Rapid Species Identification and Antifungal Susceptibility Testing of *Candida* Isolated from Different Hospital Acquired Infections by VITEK 2 System

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**Abstract**

Hospital acquired *Candida* infection is a major cause of morbidity and mortality especially in critically ill and immunocompromised patients. Therefore, an accurate and early identification is necessary for the management of patients. The aim of our study was rapid identification of *Candida* species and their antifungal susceptibility testing (AST) by VITEK 2 system in hospital acquired fungal infections. A total of 50 *Candida* isolates were identified by both conventional methods and by Vitek-2 system. Antifungal susceptibility of each isolate was determined by broth microdilution method and Vitek-2 system. Out of these 50 *Candida* isolates, *C. albicans* (n = 29) were most commonly isolated, followed by *C. tropicalis* (n = 9), *C. krusei* (n = 6), *C. glabrata* (n = 4), and *C. parapsilosis* (n = 2). *C. albicans*, *C. tropicalis* and *C. krusei* showed resistance to Flucytosine. *C. albicans* and *C. glabrata* showed resistance to Voriconazole. *C. krusei* showed resistance to Amphotericin B. All the correlation coefficient indices were statistically significant between Vitek-2 system and broth microdilution method in antifungal susceptibility testing of different *Candida* species. Sensitivity and specificity of Vitek2 system method in antifungal susceptibility testing for Flucytosine were 84%, 86% respectively, for Voriconazole were 94%, 96% respectively, and for Amphotericin B were 96%, 98% respectively. Our study revealed that Vitek-2 system reduces the period required for identification and antifungal susceptibility of *Candida* species. So, Vitek-2 system appeared to be a rapid reliable method for identification and AST for the *Candida* species to prescribe appropriate antifungal agents for early and better management of fungal infections especially in critically ill and immunosuppressed patients.

**Keywords**

*Candida* species, Vitek 2 system, Hospital acquired fungal infections, Antifungal drugs, Antifungal resistance, Broth microdilution method

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**Introduction**

Hospital acquired Yeast infections has been markedly increasing resulting in high morbidity and mortality (Espinel-Ingroff et al., 2005). This is particularly important in cancer patients who are undergoing chemotherapy, especially if neutropenic, and these infections can lead to bad prognosis (Vento et al., 2003). The most common causative pathogens for hospital acquired fungal infections were *Candida* species especially in both immunocompromised and seriously ill patients. In spite that the most commonly isolated species in clinical laboratories is *Candida albicans*, non-albicans species has been increasing in the frequency (Barbara Graf et al., 2011). The most common non-albicans species were *C. tropicalis*, *C. parapsilosis* and *C. glabrata* which were considered major causative pathogens of candidemia (Meyer et al., 2009).
Fungal candidemia prognosis depends on the host immunological status, the yeast species virulence, the antifungals resistance of the causative yeast, and the antifungal therapy efficacy. Fungal infection especially in immunocompromised patients can be rapidly fatal if not early and accurately treated. Thus, early identification of species and antifungal susceptibility testing in cases of critical infections is crucial (Pereira et al., 2010). Azole resistance has emerged in many Candida species, like C. glabrata which is known to have acquired resistance to fluconazole and otherazole drugs. On the other hand, C. krusei showed intrinsic resistance to older azoles antifungals.

Amphotericin resistance has been detected in species, such as C. lusitaniae and C. haemulonii (Rodriguez-Tudela et al., 2008). This emerged antifungal resistance, particularly withazole drugs, amphotericin B and echinocandins (which is a new class of antifungal) necessitates the accurate in vitro antifungal susceptibility testing. The empiric therapy for treatment of hospital acquired fungal infections caused by unknown Candida spp. should be avoided (Clinical and Laboratory Standards Institute, 2008; Diekema et al., 2009). Identification of Candida isolates by either classical or conventional methods is still typically done by biochemical, morphological and physiological tests.

These phenotypic systems are usually less accurate and time-consuming. In addition, they can't identify the Candida at the species level. To have a reliable system for species identification, the performance of classical methods should be reassessed (Maurizio Sanguinit et al., 2007). The Clinical and Laboratory Standards Institute (CLSI) and the European Committee on Antimicrobial Susceptibility Testing (EUCAST) considered broth microdilution methods for antifungal Susceptibility Testing as the standard reference methods for antifungal susceptibility testing (Verweij et al., 1999; Rodriguez-Tudela et al., 2008). Although a number of AST systems are commercially available, their performance is variable and time consuming (Buchaille et al., 1998; Cuenca-Estrella et al., 2005; Hata et al., 2007; and Zaragoza et al., 2011). The Vitek 2 antifungal susceptibility system is a fully automated commercial system that determines growth of yeast spectrophotometrically and simultaneously allowed both identification of fungal species and antifungal susceptibility testing. The species identification by the Vitek 2 cards is performed through comparison of the biochemical profile with an extensive database (Al-Sweih et al., 2005 and Mokaddas et al., 2007). AST-Y0S1 cards used and can detect antifungal susceptibility for amphotericin B (AMB), fluconazole (FLC), flucytosine (5FC), and voriconazole (VRC) antifungal drugs. The minimum inhibitory concentration (MIC) can be determined by microdilution methodology in μg/ml (Pfaller et al., 2007). The Vitek 2 system has been reported by many scientists to have high reproducibility and an excellent agreement with the CLSI microdilution reference procedure (>95%) for fluconazole and, more recently, for amphotericin B, flucytosine, and voriconazole (Posteraro et al., 2009). Antifungal susceptibility in MIC results can be determined the after 9.1 to 27.1 h of incubation (mean, 12 to 14 h) (Pfaller et al., 2007). Thus, the U.S. FDA approved in 2006 the clinical use of the Vitek 2 system to detect antifungal susceptibility (Pfaller et al., 2007). Early and rapid identification and drug susceptibility testing of Candida infections can help prompt optimization of antimicrobial therapy and save the life of many patients (Sood et al., 2000).
Materials and Methods

Patients

This study was carried out at the Medical Microbiology and Immunology Department, Faculty of medicine, Tanta University, Egypt.

Samples were collected from patients who were admitted to Tanta University Hospitals over a period of 6-9 months. Inclusion criteria of patients were immunocompromised patients such as cancer patients receiving chemotherapy especially with neutropenia or cell mediated immunodeficiencies, patients under corticosteroid therapy, and diabetic patients that are at high risk of fungal infection. Exclusion criteria were all samples with laboratory confirmed isolates other than Candida infections, and patients under antifungal treatment.

Materials and Methods

Patients’ demographics were recorded followed by clinical examination to determine the type of infection, and Microbiological investigations as follows:

Samples collection, transport and isolation of Candida species

Different samples including oral, vaginal, anorectal, urine, stool, respiratory tract specimens, endotracheal aspiration and blood samples were collected under aseptic precautions. Samples were transported as soon as possible to the medical Microbiology and Immunology Department, faculty of medicine, Tanta university and were subjected to the following: direct smear examination, culture on Sabouraud’s Dextrose agar (Oxoid). Blood samples were cultured on blood culture bottles (Oxoid), and then subcultured on Sabouraud’s Dextrose agar. Arising colonies were identified by colony morphology and stained films, germ tube test, and sugar fermentation.

Antifungal susceptibility testing by broth microdilution method

Antifungal susceptibility testing was performed according to CLSI broth microdilution (BMD) reference method (Clinical and Laboratory Standards Institute, 2008; Verweij, 1999). The MICs for flucytosine, voriconazole, and amphotericin B were determined. The following antifungal compounds were included in our assay: Amphotericin B (0.03-16 µg/mL, Sigma-Aldrich), flucytosine (0.12-64 µg/mL, Sigma-Aldrich), and voriconazole (0.015-8 µg/mL, Pfizer S.A., NY). A stock solution of each antifungal agent was prepared in two-milliliter aliquots in either dimethyl-sulfoxide (amphotericin B and voriconazole) or in distilled water (flucytosine). The media used for the final drug dilutions was RPMI 1640 with potassium bicarbonate and without L-glutamine, buffered to pH 7 using 165 mM MOPS buffer (Sigma-Aldrich). The media were prepared as 2x stocks, and 100 µL was added to each well of the microdilution plates. The plates were sealed and were stored at -80 ºC until use. The amphotericin B MIC was read as the lowest concentration that produced the complete inhibition of growth, the flucytosine and voriconazole MICs were read as the lowest concentrations that produced a prominent decrease in turbidity (an approximately 50% reduction in growth) relative to the growth for the drug-free control (National Committee for Clinical Laboratory Standards, 2002).

Identification of Candida species and antifungal susceptibility by VITEK 2 system using ID-YST card

Before testing, a suspension of each isolate was inoculated onto Sabouraud dextrose agar
slants to ensure the purity and the viability of the cultures. The inoculum suspensions for the VITEK 2 were prepared in sterile saline at turbidity equal to a 2.0 McFarland standard. The individual test cards were automatically filled with the prepared culture suspension, sealed, and incubated by the VITEK 2 instrument. The cards were incubated at 35.5°C for 18 h, and optical density readings were taken automatically every 15 min. The final profile results were compared with the database, and the identification of the unknown organism was obtained, a final identification of "excellent," "very good," "good," "acceptable or "low-discrimination" was considered to be correct. For antifungal susceptibility test: The VITEK 2 cards containing serial two fold dilutions of amphotericin B, flucytosine, and voriconazole were provided by the manufacturer. Candida inocula were prepared in sterile distilled water from a 24-h culture and were incubated on Sabouraud dextrose agar at 35 ºC or 30 ºC. The inocula for the VITEK 2 were prepared in sterile saline to turbidity equal to a 2.0 McFarland standard. Each standardized inoculum suspension was placed into a VITEK 2 cassette along with a sterile polystyrene test tube and a yeast susceptibility test card. The cassettes were placed in the VITEK 2 instrument and the respective yeast suspensions were diluted appropriately, after which the cards were filled, incubated, and read automatically by the VITEK 2.

The time of incubation varied from 10 to 30 h based on the growth rate in the drug-free control well, and the results were expressed as MICs in micrograms per milliliter.

**Results and Discussion**

The present study was done on 50 Candida isolates identified into species level by Vitek-2 system. C. albicans (n = 29) (58%) were most commonly isolated, followed by C. tropicalis (n = 9) (18%), C. krusei (n = 6) (12%), C. glabrata (n = 4) (8%), and C. parapsilosis (n = 2) (4%).

As shown in table 1, AST for Candida albicans, showed that all of them were susceptible for Amphotericin B by both Vitek-2 system and BMD method. 27 isolates (93.1%) were susceptible for Voriconazole by Vitek-2 system while 28 (96.6%) were susceptible for the same drug by BMD method. 26 C. albicans (89.7%) were susceptible for Flucytosine by Vitek-2 system and 28 (96.6%) were susceptible for Flucytosine by BMD method but 3 (10.3%), 2 (6.9%) were resistant to both Flucytosine and Voriconazole by Vitek-2 system respectively, 1 (3.4%) was resistant to both Flucytosine and Voriconazole by BMD method. As regards to C. tropicalis (n=9), AST showed that all of them were susceptible for Amphotericin B and Voriconazole by both Vitek-2 system and BMD method, eight (88.9%) were susceptible for Flucytosine by both Vitek-2 system BMD method and only one (11.1%) was resistant to Flucytosine by both Vitek-2 system BMD method. Among C. krusei (n=6), all of them were susceptible for Voriconazole by both Vitek-2 system and BMD method, 4 (66.7%) were susceptible for Amphotericin B by Vitek-2 system and 5 (83.3%) were susceptible for Amphotericin B by BMD method, 2 (33.3%) were susceptible for Flucytosine by Vitek-2 system and 1 (16.7%) was susceptible for Flucytosine by BMD method and 4 (66.7%), 2 (33.3%) showed resistance to both Flucytosine and Amphotericin B by Vitek-2 system and BMD method respectively. All of C. glabrata isolates (n=4) were susceptible for Flucytosine and Amphotericin B by both Vitek-2 system and BMD method, 3 (75%) were susceptible for Voriconazole by both Vitek-2 system and
BMD method and 1 isolate (25%) was resistant to Voriconazole. Lastly, *C. parapsilosis* (n=2) were susceptible for Voriconazole, Flucytosine, and Amphotericin B by both Vitek-2 system and BMD method.

All the correlation coefficient indices were statistically significant between Vitek-2 system and broth microdilution method in antifungal susceptibility testing of different *Candida* species (Table 2). Sensitivity and Specificity of Vitek2 system method in antifungal susceptibility testing for Flucytosine were 84%, 86% respectively, Sensitivity and Specificity for Voriconazole were 94%, 96% respectively, and Sensitivity and Specificity for Amphotericin B were 96%, 98% respectively. We used broth microdilution method as reference method (Table 3).

**Table.1** Antifungal susceptibility testing of different *Candida* species by Vitek2 system and broth microdilution method (BMD)

| Species name (n=50) | Identification method | Flucytosine | Voriconazole | Amphotericin B |
|--------------------|-----------------------|-------------|--------------|---------------|
| C. albicans (n=29) | Vitek 2               | 26 (89.7%)  | 27 (93.1%)   | 29 (100%)     |
|                    | BMD                   | 28 (96.6%)  | 28 (96.6%)   | 29 (100%)     |
| C. tropicalis (n=9)| Vitek 2               | 8 (88.9%)   | 9 (100%)     | 9 (100%)      |
|                    | BMD                   | 8 (88.9%)   | 9 (100%)     | 9 (100%)      |
| C. krusei (n=6)    | Vitek 2               | 2 (33.3%)   | 6 (100%)     | 4 (66.7%)     |
|                    | BMD                   | 1 (16.7%)   | 6 (100%)     | 5 (83.3%)     |
| C. glabrata (n=4)  | Vitek 2               | 4 (100%)    | 3 (75%)      | 4 (100%)      |
|                    | BMD                   | 4 (100%)    | 3 (75%)      | 4 (100%)      |
| C. parapsilosis (n=2)| Vitek 2            | 2 (100%)    | 2 (100%)     | 2 (100%)      |
|                    | BMD                   | 2 (100%)    | 2 (100%)     | 2 (100%)      |

S= susceptible R=Resistant
N.B: The CLSI interpretive breakpoints for flucytosine (susceptible less or equal to 4 μg/mL, resistant more or equal to 32 μg/mL), for voriconazole (susceptible less or equal to 1 μg/mL, resistant more or equal to 4 μg/mL) and for amphotericin B, isolates with MICs of ≥1 μg/mL were categorized as resistant.

**Table.2** Comparison between Vitek2 system and broth microdilution method in antifungal susceptibility testing of different *Candida* species

| Species name | Vitek 2 | BMD |
|--------------|---------|-----|
|              | Flucytosine | Voriconazole | Amphotericin B |
|              | r | P.value | r | P.value | r | P.value |
| C. albicans  | 0.574 | 0.619 | 0.924 |
| C. tropicalis| 0.854 | 0.863 | 0.863 |
| C. krusei    | 0.523 | 0.831 | 0.523 |
| C. glabrata  | 0.812 | 0.819 | 0.924 |
| C. parapsilosis| 0.803 | 0.803 | 0.924 |

*statistically significant

r=Correlation coefficient
Candida species is a major causative organism of hospital acquired systemic mycosis, morbidity and mortality worldwide, especially in critically ill and immunocompromised patients (Sardi et al., 2013). Among Candida species, C. albicans, C. glabrata, C. tropicalis, C. parapsilosis, and C. krusei were the most common species recovered in clinical laboratories (Graf et al., 2000). Our study was carried on 50 Candida isolates identified into species level by Vitek-2 system. C. albicans (58%) were most commonly isolated, followed by C. tropicalis (18%), C. krusei (12%), C. glabrata (8%), and C. parapsilosis (4%). These results are in agreement with a previous study of Jha et al., 2006 in which the majority of Candida species were C. albicans (70%) followed by C. tropicalis (13.33%), C. krusei (10%), C. glabrata, C. parapsilosis (3.33%), and C. stellatoidea (3.33%). Also Kumari et al., 2014 found similar results. In our study, we also evaluated the Vitek-2 AST system with the CLSI broth microdilution method for antifungal susceptibility testing of Candida species. Most of Candida isolates were susceptible to both antifungal drugs tested by AST Vitek-2 cards and the CLSI BMD method, but some of C. albicans, C. tropicalis and C. krusei showed resistance to Flucytosine by both Vitek-2 system and BMD method. Some of C. albicans and C. glabrata strains showed resistance to Voriconazole. Similarly, Magill et al., (2006) and Pfaffer et al., (2007) detected resistance to azole antifungal drugs in C. albicans and C. glabrata species. Four (66.7%) of the isolates of C. krusei were resistant to Flucytosine drug and 2 (33.3%) were resistant to amphotericin B by Vitek-2 system and 5 (83.3%) were resistant to Flucytosine and 1 (16.7%) was resistant to amphotericin B by CLSI broth microdilution method. This has noted by other workers, Pahwa et al., (2014) and Zhang et al., (2015) who found that C. krusei was the most resistant species to many antifungal drugs and had intrinsic resistance to azole drugs and poor susceptibility to other antifungals, including amphotericin B. For this reason, Flucytosine and amphotericin B should be avoided in treatment of C. krusei fungal infections. Vitek-2 system was the first commercially available automated approach to AST and provides optimal susceptibility test standardization (Alexander and Pfaffer, 2006). In our study all the correlation coefficient indices between Vitek-2 system and broth microdilution method (reference method) in antifungal susceptibility testing of different Candida species were statistically significant and sensitivity and specificity of Vitek 2 system method in antifungal susceptibility testing for Flucytosine were 84%, 86% respectively, for Voriconazole were 94%, 96% respectively, and for Amphotericin B were 96%, 98% respectively. Our results were in parallel with that of Pfaffer et al., (2007). We could conclude that Vitek-2 system can be used as a reliable method for AST in addition to its reliability as a rapid method for Candida species identification.

The present study revealed that Vitek-2 system reduces the period required for identification and antifungal susceptibility of

### Table 3 Sensitivity and specificity of Vitek2 system method in antifungal susceptibility testing of different Candida species

| Antibiotic     | Sensitivity | Specificity | PPV  | NPV  | Accuracy |
|----------------|-------------|-------------|------|------|----------|
| Flucytosine    | 84%         | 86%         | 85%  | 84%  | 85%      |
| Voriconazole   | 94%         | 96%         | 96%  | 94%  | 95%      |
| Amphotericin B | 96%         | 98%         | 98%  | 96%  | 97%      |
Candida species isolates. So, Vitek-2 system appeared to be a rapid reliable method for identification and AST for the Candida species to prescribe appropriate antifungal agents for the better management of hospital acquired fungal infections especially in critically ill and immunosuppressed patients.

References

Alexander BD and Pfaller MA. 2006. Contemporary tools for the diagnosis and management of invasive mycosis. Clin. Infect. Dis. 43(Suppl. 1): S15–S27.

Al-Sweih N S, Ahmad Z U, Khan S, Khan and Chandy R. 2005. Prevalence of Candida dubliniensis among germ tube-positive Candida isolates in a maternity hospital in Kuwait. Mycoses 48:347-351.

Barbara G, Thomas A, Edith Z and Ulf BG. 2011. Evaluation of the VITEK 2 System for Rapid Identification of Yeasts and Yeast-Like Organisms; 55:1563–1570.

Buchaille L, Freydiere AM, Guinet R, Gille Y. 1998. Evaluation of six commercial systems for identification of medically important yeasts. Eur J ClinMicrobiol Infect Dis 17:479-488.

Cuenca-Estrella M, Gomez-Lopez A, Mellado E, Rodriguez-Tudela JL. 2005. Correlation between the procedure for antifungal susceptibility testing for Candida spp. of the European Committee on Antibiotic Susceptibility Testing (EUCAST) and four commercial techniques. ClinMicrobiol Infect 11:486-492.

Diekema DJ, Messer SA, Boyken LB, Hollis RJ, Kroeger J, Tendolkar S, Pfaller MA. 2009. In Vitro activity of seven systemically active antifungal agents against a large global collection of rare Candida species as determined by CLSI broth microdilution methods. J ClinMicrobiol 47:3170-3177.

Espinel-Ingroff A, Barchiesi F, Cuenca-Estrella M, Pfaller MA, Rinaldi M, Rodriguez-Tudela JL, Verweij PE. 2005. International and multicenter comparison of EUCAST and CLSI M27-A2 broth microdilution methods for testing susceptibilities of Candida spp. to fluconazole, itraconazole, posaconazole, and voriconazole. J Clin Microbiol 43:3884-3889.

Graf B, Adam T, Zill E, Gőbel UB. 2000. Evaluation of the VITEK 2 system for rapid identification of yeasts and yeast-like organisms. J ClinMicrobiol.; 38:1782–5.

Hata DJ, Hall L, Fothergill AW, Larone DH, Wengenack NL. 2007. Multicenter Evaluation of the New VITEK 2 Advanced Colorimetric Yeast Identification Card. J ClinMicrobiol 45:1087-1092.

Jha BJ, Dey S, Tamang MD, Joshy ME, Shivananda PG, Brahmadatan KN. 2006. Characterization of Candida species isolated from cases of lower respiratory tract infection. Kathmandu Univ Med J (KUMJ); 4:290–4.

Kumari KS, Raghunath P, Harshawardhan B, Chaudhury A. 2014. Distribution of Candida albicans and the non-albicans Candida species in different clinical specimens from South India. Int J Microbiol Res.; 5:1–5.

Magill SS, Shields C, Sears CL, Choti M, and Merz WG. 2006. Triazole-cross resistance among Candida spp.: case report, occurrence among blood stream isolates, and implication for antifungal therapy. J. Clin. Microbiol. 44:529–535.

Maurizio S, Rosaria P, Michela S, Marilena LS, Giovanni P, Giovanni F and Brunella P. 2007. Evaluation of VITEK 2 and RapID Yeast plus Systems for Yeast Species Identification:
Experience at a Large Clinical Microbiology Laboratory.

Meyer W, Aanensen DM, Boekhout T, Cogliati M, Diaz MR, Esposto MC, Fisher M, Gilgado Hagen F, Kaoccharoen S, Litvintseva AP, Mitchell TG, Simwami SP, Trilles L, Viviani MA, Kwon-Chung KJ. 2009. Consensus multi-locus sequence typing scheme for Cryptococcus neoformans and Cryptococcus gattii. Med Mycol 47:561-570.

Mokaddas, EM, Al Sweih NA, and Khan ZU. 2007. Species distribution and antifungal susceptibility of Candida bloodstream isolates in Kuwait: a 10-year study. J. Med. Microbiol. 56:255-259.

National Committee for Clinical Laboratory Standards. 2002. Reference method for broth dilution antifungal susceptibility testing of yeasts: approved standard, 2nd ed., M27-A2. National Committee for Clinical Laboratory Standards.

Pahwa N, Kumar R, Nirkhiwale S, Bandi A. 2014. Species distribution and drug susceptibility of Candida in clinical isolates from a tertiary care centre at Indore. Indian J Med Microbiol.; 32:44-8.

Park BJ, Arthington-Skaggs BA, Hajjeh RA et al., 2006. Evaluation of amphotericin B interpretive break points for Candida blood stream isolates by correlation with therapeutic outcome. Antimicrob. Agents Chemother. 50: 1287–1292.

Pereira GH, Muller PR, Szeszs MW, Levin AS, Melhem MS. 2010. Five-year evaluation of bloodstream yeast infections in a tertiary hospital: the predominance of non-C. albicans species. Med Mycol 48:839-842.

Pfaller MA, Diekema DJ, Procop GW, Rinaldi MG. 2007. Multicenter comparison of the Vitek 2 antifungal susceptibility test with the CLSI broth microdilution reference method for testing amphotericin B, fluocytosine, and voriconazole against Candida species. J Clin Microbiol., 45:3522–8.

Pfaller MA, Diekema DJ, Rex JH et al., 2006. Correlation of MIC with outcome for Candida species against voriconazole: analysis and proposal for interpretive breakpoints. J. Clin. Microbiol. 44:819–826.

Posteraro B, Martucci R, La Sorda M, Fiori B, Sanglard D, De Carolis E, Florio AR, Fadda G, and Sanguinetti M. 2009. Reliability of the Vitek 2 yeast susceptibility test for detection of in vitro resistance to fluconazole and voriconazole in clinical isolates of Candida albicans and Candida glabrata. J. Clin. Microbiol. 47:1927-1930.

Rex JH, Pfaller MA, Galgiani JN et al., 1997. Development of interpretive breakpoints for antifungal susceptibility testing: conceptual framework and analysis of in vitro-in vivo correlation data for fluconazole, itraconazole, and Candida infections. Clin. Infect. Dis. 24:235–247.

Rodero L, Cuenca-Estrella M, Cordoba S, Cahn P, Davel G, Kaufman S, Guelfand L, Rodriguez-Tudela JL. 2002. Transient fungemia caused by an amphotericin B-resistant isolate of Candida haemulonii. J Clin Microbiol 40:2266-2269.

Sardi JC, Scorzoni L, Bernardi T, Fusco-Almeida AM, Mendes Giannini MJ. 2013. Candida species: Current epidemiology, pathogenicity, biofilm
formation, natural antifungal products and new therapeutic options. J Med Microbiol., 62(Pt 1):10–24.
Sood P, Mishra B, Dogra V, Mandal A. 2000. Comparison of Vitek Yeast Biochemical Card with conventional methods for speciation of Candida. Indian J Pathol Microbiol.; 43:143–5.
Vento S1, Cainelli F et al., 2003. Methods and compositions for detection of microorganisms and cells and treatment of diseases and disorders. United States Patent. Lancet Oncol. 7763420; 4(10): 595-604.
Verweij PE, Breuker IM, Rijs AJ, Meiss JF. 1999. Comparative study of seven commercial yeast identification systems. J Clin Pathol 52:271-273.
Zaragoza O, Mesa-Arango AC, Gomez-Lopez A, Bernal-Martinez L, Rodriguez-Tudela JL, Cuenca-Estrella M. 2011. A Process Analysis of Variables for Standardization of Antifungal Susceptibility Testing of Non-Fermentative Yeasts. Antimicrob Agents Chemother 55:1563-1570.
Zhang L, Xiao M, Watts MR, Wang H, Fan X, Kong F, et al., 2015. Development of fluconazole resistance in a series of Candida parapsilosis isolates from a persistent candidemia patient with prolonged antifungal therapy. BMC Infect Dis., 15:340.

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