Fatal *Hormonema dematioides* Peritonitis in a Patient on Continuous Ambulatory Peritoneal Dialysis: Criteria for Organism Identification and Review of Other Known Fungal Etiologic Agents

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We report a fatal case of a fungal peritonitis caused by the yeast-like dematiaceous mould *Hormonema dematioides* in a 45-year-old woman. The woman had a 13-year history of insulin-dependent diabetes mellitus and had been on continuous ambulatory peritoneal dialysis for chronic renal failure. *H. dematioides* was repeatedly isolated from the dialysate culture specimens collected on days 3, 9, 16, and 20 of her hospital stay. Preliminary culture reports on day 7 of the growth of a yeast-like fungus, a probable *Candida* species, prompted the administration of fluconazole (FLU). Intrapерitoneal and intravenous FLU failed to eliminate the mould, and the patient expired on day 21 of her hospital stay. We use this case to present what appears to be the first report of fungal peritonitis due to *H. dematioides*, to provide laboratorians with criteria for differentiating this organism from the similar mould *Aureobasidium pullulans* and from various yeast genera, and to provide a review of known fungal taxa inciting peritonitis.

Fungal peritonitis is a serious and potentially life-threatening complication of both intermittent peritoneal dialysis and continuous ambulatory peritoneal dialysis (CAPD). Investigators reviewing significant numbers of CAPD-associated fungal peritonitis episodes cite yeasts, particularly *Candida* species, as the predominant etiologic agents (10, 12, 13, 20, 29, 37, 38, 50, 52, 53, 54, 58, 61, 63, 65, 66, 68, 73, 78). Filamentous fungi complicating CAPD, although reported less frequently and fewer in number, encompass a wide array of agents, from the classic, systemic pathogens (4, 42, 45) to zygomycetous species (55, 64) and members of numerous moniliaceous (3, 11, 16, 25, 27, 30, 33, 39, 40, 48, 51, 57, 67, 71, 75, 76, 77) and dematiaceous genera (1, 2, 6, 7, 14, 21, 28, 31, 34, 43, 44, 59, 69, 80). See Table 1 for a listing of reported etiologic agents of fungal peritonitis. Filamentous *Candida*-associated fungi displaying cream-colored (moniliaceous) colonies and yeast-like synanomorphs may initially be considered *Candida* or *Cryptococcus* species. Two such organisms, *Hormonema dematioides* Lagerberg et Melin [teleomorph, *Sydowia polyspora* (von Tavel) Müller], the subject of this report, and *Aureobasidium pullulans* (deBary) Arnaud, an agent previously reported in fungal peritonitis (7, 14), are both initially somewhat mucoid, yeast-like species. Two such organisms, *Aureobasidium pullulans* usually fails to give a code while *H. dematioides* may code as *Cryptococcus albidus* (49). Both organisms may present diagnostic or identification difficulties in the setting of the CAPD-associated fungal peritonitis patient.

Case report. A 45-year-old woman on CAPD presented at the emergency room of Chonnam University Hospital on 19 March 1996 with nausea, anorexia, increased body weight (from 56 to 74 kg), abdominal distention, and pitting edema. She had a 13-year history of insulin-dependent diabetes mellitus and had had an arteriovenous shunt inserted in February of 1995. Malfunction of the shunt required switching from hemodialysis to CAPD in April 1995. On 1 March 1996, the patient developed abdominal pain and her dialysate became cloudy. Cefazolin and vancomycin were administered intraperitoneally for 20 days without clinical improvement. Upon admission from the emergency room, the patient’s dialysate cell count was 306/μl, with a predominance of polymorphonuclear neutrophils (70%). The hemoglobin level was 6.6 g/dl, the leukocyte count was 6,700/μl, the blood urea nitrogen level was 12.1 mg/dl, and the serum creatinine level was 5.0 mg/dl. The patient was initially treated with intraperitoneal ceftazidime and imipenem. Fluconazole therapy was started on hospital day 7, following a preliminary culture report indicating the presence of a yeast-like fungus, probably a *Candida* species, in the dialysate. Dialysate cell counts on day 6 were 2,600/μl, with a predominance of polymorphonuclear neutrophils. On day 8, the patient’s abdominal pain and fever slightly improved, but vasopressive drug and O2 therapies were started due to the occurrence of respiratory insufficiency and hypotension. Dialysate cell counts were 675 and 441/μl on days 9 and 17, respectively. The same yeast-like fungus was cultured from the dialysate on days 3, 9, 16, and 20. Fluconazole was administered intraperitoneally (200 mg/day) for 15 days and intrave-
nously (800 mg/day) for the last 2 days. The catheter tip was removed on day 20. On day 21 the patient began to lose consciousness, appeared to have signs of acute respiratory insufficiency due to hypoxia and septic shock, and expired. Blood cultures for the causative organism remained negative.

**Mycology.** All four peritoneal fluid culture specimens collected during the patient's hospital stay (on days 3, 9, 16, and 20) revealed the same organism. Three of the dialysates were inoculated onto Sabouraud dextrose agar (SDA) (Becton Dickinson, Cockeysville, Md.), prepared in-house (Fig. 1), while one was inoculated into BACTEC 16A and 17A bottles (Becton Dickinson, Towson, Md.). Only the BACTEC 16A bottle (aerobic medium) was positive after 48 h of incubation. Pure growth of cream-colored mucoid colonies was observed on SDA and on the blood agar plate subculture from the BACTEC 16A in 24 to 48 h at 35°C. Growth at 35°C was slow, and a Gram stain of organisms from the colony revealed oval-shaped yeast forms. API 20C yeast identification system strips, tested a total of seven times with identical results, indicated assimilation of glucose, glycerol, 2-keto-gluconate, 1-arabinose, D-xylose, adonitol, xylitol, galactose, inositol, sorbitol, cellobiose, maltose, saccharose, trehalose, melibiose, and raffinose, giving a numerical code of 6773277. The API database, which provides a list of species and their probabilities, with a confidence estimate for each identification, indicated the code as an unacceptable profile with no identification. Ancillary testing on cornmeal agar (Difco Laboratories, Detroit, Mich.) by the Dalmau method (17) indicated the presence of hyphae and blastospore conidia. Conidia occurred asynchronously from the hyphae as viewed under the coverslip after 72 h of incubation at 25°C (Fig. 2). Prolonged incubation of the isolates for 1, 2,

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**TABLE 1. Reported Etiologic Agents of Fungal Peritonitis**

<table>
<thead>
<tr>
<th>Organism</th>
<th>Reference(s)</th>
<th>Reference(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternaria species</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>Alternaria alternata</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>Aspergillus species</td>
<td>30, 51, 57, 75, 76</td>
<td></td>
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<tr>
<td>Aspergillus flavus</td>
<td>8</td>
<td></td>
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<tr>
<td>Aspergillus fumigatus</td>
<td>60, 72, 79</td>
<td></td>
</tr>
<tr>
<td>Aspergillus niger</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Aureobasidium pullulans</td>
<td>7, 14</td>
<td></td>
</tr>
<tr>
<td>Bipolaris hawaiensis</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>Bipolaris spicifer (Drechslera spicifer)</td>
<td>59</td>
<td></td>
</tr>
<tr>
<td>Candida albicans</td>
<td>12, 13, 22, 37, 38, 52, 54, 65, 68, 73, 78, 81</td>
<td></td>
</tr>
<tr>
<td>Candida famata</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td>Candida (Torulopsis) glabrata</td>
<td>10, 37</td>
<td></td>
</tr>
<tr>
<td>Candida guilliermondii</td>
<td>54</td>
<td></td>
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<tr>
<td>Candida krusei</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Candida lusitaniae</td>
<td>20</td>
<td></td>
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<tr>
<td>Candida norvecensis</td>
<td>58</td>
<td></td>
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<tr>
<td>Candida parapsilosis</td>
<td>13</td>
<td></td>
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<tr>
<td>Candida tropicalis</td>
<td>37</td>
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</tr>
<tr>
<td>Chrysosenia sitophila (Monilia sitophila)</td>
<td>67</td>
<td></td>
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<tr>
<td>Coccioides immitis</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Curvularia species</td>
<td>21, 31, 43</td>
<td></td>
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<tr>
<td>Curvularia lunata</td>
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<td></td>
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<tr>
<td>Cryptococcus neoformans var.</td>
<td>46, 47, 82</td>
<td></td>
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<tr>
<td>Histoplasma capsulatum var.</td>
<td>41, 42, 45</td>
<td></td>
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<tr>
<td>Malassezia furfur</td>
<td>10</td>
<td></td>
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<tr>
<td>Malassezia pachydermatis</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Paecilomyces variotii</td>
<td>11, 16, 48</td>
<td></td>
</tr>
<tr>
<td>Penicillium species</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Rhizopus species</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>Rhizopus microsporus</td>
<td>55</td>
<td></td>
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<tr>
<td>Rhodotypha glutinis</td>
<td>37</td>
<td></td>
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<tr>
<td>Rhodotorula rubra</td>
<td>35, 61</td>
<td></td>
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<tr>
<td>Saccharomyces cerevisiae</td>
<td>53</td>
<td></td>
</tr>
<tr>
<td>Trichoderma longibrachiatum</td>
<td>27</td>
<td></td>
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<tr>
<td>Trichoderma virida</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Trichosporon species</td>
<td>13, 80</td>
<td></td>
</tr>
<tr>
<td>Trichosporon cutaneum</td>
<td>9, 20, 50</td>
<td></td>
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<tr>
<td>Verticillium species</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Wangiella dermatitidis</td>
<td>44</td>
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</tbody>
</table>
and 3 weeks on SDA revealed their dematiaceous nature (Fig. 3). Subsequent subcultures of the isolate at 25°C were totally brown to black. A 5-day slide culture revealed the presence of moniliaceous blastic conidia being produced from dematiaceous hyphae (Fig. 4).

Pathogenicity and identifying features. Fungal peritonitis in patients on CAPD, although significantly less frequent than bacterial peritonitis (3 to 15% versus >80%, respectively), is a well-documented clinical entity (13, 38, 54, 65, 78). Signs and symptoms are essentially the same in both presentations and may include cloudy dialysate effluent, dialysate leukocyte counts greater than 100/mm³, neutrophil counts greater than 50%, abdominal pain, distension, rigidity, nausea and vomiting, diarrhea, and fever. Because of these similarities and the higher incidence of bacterial peritonitis, fungal etiologies may be overlooked and may have contributed, in part, to a delayed antifungal regimen in the case of this patient. She received cefazolin and vancomycin intraperitoneally for 20 days, without improvement, followed by ceftazidime and imipenem intraperitoneally for another 7 days. Not until hospital day 7 (episode day 28), with the report of a *Candida* species in the dialysate, was fluconazole therapy started. Although the route of infection is not clear, several reports have cited altered host flora due to prior or prolonged use of broad-spectrum antibacterial therapy as a significant risk factor and/or as being associated with the development of fungal peritonitis (13, 38, 54, 65, 78). Fungal cultures taken earlier in the course of this patient’s episode or during the administration of antibacterial agents would have provided direction for more appropriate or additional antifungal therapy.

The recovery of cream-colored, mucoid colonies from the dialysate on hospital day 7 (episode day 28) provided the first evidence of a fungal pathogen. Cream-colored mucoid colonies are consistent with a variety of fungal genera, both yeast-like and filamentous, including *Candida*, *Cryptococcus*, *Aureobasidium*, and *Hormonema*. In the genera *Aureobasidium* and *Hormonema*, cream-colored colonies become brownish to olivaceous black with time, thereby requiring extended incubation for recognition of their dematiaceous nature. The API 20C yeast identification system utilized with these colonies failed to provide an identification, giving an unrecognizable code of 6773277. McCarthy et al. recently reported on 4 of 11 isolates of *H. dematioides* coding as *C. albidus* by this method (49). The remaining 7 isolates in their group revealed several different unrecognizable codes, which did not include this isolate’s number, 6773277. Their results reinforce the necessity of performing critical microscopic observations (for blastic conidia, hyphae, pseudohyphae, etc.) and demonstrate the futility of relying solely on binary codes and/or physiologic characteristics for these similar, cream-colored, mucoid taxa. Because the API 20C method failed to provide an identification, the case isolate was subsequently identified by ancillary testing utilizing the Dalmau method for determining the method of conidiogenesis and extended incubation for revealing its dematiaceous affinities. Slide culture preparations normally used for studying methods of conidiogenesis in filamentous fungi.
<table>
<thead>
<tr>
<th>Species</th>
<th>Macroscopic morphology</th>
<th>Microscopic morphology</th>
<th>Physiology</th>
<th>Comments</th>
<th>Reference(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hormonema dematioides</strong></td>
<td>Creamy, moist, mucoid, white to cream initially, becoming brown to black</td>
<td>Hyphae hyaline and dematiaceous; hyaline, oval-shaped blastic conidia, asynchronous, from hyaline and dematiaceous hyphae; nonbudding</td>
<td>Cycloheximide: -; 25°C: +; 35°C: -; 42°C: V; Urease: V; Nitrate: V; Glucose fermentation: -; D-Gluconate: NG; methyl-α-Glucoside: NG</td>
<td>Cornmeal agar Dalmau plate to determine method of conidiogenesis</td>
<td>18, 19, 32, 62</td>
</tr>
<tr>
<td><strong>Aureobasidium pullulans</strong></td>
<td>Creamy, moist, white to cream initially, becoming partly brown to black (frequently with a white, radiating fringe at the periphery)</td>
<td>Hyphae hyaline and dematiaceous; hyaline, oval-shaped blastic conidia, synchronous, from hyaline hyphae only; nonbudding</td>
<td>Cycloheximide: -; 25°C: +; 35°C: -; 42°C: V; Urease: V; Nitrate: V; Glucose fermentation: -; D-Gluconate: G; methyl-α-Glucoside: G</td>
<td>Cornmeal agar Dalmau plate to determine method of conidiogenesis</td>
<td>18, 19, 32, 62</td>
</tr>
<tr>
<td><strong>Candida albicans</strong></td>
<td>Cream colored, numerous phenotypes (dry, wrinkled, mucoid)</td>
<td>Variably sized, globose to oval budding yeast; pseudohyphae and true hyphae; germ tube positive</td>
<td>Cycloheximide: -; 25°C: +; 35°C: +; 42°C: +; Urease: -; Nitrate: -; Glucose fermentation: -; D-Gluconate: +; methyl-α-Glucoside: +</td>
<td>Numerous other yeast species are etiologic agents of CAPD-associated fungal peritonitis</td>
<td>62, 74</td>
</tr>
<tr>
<td><strong>Cryptococcus albidus</strong></td>
<td>Cream-colored to beige to slight pink, mucoid colonies</td>
<td>Large, round budding yeast; no true hyphae or pseudohyphae</td>
<td>Cycloheximide: -; 25°C: +; 35°C: W; 42°C: +; Urease: +; Nitrate: +; Glucose fermentation: +; D-Gluconate: -; methyl-α-Glucoside: -</td>
<td>Some H. dematioides isolates may code as C. albidus by API 20C</td>
<td>49, 62, 74</td>
</tr>
<tr>
<td><strong>Candida parapsilosis</strong></td>
<td>Cream-colored, moist</td>
<td>Branched pseudohyphae, oval budding yeast</td>
<td>Cycloheximide: -; 25°C: +; 35°C: -; 42°C: -; Urease: -; Nitrate: -; Glucose fermentation: -; D-Gluconate: +; methyl-α-Glucoside: +</td>
<td>A common yeast negative for growth on cycloheximide yeast that could be confused with H. dematioides</td>
<td>74</td>
</tr>
</tbody>
</table>

a On SDA.
b Cornmeal agar, Dalmau method.
c Physiology was studied under the following conditions: on medium with cycloheximide; at 25, 35, and 42°C; on Christensen’s urea agar slant (Urease); and by the method of Pincus et al. (62) (Nitrate). Results are reported as follows: –, negative; +, positive; V, variable; W, weak; NG, no growth; and G, growth.

112x317
lates of may actually have been caused by misidentified iso-
conidia in (unpublished data). Additional human sites from
which the organism has been recovered include cerebrospinal
an immunocompetent host (15). Additional human sites from
pathogenicity in humans has been previously documented as
Testing Laboratory (FTL) at the University of Texas Health
ments, as evidenced by the isolates submitted to the Fungus
H. dematioides is an important wood-bluing fungus often
isolated strains (32). Microscopically, hyphae are septate, hy-
are generally less satisfactory than the Dalmau method for
VOL. 36, 1998 NOTES 2161
A. pullulans
(FTL isolates [unpublished data]).

are generally less satisfactory than the Dalmau method for
visualizing the asynchronous or synchronous development of
conidia in Hormonema and Aureobasidium species, respect-

H. dematioides is an important wood-bluing fungus often
isolated from discolored coniferous wood or needles (32). It is
also appears to occupy an ecological niche in moist environ-
ments, as evidenced by the isolates submitted to the Fungus
Testing Laboratory (FTL) at the University of Texas Health
Science Center at San Antonio from high-humidity areas. Its
pathogenicity in humans has been previously documented as
an agent of subcutaneous phaeohyphomycosis of the hands of
an immunocompetent host (15). Additional human sites from
which the organism has been recovered include cerebrospinal
fluid, blood, stool, pleural fluid, a surgical wound, and a knee
(FTL isolates [unpublished data]).

Because authors have illustrated H. dematioides under the
name of A. pullulans, some cases of infection ascribed to A.
pullulans may actually have been caused by misidentified iso-
lates of H. dematioides. Recently Clark et al. described a case
of peritonitis caused by A. pullulans in a patient on CAPD (14).
Caporale et al. reported A. pullulans as an agent of peritoneal
catheter colonization and peritonitis (7). The present case
demonstrates that H. dematioides can also cause CAPD-asso-
ciated peritonitis. The pure growth of the organism from four
separate specimens from a patient who had diffuse abdominal
pain and turbid dialysates indicates that it was the cause of
peritonitis and not a contaminant.

Colonies on SDA at 25°C are white to cream, smooth, and
soon covered with a light slimy mass of blastoconidia. Poorly
condiating cultures are olivaceous black with a wooly mycelial
mat. The optimum temperature for growth is 24°C, with a daily
growth rate of >6 mm; no growth is observed on media con-
taining cycloheximide. Isolates that have been subcultured re-
peatedly conidiate poorly and tend to grow faster than freshly
isolated strains (32). Microscopically, hyphae are septate, hy-
aline, and initially thin walled and soon become brown and
thick walled, with cells wider than they are long. Hyaline,
smooth, ellipsoidal blastic conidia (4.5 to 12 μm by 3 to 4.5
μm) are borne asynchronously by percurrent proliferation
(each successive conidium growing through the tip of the co-
m) are borne asynchronously by percurrent proliferation

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μm) are borne asynchronously by percurrent proliferation
(each successive conidium growing through the tip of the co-
m) are borne asynchronously by percurrent proliferation

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