmi.2020.06.026. Epub 2020 Jun 30.

Promising effect of in-situ lyticase enzyme therapy on peritoneal dialysis catheter obstruction from *Acremonium* fungal biofilm: A case report

Thana Thongsricome [1], Talerngsak Kanjanabuch [1 2 3], Nopparat Maeboonruen [3], Preeyarat Pavatung [2], Pisut Katavetin [1 3], Somchai Eiam-Ong [1]

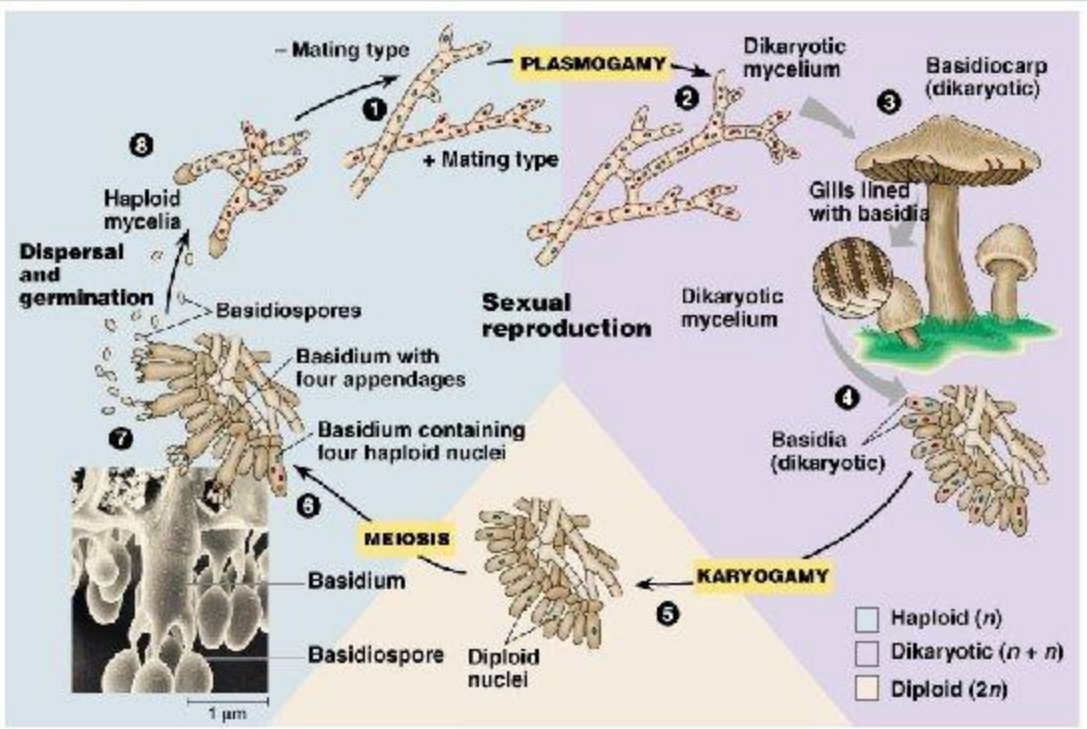
Med Mycol Case Rep . 2020 Dec;30:26-28. doi: 10.1016/j.mmcr.2020.09.006.

Identification by Matrix-Assisted Laser Desorption Ionization-Time of Flight Mass Spectrometry and Antifungal Susceptibility **Testing** of Non-Aspergillus Molds.Li Y, Wang H, Hou X, Huang JJ, Wang PC, Xu YC.

Front Microbiol. 2020 Jun 3;11:922. doi: 10.3389/fmicb.2020.00922. eCollection 2020.PMID: 32582045

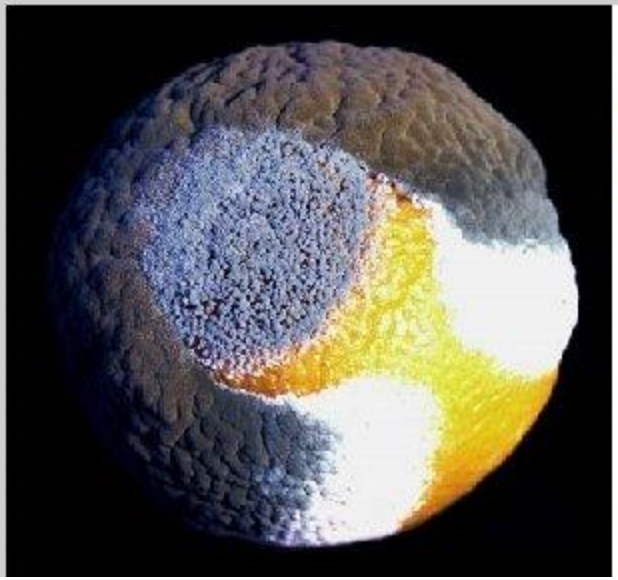
D. Basidiomycota - Life cycle

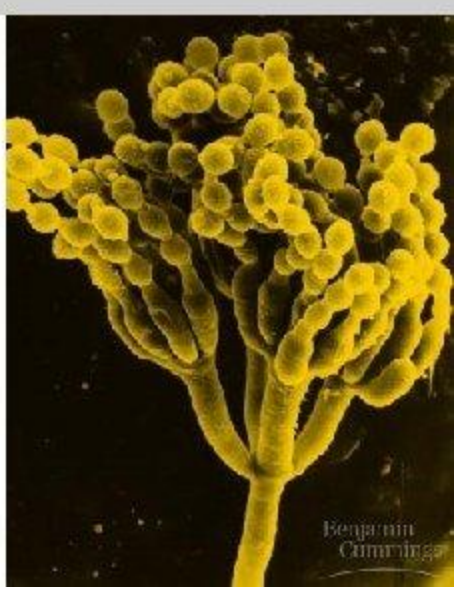
1. Dikaryotic growth
2. Fruiting body: basidiocarp
3. Fertile layer on gills with basidia ("clubs")
4. Four spores per basidium
5. Asexual reproduction is rare



E. Deuteromycota - "fungi imperfecti"

1. Not a true phylum (not a natural group): polyphyletic
2. Fungi with no known sexual reproduction
3. Asexual reproduction by conidia





References

Hoenigl M. Invasive fungal disease complicating COVID-19: when it rains it pourexternal icon. Clin Infect Dis. 2020 Sep 5

Garcia-Vidal C, Sanjuan G, Moreno-García E, et al. Incidence of co-infections and superinfections in hospitalized patients with COVID-19: a retrospective cohort studyexternal icon. Clin Microbiol Infect. 2020 Jul 31

Lansbury L, Lim B, Baskaran V, Lim WS. Co-infections in people with COVID-19: a systematic review and meta-analysisexternal icon. J Infect. 2020 May 27

Gangneux JP, Bougnoux ME, Dannaoui E, Cornet M, Zahar JR. Invasive fungal diseases during COVID-19: We should be preparedexternal icon. J Mycol Med 2020 Jun

Song G, Liang G, Liu W. Fungal co-infections associated with global COVID-19 pandemic: A clinical and diagnostic perspective from Chinaexternal icon. Mycopathologia. 2020 Jul 31

Koehler P, Cornely OA, Böttiger BW, Dusse F, Eichenauer DA, Fuchs F, et al. COVID-19 associated pulmonary aspergillosisexternal icon. Mycoses. 2020 May 15

Chen N, Zhou M, Dong X, Qu J, Gong F, Han Y, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive studyexternal icon. Lancet. 2020 Jan 30

Beer KD, Jackson BR, Chiller T, Verweij PE, Van de Veerdonk FL, Wauters J. Does pulmonary aspergillosis complicate COVID-19?external icon Crit Care Exp. 2020 Sep 18

Mohamed A, Rogers TR, Talento AF. COVID-19 associated invasive pulmonary aspergillosis: diagnostic and therapeutic challengesexternal icon. J Fungi. 2020 Jul 22

Verweij PE, Gangneu J, Bassetti M, Bruggemann RJM, Cornely OA, Koehler P, et al. Diagnosing COVID-19-associated pulmonary aspergillosisexternal icon. Lancet Microbe. 2020 May 10

Koehler P, Bassetti M, Chakrabarti A, Chen SCA, Colombo AL, Hoenigl M, et al. Defining and managing COVID-19-associated pulmonary aspergillosis: the 2020 ECMM/ISHAM consensus criteria for research and clinical guidanceexternal icon. Lancet. 2020 Dec 14

Dellière S, Dudoignon E, Fodil S, Voicu S, Collet M, Oillic P, et al. Risk factors associated with Covid-19-associated pulmonary aspergillosis in ICU patients: a French multicentric retrospective cohortexternal icon. Clin Microbiol Infect. 2020 Dec 13

Marr KA, Platt A, Tornheim JA, Zhang SX, Datta K, Cardozo C, et al**.** Aspergillosis complicating severe coronavirus disease. Emerg Infect Dis. 2021 Jan

Benedetti MF, Alava KH, Sagardia J, et al. COVID-19 associated pulmonary aspergillosis in ICU patients: Report of five cases from Argentinaexternal icon. Med Mycol Case Rep. 2020 Dec 7

Arastehfar A, Carvalho A, van de Veerdonk, FL, Jenks JD, Koelher P, Krause R, et al. COVID-19 associated pulmonary aspergillosis (CAPA) – from immunology to treatmentexternal icon. 2020 Jun 24

CDC: Information for Healthcare Professionals About Aspergillosis

Nucci M, Barreiros G, Guimarães LF, Deriquehem VA, Castiñeiras AC, Nouér SA. Increased incidence of candidemia in a tertiary care hospital with the Covid-19 pandemicexternal icon. Mycoses. 2020 Dec 4

Hughes S, Troise O, Mughal N, Moorse LSP. Bacterial and fungal coinfection among hospitalized patients with COVID-19: a retrospective cohort study in a UK secondary-care settingexternal icon. Clin Microbiol Infect. 2020 Jun 27

Posteraro B, Torelli R, Vella A, Leone PM, De Angelis G, De Carolis E, et al. Pan-echinocandin-resistant *Candida glabrata*bloodstream infection complicating COVID-19: a fatal case reportexternal icon. J Fungi. 2020 Sep 6

Meijer EFJ, Dofferhoff ASM, Hoiting O, Buil JB, Meis JF. Azole-resistant COVID-19-associated pulmonary aspergillosis in an immunocompetent host: a case reportexternal icon. J Fungi. 2020 Jun 6

Benedict K, Kobayashi M, Garg S, Chiller T, Jackson BR. Symptoms in blastomycosis, coccidioidomycosis, and histoplasmosis versus other respiratory illnesses in commercially insured adult outpatients, United States, 2016–2017external icon. Clin Infect Dis. 2020 Oct 16

Shah AS, Heidari A, Civelli VF, Sharma R, Clark CS, Munoz AD, et al. The coincidence of 2 epidemics, coccidioidomycosis and SARS-CoV-2: a case reportexternal icon. J Investig Med High Impact Case Rep. 2020 Jun 4

Bertolini M, Mutti MF, Barletta JA, et al. COVID-19 associated with AIDS-related disseminated histoplasmosis: a case reportexternal icon. Int J STD AIDS. 2020 Sep 9

Rabagliati R, Rodríguez N, Núñez C, Huete A, Bravo S, Garcia P. COVID-19-Associated Mold Infection in Critically Ill Patients, Chile. Emerging infectious diseases. 2021 May

Garg D, Muthu V, Sehgal IS, Ramachandran R, Kaur H, Bhalla A, et al. Coronavirus Disease (Covid-19) Associated Mucormycosis (CAM): Case Report and Systematic Review of Literatureexternal icon. Mycopathologia. 2021 Feb 5

Kanwar A, Jordan A, Olewiler S, Wehberg K, Cortes M, Jackson BR. A Fatal Case of Rhizopus azygosporus Pneumonia Following COVID-19external icon. Journal of Fungi. 2021 Feb 28

Cornely OA, Alastruey-Izquierdo A, Arenz D, et al. Global guideline for the diagnosis and management of mucormycosis: an initiative of the European Confederation of Medical Mycology in cooperation with the Mycoses Study Group Education and Research Consortiumexternal icon. The Lancet Infectious diseases. 2019 Nov 4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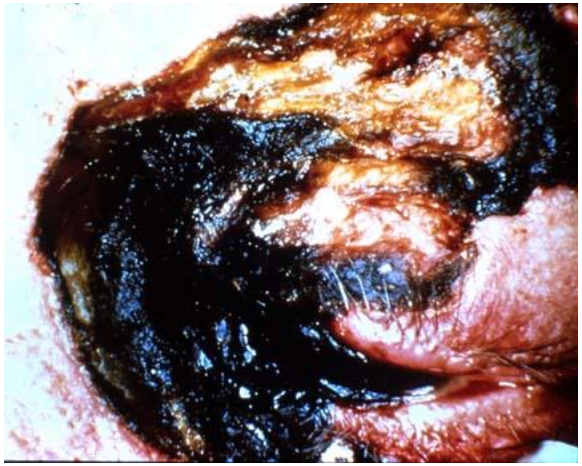


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توجه

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