Hormographiella aspergillata: an emerging basidiomycete in the clinical setting? A case report and literature review

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Abstract

Background: Filamentous basidiomycetes are mainly considered to be respiratory tract colonizers but the clinical significance of their isolation in a specimen is debatable. Hormographiella aspergillata was first reported as a human pathogen in 1971. We discuss the role of this mold as a pathogen or colonizer and give an update on diagnostic tools and in vitro antifungal susceptibility.

Case presentation: We identified three cases of H. aspergillata with respiratory symptoms in a short period of time. One invasive infection and two colonizations were diagnosed. Culture supernatants showed that H. aspergillata can produce galactomannan and β-D-glucan but not glucuronoxylomannan. For the first time, isavuconazole susceptibility was determined and high minimum inhibitory concentrations (MICs) were found. Liposomal amphotericin B and voriconazole have the lowest MICs.

Conclusion: To date, 22 invasive infections involving H. aspergillata have been reported. On isolation of H. aspergillata, its pathogenic potential in clinical settings can be tricky. Molecular identification and antifungal susceptibility testing are essential considering high resistance against several antifungal therapies.

Keywords: Hormographiella aspergillata, Coprinus cinereus, Mould, Antifungal susceptibility, Fungal colonization, Basidiomycete

Background
Filamentous basidiomycetes are mainly considered to be respiratory tract colonizers but increasingly these molds are being documented in invasive infections [1]. Hence, the clinical significance of their isolation in a specimen is debatable. Hormographiella aspergillata is a filamentous basidiomycete growing on horse dung. It was found in numerous environmental substrates and first reported as a human pathogen in 1971 [2–4]. Since, a few infections were reported all over the world with various clinical outcomes, essentially pulmonary but also disseminated or located to the eye or the skin [2, 5–22]. Thus, data are sparse for the diagnosis and management of such infections. Here, we report a new case of human infection involving H. aspergillata and two cases of colonization. We then review all previously published cases and discuss diagnostic strategy and clinical management.

Case presentation
The first case (HA1) was an 70-year-old man admitted to the hematology department for prolonged febrile
neutropenia and anorexia. He had a history of acute myeloid leukemia (AML) and hematopoietic stem cell transplantation (HSCT). His C-reactive protein (CRP, positivity threshold value: 3 mg/L) was 135 mg/L and empirical antibiotic therapy (ceftriaxone) was started at day 210 (D210, 7th month) post-HSCT. Chest computed tomography (CT) scan showed right lower lobe opacification (Fig. 1a) that had increased 1 week later (Fig. 1b). Invasive fungal infection (IFI) was suspected, and liposomal amphotericin B (IAmB 5 mg/kg/day) was started on D232 (7th month). Microscopic examination of a bronchoalveolar lavage (BAL) sampled at D237 (7th month) showed septate hyphae (Fig. 2) but cultures on Sabouraud media incubated at 25 °C and 35 °C were sterile after 7 days. *H. aspergillata* was identified by sequencing the internal transcribed spacer (ITS) region of fungi directly from the BAL. Interestingly, serum galactomannan monitoring was negative (< 0.1 on repeated samples; Platelia* Aspergillus* assay, Bio-Rad; positivity threshold index: > 0.5) and β-D-glucan (Fungitell®, Cape Cod; positivity threshold value: 80 pg/mL) was weakly positive on D237 (7th month; 98 pg/mL) but negative on D248 (8th month; 46 pg/mL). In accordance with the 2008 European Organization for Research and Treatment of Cancer/Invasive Fungal Infections Cooperative Group and the National Institute of Allergy and Infectious Diseases Mycoses Study Group (EORTC/MSG) criteria, the patient was classified as having probable IFI [23]. His condition worsened following pulmonary *Stenotrophomonas maltophilia* infection and so it was decided to initiate palliative care. IAmB was stopped on D253 (8th month), 3 weeks after its introduction. The patient died on D298 (9th month).

The second patient (HA2) was a 49-year-old man admitted to the intensive care unit for pneumopathy with acute respiratory failure. He had a history of psychiatric disorders, diabetes mellitus, asthma, smoking and middle cerebral artery stroke with persistent sequelae. CRP was negative on admission. The following day, it was positive at 108.0 mg/L but procalcitonin remained negative. Mechanical ventilation and empirical antibiotic therapy (cefazidime) were initiated. A mucous plug containing purulent secretions in the left lung was removed by fibroscopy and transmitted to Bacteriology and Mycology Laboratories. Microscopy examinations of samples were negative but cultures identified oropharyngeal microbiota associated with a white mold on Sabouraud media at 25 °C and 35 °C after 7 days. Subcultures of mold grew with white to slightly cream-colored velvety colonies (Fig. 3a and b) on potato dextrose agar media. Microscopy examination of cultures showed hyaline septate hyphae with conidiophores producing cylindrical arthroconidia (Fig. 3c and d). *H. aspergillata* identification was confirmed by sequencing the ITS region. In vitro antifungal susceptibility testing was performed via broth microdilution technique according to the European Committee on Antimicrobial Susceptibility Testing (EUCAST) guidelines [24]. Minimum inhibitory concentrations (MICs) are given in Table 1. The chest CT scan was unremarkable and there was no risk factor for IFI and so no antifungal
therapy was initiated. The inflammatory syndrome decreased rapidly 3 days later, and the patient’s condition improved. A putative diagnosis of bacterial aspiration pneumonia with fungal colonization was established.

The third patient (HA3) was a 28-year-old woman admitted for investigation of an inflammatory disease affecting the central nervous system treated by methylprednisolone for 3 days (1 g/day). Bronchial fibroscopy was performed along with other investigations. Initial microscopy examination of the sample was negative but *H. aspergillata* grew after 3 weeks on Lowenstein-Jensen medium at 35 °C because of mycobacterial suspicion (identification confirmed by ITS sequencing). Antifungal susceptibility testing was performed as described above (Table 1). The patient was asymptomatic and her chest CT scan normal, suggesting colonization, and so no antifungal treatment was initiated.

**Literature review**

We reviewed the literature since 1971 to date using the terms “*Hormographiella aspergillata*” or “*Coprinus cinereus*” and “infection” in MEDLINE database (Tables 1 and 2). For each strain, antifungals MIC with the method used were reported in Table 1 when available. According to the 2008 EORTC/MSG criteria, all probable or proven IFI due to *H. aspergillata* were reported in Table 2 with significant clinical details.

**Discussion and conclusions**

*Hormographiella aspergillata* is an environmental filamentous basidiomycete found in numerous substrates including soils, leaves, pressmud compost and in the air [3, 4]. It is the anamorph form of *Coprinopsis cinerea* (formerly *Coprinus cinereus*), which commonly grows on horse dung. It can be an opportunistic pathogen and is the second filamentous basidiomycete responsible for human infection after *Schizophyllum commune* [25]. To date, 22 invasive infections involving *H. aspergillata* have been reported (Table 2), mostly identified by sequencing of the 28S rDNA or ITS regions [2, 5–22]. Most cases were diagnosed in Europe, but some were documented in the United States, Japan and India, in both rural and urban areas [2, 5–22]. Infection cases occurred mainly in neutropenic patients. Although *H. aspergillata* is primarily responsible for pulmonary

![Fig. 3](image-url) Macroscopic and microscopic morphology of *Hormographiella aspergillata* on potato dextrose agar (PDA) subculture after 3 days of incubation at 25 °C. a White to cream colored velvety colonies with irregular margin on the recto side. b Verso side of the colonies showing light yellow color. c, d Slide culture of *Hormographiella aspergillata* showing hyaline septate hyphae with conidiophores and cylindrical arthroconidia without clamp connection, scale-bar: 200 μm (c) and 50 μm (d).
sidiomycete pathogens such as cross-reactions have already been described with other *B. neofor- mans* widely used to diagnose cryptococcosis. Some ylomannan is a capsular antigen of *Cryptococcus* production of galactomannan, than 500 pg/mL [18, 22]. We attempted to evaluate the tions reported strongly positive galactomannan assays were negative and only two observa-

...tions since in all documented reports...tory Standards Institute (CLSI) breakpoints to interpret the antifungal MICs for *H. aspergillata*. However, previous articles have reported in vitro resistance to echinocandins, fluconazole along with high MIC for flucytosine (Table 1). We found higher MICs for isavuconazole (4 and 16 mg/L) than what is usually observed for basidiomycetes [28, 29]. In the light of our findings and data from the literature, lAmB and voriconazole have the lowest MICs. However, *H. aspergillata* infections have a poor prognosis even when surgical debridement is performed.

In conclusion, on isolation of *H. aspergillata*, its pathogenic potential in clinical samples should be interpreted together with the patient’s history. Formal identification of the fungus can be tricky and usually requires molecular tools in addition to culture. Basidiomycetes can also be contaminants or colonizers and so microscopy examination of samples and/or histology in

### Table 1 Antifungal susceptibility testing of *Hormographiella aspergillata* from the literature and our cases

| References       | Year  | Method                                           | MIC (mg/L) for single isolates |
|------------------|-------|--------------------------------------------------|-------------------------------|
| Speller and Maciver [2]. | 1971  | Dilution method on Yeast Morphology Agar         | AmB 5-FC FCZ ITZ VRZ PSZ ISA CSF MCF |
| Verweij et al. [6] | 1997  | Broth macrodilution method with RPMI-1640        | 0.25 > 250 / / / / / / / / |
| Lagrou et al. [8] | 2005  | E-test*                                          | 0.5 / > 64 8 / / / / / / / / |
| Abuali et al. [10] | 2009  | Broth microdilution method according to CLSI M38-A2 | 4 / / / 0.25 0.5 / > 2 > 4 |
| Conen et al. [11] | 2011  | E-test*                                          | 0.5 / 256 / 0.125 / 32 / |
| Conen et al. [11] | 2011  | E-test*                                          | 0.5 / / / 0.125 2 / / / / |
| Conen et al. [11] | 2011  | E-test*                                          | 0.5 / / / 0.125 2 / / / / |
| Suarez et al. [12] | 2011  | Broth microdilution method according to EUCAST   | 2 / 64 > 8 1 / / 2 / |
| Bojic et al. [14] | 2013  | E-test*                                          | 0.094 > 32 > 256 / 0.125 0.064 / / / / |
| Nanno et al. [17] | 2016  | Not available                                    | 0.125 > 64 4 0.25 0.015 / / > 16 |
| Koonca et al. [18] | 2016  | Sensititre YeastOne                              | 0.12 / 16 / 0.03 0.125 / / / / |
| Jain et al. [21] | 2019  | E-test*                                          | 0.3 / / / 4 0.5 / / 4 4 |
| Our report HA2    | 2019  | Broth microdilution method according to EUCAST   | 0.125 / / > 8 2 4 4 / / |
| Our report HA3    | 2019  | Broth microdilution method according to EUCAST   | 0.125 / / > 8 8 > 8 16 / / |

*AMB Amphotericin B, 5-FC Flucytosine, FCZ Fluconazole, ITZ Itraconazole, VRZ Voriconazole, PSZ Posaconazole, ISA Isavuconazole, CSF Caspofungin, MCF Micafungin*

H. aspergillata can also be a colonizer of the respiratory tract, as illustrated in our three patients, all of whom had an underlying respiratory condition. The weak clinical significance of the isolation of basidiomycetes in healthy subjects, in contrast with their life-threatening potential in immunocompromised patients, has already been described with *Schizophyllum commune* or *Ceriporia lacerata*, for example [27, 28]. These fungi are widely present in the environment, and their spores are easily inhaled and can grow in pulmonary alveoli in cases of local or systemic impaired function of alveolar macrophages.

As yet there are no EUCAST nor Clinical and Laboratory Standards Institute (CLSI) breakpoints to interpret the antifungal MICs for *H. aspergillata*. However, previous articles have reported in vitro resistance to echinocandins, fluconazole along with high MIC for flucytosine (Table 1). We found higher MICs for isavuconazole (4 and 16 mg/L) than what is usually observed for basidiomycetes [28, 29]. In the light of our findings and data from the literature, lAmB and voriconazole have the lowest MICs. However, *H. aspergillata* infections have a poor prognosis even when surgical debridement is performed.

In conclusion, on isolation of *H. aspergillata*, its pathogenic potential in clinical samples should be interpreted together with the patient’s history. Formal identification of the fungus can be tricky and usually requires molecular tools in addition to culture. Basidiomycetes can also be contaminants or colonizers and so microscopy examination of samples and/or histology in
combination with biomarkers are crucial for diagnosis. Respiratory tract colonization is probably not uncommon given that the fungus is widespread in the environment but seems to be restricted to patients with underlying respiratory diseases. AmB and voriconazole seem to be the antifungals of choice.

Table 2 Literature review of Hormographiella aspergillata infections in humans published since 1971

| References            | Country        | Year  | Infection site | Underlying disease | Diagnosis Samples - Methods | Antifungal treatment | Surgery | Outcome |
|-----------------------|----------------|-------|----------------|--------------------|-----------------------------|----------------------|---------|---------|
| Speller and MacIver [2]| England        | 1971  | Heart          | Proven             | Autopsy Histology + culture | None                 | Yes     | Died    |
| Nenoff et al. [5]     | Germany        | 1997  | Lung           | Proven             | Autopsy Histology + culture | AmB                  | No      | Died    |
| Verweij et al. [6]    | Netherlands    | 1997  | Lung           | Proven             | Autopsy Histology + culture + RFLP | AmB + ITZ | No      | Died    |
| Surmont et al. [7]    | Belgium        | 2002  | Lung           | Proven Lymphoma    | Transthoracic puncture DE + culture | AmB                 | No      | Alive   |
| Lagrou et al. [8]     | Belgium        | 2005  | Lung           | Probable           | AML BAL DE + culture CSF    | No                   | Died    |
| Greer et al. [9]      | USA            | 2008  | Heart          | Proven Valve prosthesis Resected valve | Histology + culture IAmB | Yes     | Alive   |

| References            | Country        | Year  | Underlying disease | Diagnosis Samples - Methods | Antifungal treatment | Surgery | Outcome |
|-----------------------|----------------|-------|--------------------|-----------------------------|----------------------|---------|---------|
| Speller and MacIver [2]| England        | 1971  | Heart              | Proven Prosthetic Valve Autopsy Histology + culture | None                 | Yes     | Died    |
| Nenoff et al. [5]     | Germany        | 1997  | Lung              | Proven ALL Autopsy Histology + culture | AmB                 | No      | Died    |
| Verweij et al. [6]    | Netherlands    | 1997  | Lung              | Proven ALL Autopsy Histology + culture + RFLP | AmB + ITZ            | No      | Died    |
| Surmont et al. [7]    | Belgium        | 2002  | Lung              | Proven Lymphoma Transthoracic puncture DE + culture | AmB                 | No      | Alive   |
| Lagrou et al. [8]     | Belgium        | 2005  | Lung              | Probable AML BAL DE + culture CSF | No                   | Died    |
| Greer et al. [9]      | USA            | 2008  | Heart              | Proven Valve prosthesis Resected valve | Histology + culture IAmB | Yes     | Alive   |
| Abuali et al. [10]    | USA            | 2009  | Skin             | Proven AML Skin biopsy Culture | VRZ + CSF + IAmB + CSF | No      | Died    |
| Conen et al. [11]     | Switzerland    | 2011  | Lung, eye, CNS, blood | Proven AML Autopsy Histology + culture VRZ + CSF | No                   | Died    |
| Bojic et al. [14]     | Austria        | 2013  | Skin, lung        | Proven AML Skin biopsy History | CSF + ITZ            | No      | Died    |
| Corzo-León et al. [15]| USA            | 2015  | Lung              | Probable AML BAL DE + culture CSF + VRZ | No                   | Alive   |
| Heiblig et al. [16]   | France         | 2015  | Sinus, orbit, CNS | Proven AML Sinus biopsy DE + culture CSF + PSZ + IAmB + VRZ | Yes     | Died    |
| Nanno et al. [17]     | Japan          | 2016  | Lung, CNS, small intestine | Proven MDS Lung biopsy History + culture + βDG ITZ + IAmB + CSF + VRZ + MCF | No     | Died    |
| Koncan et al. [18]    | Italy          | 2016  | Lung              | Proven MPAL Lung resection Culture + PF-PCR + βDG | PSZ + VRZ | Yes     | Alive   |
| Correa-Martinez et al. [19]| Germany   | 2017  | Skin              | Proven Nephroblastoma Skin biopsy History + culture | PSZ + VRZ | Yes     | Alive   |
| Godet et al. [20]     | France         | 2017  | Lung              | Proven AML Lung biopsy DE + PF-PCR | VRZ + IAmB (IV + nebulized) | Yes     | Alive   |
| Jain et al. [21]      | India          | 2019  | Eye               | Proven Intraocular lens implantation Corneal tissue DE + culture + PF-PCR Natamycin + ITZ + VRZ | Yes | Alive (loss of the eye) |
| Chauhan et al. [22]   | USA            | 2019  | Lung, CNS         | Proven CML Autopsy Histology + culture + PF-PCR + βDG | MCF | No | Died |
| Our report HA1        | France         | 2019  | Probable           | Proven AML BAL DE + PF-PCR + βDG | IAmB | No | Died |

Search for previously published cases using the terms “Hormographiella aspergillata” or “Coprinus cinereus infection” in MEDLINE database.

*ALL Acute lymphoid leukemia, AML Acute myeloid leukemia, BAL Biphenotypic acute leukemia, X-ALD X-linked adrenoleukodystrophy, CML Chronic myeloid leukemia, MDS Myelodysplasia syndrome, MPAL Mixed phenotype acute leukemia, CNS Central nervous system, AmB Deoxycholate amphotericin B, ITZ Itraconazole, CSF Caspofungin, VRZ Voriconazole, PSZ Posaconazole, IAmB Liposomal amphotericin B, MCF Micafungin, IV Intravenous, RFLP Restriction fragment length polymorphism, DE Direct examination, PF-PCR Pan-fungal-polymerization chain reaction, βDG 1, 3-beta-D glucan
Table 3  Galactomannan (GM), β-D-glucan and glucuronoxylomannan antigen assays on culture supernatant for each strain, 5 to 10 colonies incubated at 35 °C for 4 days on Sabouraud media were suspended in 1 ml distilled water. After vigorous agitation, the suspensions were centrifuged for 5 min at 10,000 g. 1: 1:10 and 1:100 dilutions of the supernatants were then tested with Platelia® Aspergillus assay (Bio-Rad, France), Fungitell® assay (Associates of Cape Cod Inc., USA) and Biosynex® CryptoPS assay (Biosynex, France) according to the manufacturer’s recommendations.

| Isolate | Dilution factor | Galactomannan | β-D-glucan (pg/mL) | Glucuronoxylomannan |
|---------|----------------|--------------|-------------------|---------------------|
| HA2     | 1              | > 3,5        | > 500             | Negative            |
|         | 10             | > 3,5        | > 500             | n.d.                |
|         | 100            | 0.2423       | 51,048            | n.d.                |
| HA3     | 1              | > 3,5        | > 500             | Negative            |
|         | 10             | > 3,5        | > 500             | n.d.                |
|         | 100            | 0.4197       | 98,804            | n.d.                |

n.d. Not determined

Abbreviations
AML: Acute myeloid leukemia; BAL: Bronchoalveolar lavage; CLSI: Clinical and Laboratory Standards Institute; CRP: c-reactive protein; CT: Computed tomography; EORTC/MSG: European Organization for Research and Treatment of Cancer/ Mycoses Study Group; EUCAST: European Committee on Antimicrobial Susceptibility Testing; HSTC: Hematopoietic stem cell transplantation; IFI: Invasive fungal infection; ITS: Internal transcribed spacer; lAMiB: Liposomal amphotericin B; MIC: Minimum inhibitory concentrations

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Authors’ contributions
MM did the literature search and drafted the manuscript. MM, RAL, TM did the experimentations. RG, FM and PP provided guidance for drafting the manuscript. MM, RAL, TM did the literature search and drafted the manuscript. CN conceived the case report and oversaw the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials
New genome sequences obtained in this study have been deposited in GenBank under accession numbers MN841917, MN841918 and MN841919.

Ethics approval and consent to participate
This case report received approval from University Hospital of Clermont-ferrand Hospital Ethics and Research Committee. This document is available upon request.

Consent for publication
Written informed consent was obtained from the next-of-kin of patient HA1 and from patients HA2 and HA3 for publication of this case report and any accompanying images. Copies of the written consents are available for review by the Editor of this journal.

Competing interests
The authors have no conflicts of interest to declare.

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