Epidemiology and Outcomes of Candidemia in 2019 Patients: Data from the Prospective Antifungal Therapy Alliance Registry

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Background. Candidemia remains a major cause of morbidity and mortality in the health care setting, and the epidemiology of Candida infection is changing.

Methods. Clinical data from patients with candidemia were extracted from the Prospective Antifungal Therapy (PATH) Alliance database, a comprehensive registry that collects information regarding invasive fungal infections. A total of 2019 patients, enrolled from 1 July 2004 through 5 March 2008, were identified. Data regarding the candidemia episode were analyzed, including the specific fungal species and patient survival at 12 weeks after diagnosis.

Results. The incidence of candidemia caused by non–Candida albicans Candida species (54.4%) was higher than the incidence of candidemia caused by C. albicans (45.6%). The overall, crude 12-week mortality rate was 35.2%. Patients with Candida parapsilosis candidemia had the lowest mortality rate (23.7%; \( P < .001 \)) and were less likely to be neutropenic (5.1%; \( P < .001 \)) and to receive corticosteroids (33.5%; \( P < .001 \)) or other immuno-suppressive drugs (7.9%; \( P = .002 \)), compared with patients infected with other Candida species. Candida krusei candidemia was most commonly associated with prior use of antifungal agents (70.6%; \( P < .001 \)), hematologic malignancy (52.9%; \( P < .001 \)) or stem cell transplantation (17.7%; \( P < .001 \)), neutropenia (45.1%; \( P < .001 \)), and corticosteroid treatment (60.8%; \( P < .001 \)). Patients with C. krusei candidemia had the highest crude 12-week mortality in this series (52.9%; \( P < .001 \)). Fluconazole was the most commonly administered antimicrobial, followed by the echinocandins, and amphotericin B products were infrequently administered.

Conclusions. The epidemiology and choice of therapy for candidemia are rapidly changing. Additional study is warranted to differentiate host factors and differences in virulence among Candida species and to determine the best therapeutic regimen.

Candidemia is a major cause of morbidity and mortality in the health care setting. However, the incidence of candidemia is increasing with greater complexity of surgical procedures, patient populations at higher risk of infection, and changes in patient demographic characteristics. Prolongation of survival among critically ill patients, especially in the intensive care unit setting, has lead to increased use of invasive procedures, intravenous catheters, and intravenous hyperalimentation, all of which are risk factors for candidemia [1–3]. Recently, the introduction of additional antifungal agents has led to new strategies for empirical and prophylactic therapies. An increasing number of candidial infections are now caused by non–Candida albicans Candida species [4–10].

Candidemia remains associated with high crude and attributable mortality rates and with increased costs of
care and duration of hospitalization. Attributable mortality has been reported to range from 5% to 71%, and crude mortality rates have been reported to be as high as 81% [11–23]. Inappropriate therapy or delays in initiation of therapy have also been linked to increased mortality [24, 25]. This study was performed to evaluate contemporary epidemiology and outcomes of candidemia in multiple North American centers.

METHODS

The patient population for this study was extracted from the Prospective Antifungal Therapy (PATH) Alliance database. The PATH Alliance is a comprehensive multicenter, prospective, observational registry that collects detailed clinical data on patients with invasive fungal infections (IFIs), with special emphasis on fungal epidemiology, diagnosis, treatment, and associated patient outcomes [26, 27].

This study is based on data for the 2019 patients (pediatric and adult) enrolled from 1 July 2004 through 5 March 2008 from 23 North American centers who received a diagnosis of proven candidemia. Detailed information with regard to candidemia episodes were analyzed, including underlying patient characteristics, the specific fungal pathogen and species, anti-fungal therapy, and survival.

A diagnosis of candidemia was made on the basis of ≥1 blood cultures growing Candida species and the presence of relevant clinical signs and symptoms, as enumerated in the guidelines of the 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 [28]. Only the first episode of candidemia was reported for patients with recurrent or subsequent episodes of infection. Patients whose cultures grew ≥1 documented species of Candida were excluded from analysis. Some of these patients are described elsewhere [26].

Fisher’s exact test or χ² test, as appropriate, was used for testing associations between categorical patient characteristics and Candida species. Analysis of variance was used for testing the difference in mean values across Candida species. Survival distribution function was estimated using the Kaplan-Meier product-limit method; nonparametric (log-rank and Wilcoxon) tests were used to compare the survival functions among the different Candida species. Patients were considered to be lost to follow-up if they were discharged home or transferred to another institution prior to the 12-week assessment date and no additional information was available.

RESULTS

Among the 4010 patients with completed case reports of IFIs, 2019 patients (50.3%) with proven candidemia caused by a single species were identified by the PATH Alliance registry. The distribution of isolated Candida species is shown in figure 1. C. albicans was commonly identified (45.6%); however, collectively, non–C. albicans Candida species were more frequently isolated from blood cultures (54.4%). The majority of the other species identified included Candida glabrata (26.0%), Candida parapsilosis (15.7%), Candida tropicalis (8.1%), and Candida krusei (2.5%).

The mean age of patients was 53.5 years (range, 0–96.4 years), and 53.7% were male. Most of the patients were white (62.6%), followed by black (21.7%). Of note, 43.0% of the patients had received antifungal agents as prophylaxis or empirical therapy within 30 days prior to their diagnosis of candidemia. A comparison of patient characteristics across isolated Candida species is presented in table 1. Statistically significant differences were found in the distribution of Candida species with regard to age (P < .001), sex (P = .002), prior antifungal therapy (P < .001), presence of hematologic malignancy (P < .001), hematopoietic stem cell (P < .001) or solid organ transplantation (P = .009), neonatal intensive care unit stay (P = .009), surgery (P = .04), requirement of total parenteral nutrition (P = .04), mechanical ventilation (P = .04), use of central catheters (peripherally inserted, P = .05; tunneled, P = .01; nontunneled, P = .03), presence of neutropenia (P < .001), use of corticosteroids (P < .001) or other immunosuppressive agents (P = .002), and presence of concomitant bacterial infections (P = .04).
The 316 patients with *C. parapsilosis* candidemia were least likely to have risk factors including nontunneled central catheter (24.4%), neutropenia (5.1%), or corticosteroid (33.5%) or other immunosuppressive therapies (7.9%); they were most likely to have had recent surgery (37.0%) or a peripherally inserted central venous catheter (24.4%), neutropenia (5.1%), or corticosteroid (33.5%) or antifungal agents (70.6%), hematologic malignancy (52.9%), stem cell transplantation (17.7%), neutropenia (45.1%), or corticosteroid therapy (60.8%), and patients with *C. krusei* candidemia were less likely to require total parenteral nutrition (21.6%) or mechanical ventilation (27.5%) or to have a concomitant bacterial infection (31.4%). The 525 patients with *C. glabrata* candidemia were more likely to be older (mean age, 58.7 years) or to have undergone solid organ transplantation (12.2%). Patients with *C. albicans* candidemia were the least likely to have a hematologic malignancy (5.9%) and/or to have undergone stem cell transplantation (1.4%). Although rarely encountered, candidemia due to the rarest *Candida* species (e.g., *Candida dubliniensis* and *Candida lusitaniae*) was more likely to occur in male patients (67.0%) or in patients who had undergone stem cell transplantation (34.9%) or used immunosuppressive agents (18.6%).

Among the 2019 patients with candidemia, another 179 funga infections due to *Candida* species were identified at sites other than blood, including the abdomen (95 cases [53.1%]), lungs (17 [9.5%]), skin and soft tissue (14 [7.8%]), eyes (9
Administered antifungal agents; some patients received >1 agent. AMB-LF, any lipid formulation of amphotericin B; AMB-d, amphotericin B deoxycholate; CAS, caspofungin; FLU, fluconazole; MIC, micafungin; VOR, voriconazole.

Table 2. Antifungal therapy administered, by different Candida species.

<table>
<thead>
<tr>
<th>Antifungal agent</th>
<th>Candida species, no. (%) of treated cases</th>
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<tbody>
<tr>
<td></td>
<td>All (n = 2019)</td>
</tr>
<tr>
<td>FLU</td>
<td>1366 (67.7)</td>
</tr>
<tr>
<td>VOR</td>
<td>136 (6.7)</td>
</tr>
<tr>
<td>AMB-D</td>
<td>44 (2.2)</td>
</tr>
<tr>
<td>ABCD</td>
<td>6 (0.3)</td>
</tr>
<tr>
<td>ABLC</td>
<td>86 (4.2)</td>
</tr>
<tr>
<td>L-AMB</td>
<td>110 (5.5)</td>
</tr>
<tr>
<td>LF-AMB</td>
<td>202 (10.0)</td>
</tr>
<tr>
<td>CAS</td>
<td>769 (38.1)</td>
</tr>
<tr>
<td>MIC</td>
<td>219 (10.9)</td>
</tr>
<tr>
<td>Blindb</td>
<td>34 (1.7)</td>
</tr>
<tr>
<td>Combination therapyc</td>
<td>68 (3.4)</td>
</tr>
</tbody>
</table>

NOTE. One patient received itraconazole or posaconazole, 3 patients received anidulafungin, and 6 patients received 5-fluorocytosine. ABCD, amphotericin (AMB) colloid dispersion; ABLC, AMB lipid complex; AMB-D, AMB deoxycholate; FLU, fluconazole; L-AMB, liposomal AMB; LF-AMB, any lipid formulation of AMB; CAS, caspofungin; MIC, micafungin; VOR, voriconazole.

a Other species includes Candida lusitaniae (17 cases), Candida guillermondii (5), Candida dubliniensis (7), other (11), and unknown Candida species (3).
b Blinded therapy as part of a clinical trial.
c Some patients received >1 antifungal agents as combination and/or sequential therapy.
Table 3. Twelve-week outcome, by isolated Candida species.

<table>
<thead>
<tr>
<th>Status at 12 weeks after diagnosis of IFI</th>
<th>Candida species, no. (%) of patients</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>All (n = 2019)</td>
</tr>
<tr>
<td></td>
<td>Candida albicans (n = 921)</td>
</tr>
<tr>
<td></td>
<td>Candida glabrata (n = 526)</td>
</tr>
<tr>
<td></td>
<td>Candida parapsilosis (n = 316)</td>
</tr>
<tr>
<td></td>
<td>Candida tropicalis (n = 163)</td>
</tr>
<tr>
<td></td>
<td>Candida krusei (n = 51)</td>
</tr>
<tr>
<td></td>
<td>Othera (n = 43)</td>
</tr>
<tr>
<td>Alive</td>
<td>704 (34.9) 306 (33.2) 189 (36.0) 124 (39.2) 50 (30.7) 17 (33.3) 18 (41.9)</td>
</tr>
<tr>
<td>Dead</td>
<td>711 (35.2) 328 (35.6) 200 (38.1) 75 (23.7) 67 (41.1) 27 (52.9) 14 (32.6)</td>
</tr>
<tr>
<td>Unknown</td>
<td>604 (29.9) 287 (31.2) 136 (25.9) 117 (37.0) 46 (28.2) 7 (13.7) 11 (25.6)</td>
</tr>
</tbody>
</table>

**NOTE.** P < .001, by log-rank test.

*a* Other species included Candida lusitaniae (17 cases), Candida guillermondii (5), C. dubliniensis (7), other (11), and unknown Candida species (3).

didemia had the highest mortality rate (52.9%) in this cohort. A statistically significant difference in the 12-week survival distributions by Candida species (P < .001) was found (figure 3). Survival patterns among patients with candidemia due to C. albicans, C. glabrata, C. tropicalis, and other Candida species were similar. A statistically significant difference in the 12-week survival distributions (P < .001) was found based on age (83.2% for 0 to <19 years of age, 68.7% for 19–65 years of age, and 52.7% for >65 years of age) (figure 4). When analyzed by Candida species and age group, a similar pattern was seen with C. albicans (P < .001), C. glabrata (P < .002), and C. parapsilosis (P < .007). No statistically significant differences were observed with C. tropicalis, C. krusei, or other Candida species. No statistically significant difference in the 12-week survival distributions was found when analyzed by ethnicity (data not shown).

**DISCUSSION**

A cohort of 2019 patients with candidemia was identified and analyzed from the PATH Alliance registry, a prospective data-base of IFIs at major North American medical centers. To our knowledge, this is the largest cohort of patients with candidemia, with contemporary patients enrolled from July 2004 through March 2008. Other large series of patients with candidemia were from earlier periods, enrolled from 1991 through 2000 (1137 episodes of candidemia) [29] and from February 1995 through November 1997 (1447 adults and 144 children with candidemia) [8]. We observed a predominance of non-C. albicans Candida species (54.4%); C. albicans was the most frequently isolated species (45.6%). We report an overall, 12-week crude mortality rate of 35.2% among patients who experienced a single episode of candidemia, with the lowest mortality observed among patients with C. parapsilosis candidemia and the highest among patients with C. krusei candidemia.

Candidemia has been identified among the most common etiologic agents of bloodstream infections. It ranked seventh in a nationwide survey of 17 hospitals in Switzerland [29] and fourth in the Surveillance and Control of Pathogens of Epidemiologic Importance (SCOPE) surveillance study of bloodstream infections in hospitalized patients in the United States.

![Figure 3](image-url). Survival among patients with candidemia at 12 weeks, by Candida species (Candida albicans, Candida glabrata, Candida krusei, Candida parapsilosis, and Candida tropicalis).
Figure 4. Survival among patients with candidemia at 12 weeks, by age group

[30]. *C. albicans* has traditionally been the predominant *Candida* species isolated, followed by *C. glabrata* and other non-*C. albicans Candida* species, in both pediatric and adult patient populations [8, 29, 30]. In a worldwide surveillance program (1997–2003) that included 134,715 consecutive clinical isolates of *Candida* species from 127 medical centers in 39 countries, a trend toward a decrease in *C. albicans* and an increase in *C. tropicalis* and *C. parapsilosis* was noted [31]. In addition, species distribution differences have been reported throughout the world. For example, *C. albicans* and *C. glabrata* were most frequently identified in series from Denmark and the United States, although South America had lower rates of these species [31]. In this study population from the PATH Alliance, non-*C. albicans Candida* species were more frequently isolated than was *C. albicans* (54.4% vs. 45.6%). Patients with *C. glabrata* and *C. krusei* candidemia were the most likely to have received prior antifungal therapy. This likely reflects, in part, selective pressure because of the extensive use of prophylactic fluconazole in susceptible hosts [32, 33]. In addition, severe immunosuppression or illness, prematurity, exposure to broad-spectrum antibiotics, and older age may contribute to the increased incidence of candidemia caused by non-*C. albicans Candida* species, especially *C. glabrata*, *C. krusei*, *C. parapsilosis*, and *C. tropicalis* [34–41]. We observed an association between neutropenia and the use of corticosteroids and *C. krusei* candidemia, consistent with the underlying medical conditions of these patients, including hematologic malignancy and stem cell transplantation, and the associated prior use of azole prophylaxis. Patients with *C. krusei* candidemia were younger and did not generally have such additional risk factors as parenteral nutrition, mechanical ventilation, and concomitant bacterial infections. Older age and receipt of a solid organ transplant were associated with *C. glabrata* candidemia. Our observations suggest that the changing patient population and practices involved in their care may contribute to the continual shift in the epidemiology of *Candida* species.

In the present study, the azole antifungals were the most frequently administered antifungal agents, followed by the echinocandins. Combination therapy remains an uncommon practice in the treatment of candidemia. Overall, amphotericin B products were infrequently administered, especially amphotericin B deoxycholate, which was used for <3% of patients. The relatively recent introduction of echinocandins and azoles will necessitate re-evaluation of clinical outcomes of therapy for candidemia over time. The differences observed in the use of antifungal agents based on the different *Candida* species may, in part, be explained by the variations in their susceptibility profiles (when available), empirical therapy based on existing treatment guidelines [10], or differences in clinical practice, including prophylactic programs, among the participating centers. As outlined in the recently revised guidelines for the treatment of candidemia by the Infectious Diseases Society of America, treatment should be adjusted on the basis of the *Candida* species isolated (42).

Retrospective cohort studies involving patients with candidemia and varying underlying diseases have revealed worldwide crude and attributable mortality rates of 30%–81% and 5%–71%, respectively [11–22]. In our series, patients with candidemia had a crude 12-week mortality rate of 35.2%. Survival appears to be improved, compared with that in many older studies. The identification of candidemia as one of the leading causes of bloodstream infections [30] and greater knowledge of major risk factors for candidemia [21] have likely led to higher clinical suspicion, prompt initiation of diagnostic testing, and pre-emptive or empirical treatment with new, effective, and well-tolerated antifungal agents. In this series, the use of nonculture diagnostic methods was rarely a factor in the ini-
tiation of antifungal therapy (<1%). Thus, improved outcomes could not be attributed to these diagnostic tools.

The highest and lowest crude mortality rates reported in the SCOPE surveillance study [30] were for \textit{C. krusei} and \textit{C. parapsilosis} candidemia. Similarly, candidemia due to \textit{C. krusei} was associated with the highest mortality rate observed in this series (52.9%). This can be explained, in part, by underlying immune deficits in the patient populations most frequently affected by these species, including patients with hematologic malignancies and stem cell transplant recipients. Our findings suggest that patients with \textit{C. parapsilosis} candidemia have the lowest mortality rate (23.7%); this finding is consistent with the results of prior studies [20, 30, 43]. These patients were less likely to be neutropenic or to be receiving corticosteroids and other immunosuppressive agents; this is consistent with the mechanism by which \textit{C. parapsilosis} causes infection, in association with contaminated infusates and catheters. As was reported in a separate analysis [44], we observed similar mortality rates for \textit{C. albicans} and \textit{C. glabrata} candidemia in this study. Our findings, based on a large number of patients, strongly suggest that there may not be significant differences in survival associated with infection due to the 2 most common \textit{Candida} species. Additional prospective or case-control studies are needed to delineate differences between other specific \textit{Candida} species.

Limitations of the present study include differences in clinical practices across different centers, limited follow-up data, the inability to clearly distinguish between prophylactic and empirical therapy or sequential and concomitant antifungal therapy, and the collection of data from only institutions in North America. Despite these limitations, the data collected by the PATH Alliance registry include a very large number of patients with IFIs with a broad spectrum of underlying conditions. This database will likely prove to be a significant asset in the understanding of IFIs, including candidemia [45]. Differences in the outcomes and presentations of IFIs will be addressed by the PATH Alliance with large cohort studies and case-control studies to provide more information on optimal approaches to candidemia and other IFIs.

**PROSPECTIVE ANTIFUNGAL THERAPY (PATH) ALLIANCE**

**Contributing sites.** Thomas Jefferson University Hospital (Philadelphia, PA), Massachusetts General Hospital (Boston), University of Pittsburgh (Pittsburgh, PA), Duke University Medical Center (Durham, NC), University of Arkansas for Medical Sciences (Little Rock), University of Michigan Health System (Ann Arbor), Washington Hospital Center (Washington, DC), Hamilton Health Sciences (Hamilton, Ontario, Canada), University of Iowa Health Care (Iowa City), University of Washington (Seattle), University of Wisconsin Medical School (Madison), Oregon Health & Science University (Portland), University of Nebraska Medical Center (Omaha), University of Miami (Miami, FL), Mount Sinai School of Medicine (New York, New York), University of Minnesota (Minneapolis), University of Pennsylvania (Philadelphia), University of Alabama at Birmingham (Birmingham), Emory University (Atlanta, GA), Children’s Memorial Hospital (Chicago, IL), and Hôpital Maisonneuve-Rosemont (Montreal, Quebec, Canada).

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consultant work through third parties to Astellas, Topigen, and AstraZeneca. K.W. provided work on a contract basis for Astellas Pharma (US and Canada), through her previous employment at Axiom Real-Time Metrics.

References

