Original Article

In vitro activity of five antifungal agents against *Candida albicans* isolates, Sari, Iran

Shokohi T[1,2], Badali H[1,2], Amirrajab N[3], Ataollahi MR[4], Kouhpayeh SA[5], Afsarian MH[4*]

[1] Invasive Fungal Research Center, Mazandaran University of Medical Sciences, Sari, Iran
[2] Department of Medical Mycology and Parasitology, School of Medicine, Mazandaran University of Medical Sciences, Sari, Iran
[3] Department of Medical Laboratory Sciences, School of Paramedicine/Infectious & Tropical Diseases Research Center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
[4] Department of Medical Microbiology, School of Medicine, Fasa University of Medical Sciences, Fasa, Iran
[5] Department of Pharmacology, School of Medicine, Fasa University of Medical Sciences, Fasa, Iran

*** Corresponding author: Mohammad Hosein Afsarian**, Department of Medical Microbiology, School of Medicine, Fasa University of Medical Sciences, Fasa, Iran. Email: afsariyan@gmail.com

(Received: 3 September 2016; Revised: 9 October 2016; Accepted: 16 October 2016)

Abstract

Background and Purpose: *Candida albicans* is the most common causative agent of candidiasis. Candidiasis management is dependent on the immune status of the host, severity of disease, and the choice of antifungal drug. Antifungals, specifically triazoles, are widely administered for the treatment of invasive fungal infections. Herein, we aimed to evaluate the *in vitro* susceptibility of *C. albicans* isolates to fluconazole (FLZ), itraconazole (ITZ), voriconazole (VRZ), amphotericin B (AMB), and Caspofungin (CAS).

Materials and Methods: A total of 44 clinical strains of *C. albicans* were collected from 36 patients admitted to four hospitals in Mazandaran Province, Iran. The *in vitro* antifungal susceptibility testing was performed based on the Clinical and Laboratory Standards Institute methods.

Results: Generally, 34 isolates were susceptible to all the five antifungal drugs, while four isolates were susceptible or susceptible dose-dependent (SDD) and six isolates were SDD or resistant to these antifungals. The lowest minimum inhibitory concentration (MIC; 0.016 µg/ml) belonged to AMB and the highest MIC was for FLZ (16 µg/ml). The lowest MIC_{50} (0.063 µg/ml) was related to ITZ and the lowest MIC_{90} (0.25 µg/ml) pertained to CAS; in addition, the highest MIC_{50} (1 µg/ml) and MIC_{90} (4 µg/ml) were for FLZ. Four of the isolates showed resistance to both FLZ and VRZ, separately, and five isolates were resistant to ITZ. Caspofungin showed potent activity against more than 95% of the *C. albicans* isolates.

Conclusion: Overall, we reported 9.1% resistance to FLZ and VRZ, 11.3% resistance to ITZ and AMB, and 4.6% resistance to caspofungin. Our finding is in agreement with previous observations proposing that *C. albicans* isolates develop resistance to some antifungal drugs such as FLZ since they are widely used as prophylaxis.

Keywords: Antifungal agents, *Candida albicans*, *In vitro* susceptibility testing

➢ How to cite this paper:
Shokohi T, Badali H, Amirrajab N, Ataollahi MR, Kouhpayeh SA, Afsarian MH. *In vitro* activity of five antifungal agents against *Candida albicans* isolates, Sari, Iran .Curr Med Mycol. 2016; 2(2): 34-39. DOI: 10.18869/acadpub.cmm.2.2.8

Introduction

Candida species remain the predominant cause of invasive fungal infections; among them, *Candida albicans* is the most prevalent *Candida* species in clinical samples [1-3], which are the fourth leading cause of nosocomial bloodstream infections in the United States [4, 5]. Currently, systemic candidiasis is uncommon, but its incidence is on a growing trend, particularly among severely immunocompromised individuals [6-11]. Management of candidiasis depends on the immune status of the host, severity of the disease, and the choice of antifungal drug [12].

Voriconazole (VRZ) and caspofungin (CAS), as novel drugs, are used for the trea-tment of invasive fungal infections. In particular, VRZ shows broad-spectrum activity against clinically relevant yeasts. Treatment recommendations are based on numerous studies, however, routine prophylactic and therapeutic regimen of fluconazole (FLZ) in admitted and immunocompromised patients for management of candidiasis can lead to a shift toward resistant strains [3, 6-8, 13]. Several studies have reported increased FLZ resistance rates in *C. albi-cans* isolates [14], but new antifungal agents with a better activity may help improve the management of these infections [6, 7, 15-17].

In the current investigation, we aimed to evaluate the *in vitro* susceptibility of a collection of *C. albicans* to amphotericin B (AMB), fluconazole (FLZ), voriconazole (VRZ), itraconazole (ITZ) and

caspofungin (CAS) based on microdilution broth.

Materials and Methods

A total of 44 clinical isolates of *C. albicans* were collected from 36 patients admitted to four hospitals in Mazandaran Province, Iran, due to burn injury, pulmonary infection, solid tumor, and cancer. The isolates were obtained from various sources including blood (n=7), burn wound (n=19), bronchoalveolar lavage (BAL) (n=7), oropharynx (n=7), urine (n=3), and sputum (n=1) [10, 11]. The study protocol was approved by the Ethics Committee of Mazandaran University of Medical Sciences (IR.MAZUMS.REC.91-32). Correct identification of isolates was previously performed by sequence analysis of the internal transcribed spacer (ITS) regions of rDNA followed by seven housekeeping genes (i.e., *AAT1a, ACC1, ADP1, MPIb, SYA1*, *VPS13*, and *ZWP1b*) [10, 11].

Briefly, fresh colonies from Sabouraud glucose agar (SGA, Difco) were selected for gDNA extraction, and sequencing was performed on an ABI 3730xl automated sequencer (Applied Biosystems, US). Sequence data obtained in this study were adjusted using the SeqMan of Lasergene software (DNAStar Inc., US) and were compared through GenBank database and the local database at the CBS-KNAW Fungal Biodiversity Centre, Utrecht, the Netherlands.

Minimum inhibitory concentration (MIC) was determined according to the recommendations proposed by the Clinical and Laboratory Standards Institute (CLSI) M27-A3 and M27-S4 documents [18, 19]. AMB (Sigma, St. Louis, MO, USA), FLZ (Pfizer, Groton, CT, USA), ITZ (Janssen Research Foundation, Beerse, Belgium), VRZ (Pfizer), and CAS (Merck, Whitehouse Station, NJ, USA) were obtained as reagent-grade powders from the respective manufacturers for preparation of the microdilution trays based on CLSI recommendations.

The antifungal agents were diluted in the standard RPMI-1640 medium (Sigma Chemical Co. Germany) buffered to pH 7.0 with 0.165 M-morpholinepropanesulfonic acid (MOPS) (Sigma, Germany) with L-glutamine without bicarbonate to yield two times their concentrations. The buffer was dispensed into 96-well microdilution trays at a final concentration of 0.016–16 µg/ml for AMB, ITZ, and VRZ, 0.063-64 µg/ml for FLZ, and 0.008-8 µg/ml for CAS. Plates were stored at -70°C until they were used.

Briefly, homogeneous conidial suspensions were spectrophotometrically measured at the 530 nm wavelength and a percent transmission within the range of 75-77%. Therefore, the final densities of the stock inoculum suspensions of the tested isolates ranged between 2.5×10^3 and 5×10^3 colony forming units/ml, as determined by quantitative colony count on Sabouraud glucose agar (SGA, Difco). The 96-well microplates were incubated at 35°C and examined visually after 24 and 48 h to determine MIC values.

The MIC endpoints were determined using a reading mirror and were defined as the lowest concentration of drug that prevents any recognizable growth (i.e., exerts 100% inhibition for amphotericin B) or significant (>50%) growth diminution level (all other agents) compared with the growth of a drug-free control. We used the recently revised CLSI clinical breakpoint (CBP) values to identify the *C. albicans* strains [19]. Caspofungin MIC values of ≤0.25 and ≥1 µg/ml were categorized as susceptible and resistant, respectively; fluconazole MIC results of ≤2 and ≥8 µg/ml were defined as susceptible and resistant, respectively, and CLSI susceptible and resistant breakpoints for VRZ and ITZ were ≤0.12 and ≥1 µg/ml, respectively.

CBPs are not established for AMB in the CLSI M27-S4 [19]. Isolates with MIC≥2 µg/ml for AMB were considered resistant. Isolates were classified based on both the previously and the recently revised CLSI clinical breakpoints. Quality control was performed as recommended in CLSI document M27-A3 [18] using *C. krusei* ATCC 6258 and *C. parapsilosis* ATCC 22019 strains. All the tests were performed in duplicate, and differences among mean values were determined by Student's t-test, using SPSS version 7.0. P-value less than 0.05 was considered statistically significant.

Results

Table 1 summarizes the *in vitro* susceptibility patterns of 44 clinical isolates of *C. albicans*, including MIC_{50}, MlC_{90}, the geometric mean MIC values, and the range of MIC values of the five antifungal agents (Table 1).

The lowest MIC (0.016 µg/ml) pertained to AMB, and MIC ranges for VRZ and CAS were the narrowest (ranging between 0.031 µg/ml and 1 µg/ml). We found the widest range and the highest MIC for FLZ (0.25-16 µg/ml). The lowest MIC_{50} (0.063 µg/ml) was related to ITZ and the highest MIC_{50} (1 µg/ml) belonged to FLZ; in addition, the lowest MIC_{90} (0.25 µg/ml) was related to CAS and the highest MIC_{90} (4 µg/ml) to FLZ. ITZ and VRZ with MIC_{50} of 0.063 µg/m and 0.125 µg/ml, respectively, and MIC_{90} of 1 µg/ml and 0.5 µg/ml, respectively, were more active than FLZ with MIC_{50} of 1 µg/ml and MIC_{90} of 4 µg/ml (Table 1).

Table 1. *In vitro* susceptibility testing of 44 clinical isolates of *C. albicans* to five antifungal agents (minimum inhibitory concentration range, geometric (G) mean, MIC_{50}, and MIC_{90} values are expressed in µg/ml)

Antifungal	MIC[1] range	MIC $_{50}$	MIC $_{90}$	G mean	R[2] (N/%)	SDD[3] (N/%)	I[4] (N/%)
Fluconazole	0.25-16	1	4	1.099	4 (9.1)	3 (6.8)	-
Itraconazole	0.031-4	0.063	1	0.125	5 (11.3)	5 (11.3)	-
Voriconazole	0.031-1	0.125	0.5	0.133	4 (9.1)	5 (11.3)	-
Amphotericin B	0.016-4	0.125	1	0.129	5 (11.3)	-	-
Caspofungin	0.031-1	0.125	0.25	0.156	2 (4.6)	-	3 (6.8)

MIC[1]: Minimum Inhibitor Concentration, R[2]: Resistant, SDD[3]: Susceptible Dose Dependent, I[4]: Intermediate

Table 2. The characterization of 10 isolates showing susceptible dose-dependent, intermediate, or resistance to five antifungal drugs

Isolate No	Patient number	Site of isolation	Fluconazole	Itraconazole	Voriconazole	Amphotericin B	Caspofungin
5	P3	Blood	R[1]	R	R	R	S[2]
6	P3	Urine	SDD[3]	R	R	S	S
17	P12	Chest-burn wound	R	SDD	SDD	R	R
21	P14	Hand-burn wound	SDD	SDD	SDD	S	S
23	P24	Bronchoalveolar lavage (BAL)	R	R	R	R	R
24	P25	BAL	S	SDD	SDD	S	S
25	P26	BAL	S	SDD	SDD	S	S
40	P22	Abdomen-burn wound	S	SDD	S	S	I[4]
46	P28	Tongue	SDD	R	R	R	I
48	P29	Mouth	R	R	SDD	R	I

R[1]: Resistant, S[2]: Susceptible, SDD[3]: Susceptible Dose Dependent, I[4]: Intermediate

Generally, 34 isolates were significantly susceptible to the five antifungal drugs, while 10 isolates showed susceptibility, susceptible dose-dependent (SDD) or resistance to five antifungal drugs (*P<0.0001*). Out of these 10 isolates, three were collected from burn wound, three from BAL, two from oropharynx, one from urine, and one from blood culture [10, 11]. Four (9.1%) isolates were resistant to FLZ (MIC=8-16), four (9.1%) isolates to VRZ (MIC=1), five (11.3%) isolates to ITZ (MIC≥1µg/ml), and five (11.3%) isolates to AMB (MIC≥2µg/ml; Tables 1 and 2). However, CAS showed potent activity against more than 95% of the *C. albicans* isolates, only two isolates were resistant to CAS (Table 2).

Four isolates (17, 23, 46, and 48) were SDD or resistant to the five antifungal drugs. The isolate of 17 from patient 12 (P12) with burn wound was resistant to FLZ, AMB, and CAS and was SDD to ITZ and VRZ. Isolate 46 from P28 with esophageal cancer was resistant to VRZ, ITZ, and AMB, intermediate to CAS, and SDD to FLZ; moreover, isolate 48 from P29 with esophageal cancer was resistant to FLZ, ITZ, and AMB, intermediate to CAS, and SDD to VRZ. From a total of 44 isolates, only isolate 23 from BAL sample of P24 with pulmonary infection was resistant to all the five antifungal drugs (Table 2). The isolate 6 of urine sample from P3 was resistant to ITZ and VRZ and was SDD to FLZ, but isolate 5 from blood sample of the same patient showed resistance to FLZ, ITZ, VRZ, and AMB (Table 2) [10, 11].

Discussion

Candidiasis is a major cause of morbidity and mortality in patients with leukemia and solid organ transplantation and those admitted to Intensive Care Units (ICUs), and *C. albicans* is the most prevalent *Candida* species in clinical samples [2, 20]. Increasing use of antifungal agents in prophylactic regimen has resulted in the development of azole resistance in *Candida* species [6].

In this study, based on CLSI guidelines, *in vitro* antifungal susceptibility testing was performed, in which six isolates showed resistance to antifungal drugs. Five patients (P2, P3, P7, P13, and P17) were sampled from different body sites [10]. Four strains isolated from four patients (P2, P7, P13 and P17) admitted to Burn Intensive Care Unit (BICU) [10] were susceptible to the five antifungal drugs at the same time. While from three strains isolated from patient 3 (P3) [10], the strain isolated from blood was resistant to three azole drugs, but was susceptible to CAS, which indicates that CAS could be a good choice for the treatment of candidemia [16, 21, 22]. Moreover, a strain isolated from urine

was resistant to ITZ and VRZ and SDD to FLZ (Table 2), but the strain isolated from burn wound in the abdomen was susceptible to all the drugs.

In recent years, there have been several studies conducted on *C. albicans* using *in vitro* antifungal susceptibility testing, in which many *C. albicans* isolates displayed susceptibility to antifungal drugs [6, 23-26]. In this study, 13.6% of the isolates showed resistance to five antifungal drugs.

Previous studies comparing *in vitro* antifungal activity against *C. albicans* in Iran have reported different results [27-29]. For instance, *in vitro* susceptibility test performed for *C. albicans* isolates by Katiraee et al. [27] showed 25.7% resistance to FLZ and 100% susceptibility to CAS. Badiee and Alborzi [28] reported 10.3% resistance to FLZ, 8.5% resistance to ITZ, and 100% susceptibility to AMB, CAS, and VRZ. In addition, Shokohi et al. [29], reported 2.6% resistance to FLZ and AMB, 5.4% resistance to ITZ, and 100% susceptibility to CAS. However, in a study by Gross et al. conducted in Costa Rica [30], 100% of *C. albicans* isolates were susceptible to FLZ and ITZ.

Castanheira et al. [26] reported 100% susceptibility to AMB and CAS and 99.7%, 99.6%, and 99.1% susceptibility to VRZ, FLZ, and ITZ, respectively. Elfeky et al. [31], using disk diffusion method, demonstrated that 10.5% of *C. albicans* isolates were resistant to FLZ and VRZ, but 100% of the isolates were susceptible to AMB. Fothergill et al. [25] revealed that FLZ resistance was increased in *C. albicans* from 2.1% to 5.7% and that VRZ resistance was 4.5%. However, we reported 9.1% resistance to FLZ and VRZ, 11.3% resistance to ITZ and AMB, and 4.6% resistance to CAS (Table 1), which is in line with findings of previous studies. It seems that widespread use of fluconazole and itraconazole for treatment or prophylaxis in Iran may be the cause of the high azole resistance rates.

Although triazoles initially appear to be highly effective, the increase of resistance to them has been reported, and many studies have substantiated that azole resistance to *Candida* isolates has been associated with widespread use of prophylaxis such as FLZ [2, 12, 29, 32, 33]. SO, Ellis D. [34] showed that in some strains of *C. albicans* isolated from the patients treated with AMB, may acquire resistance during treatment.

Conclusion

Overall, we reported 9.1% resistance to FLZ and VRZ, 11.3% resistance to ITZ and AMB, and 4.6% resistance to caspofungin. Our finding is in agreement with previous observations that resistance to antifungal drugs in *C. albicans* isolates is on a growing trend because some antifungal drugs such as FLZ are widely administered as prophylaxis [16, 21, 22, 35, 36].

Acknowledgements

We would like to thank Deputy of Research of Mazandaran University of Medical Sciences, Sari, Iran, for their financial support (grant no.: 91-32).

Authors' contributions

T.S., H.B., and MH.A. designed and managed the study and contributed to data analysis and interpretation; MH.A wrote the main manuscript; T.S., H.B., and MHA revised the draft of manuscript; N.A., MR.A., and SA.K. set up the test and managed the research. All the authors reviewed the manuscript.

Conflicts of interest

None declared.

Financial disclosure

No financial interests related to the material of this manuscript have been declared.

References

1. Odds FC, Bougnoux ME, Shaw DJ, Bain JM, Davidson AD, Diogo D, et al. Molecular phylogenetics of *Candida albicans*. Eukaryot cell. 2007; 6(6):1041-52.
2. Pfaller MA, Diekema DJ. Epidemiology of invasive candidiasis: a persistent public health problem. Clin Microbiol Rev. 2007; 20(1):133-63.
3. Mandras N, Tullio V, Allizond V, Scalas D, Banche G, Roana J, et al. *In vitro* activities of fluconazole and voriconazole against clinical isolates of *Candida* spp. determined by disk diffusion testing in Turin, Italy. Antimicrob Agents Chemother. 2009; 53(4):1657-9.
4. Wisplinghoff H, Bischoff T, Tallent SM, Seifert H, Wenzel RP, Edmond MB. Nosocomial bloodstream infections in US hospitals: analysis of 24,179 cases from a prospective nationwide surveillance study. Clin Infect Dis. 2004; 39(3):309-17.
5. Edmond MB, Wallace SE, McClish DK, Pfaller MA, Jones RN, Wenzel RP. Nosocomial bloodstream infections in United States hospitals: a three-year analysis. Clin Infect Dis. 1999; 29(2):239-44.
6. Pfaller MA, Messer SA, Boyken L, Hollis R, Rice C, Tendolkar S, et al. *In vitro* activities of voriconazole, posaconazole, and fluconazole against 4,169 clinical isolates of *Candida* spp. and *Cryptococcus neoformans* collected during 2001 and 2002 in the ARTEMIS global antifungal surveillance program. Diagn Microbiol Infect Dis. 2004; 48(3):201-5.
7. Pfaller MA, Diekema DJ, Messer SA, Boyken L, Hollis RJ. Activities of fluconazole and voriconazole

against 1,586 recent clinical isolates of *Candida* species determined by broth microdilution, disk diffusion, and Etest methods: report from the ARTEMIS Global Antifungal Susceptibility Program, 2001. J Clin Microbiol. 2003; 41(4):1440-6.
8. Ostrosky-Zeichner L, Rex JH, Pappas PG, Hamill RJ, Larsen RA, Horowitz HW, et al. Antifungal susceptibility survey of 2,000 bloodstream *Candida* isolates in the United States. Antimicrob Agents Chemother. 2003; 47(10):3149-54.
9. Odds FC. Molecular phylogenetics and epidemiology of *Candida albicans*. Future Microbiol. 2010; 5(1):67-79.
10. Afsarian MH, Badali H, Boekhout T, Shokohi T, Katiraee F. Multilocus sequence typing of *Candida albicans* isolates from Burn Intensive Care Unit [BICU] in Iran. J Med Microbiol. 2015; 64(Pt 3):248-53.
11. Afsarian SM, Badali H, Shokohi T, Najafipour S. Molecular diversity of *Candida albicans* isolated from immunocompromised patients, based on MLST Method. Iran J Public Health. 2015; 44(9):1262-9.
12. White TC, Marr KA, Bowden RA. Clinical, cellular, and molecular factors that contribute to antifungal drug resistance. Clin Microbiol Rev. 1998; 11(2):382-402.
13. Pfaller MA, Diekema DJ. Rare and emerging opportunistic fungal pathogens: concern for resistance beyond *Candida albicans* and *Aspergillus fumigatus*. J Clin Microbiol. 2004; 42(10):4419-31.
14. Clissold SP. Fluconzole a review of it's pharmacodynamic and pharmaco kinietic properties and therapeutic potential in superficial on systemic mycosis. Drugs. 1990; 39:877-916.
15. Castanheira M, Messer SA, Jones RN, Farrell DJ, Pfaller MA. Activity of echinocandins and triazoles against a contemporary (2012) worldwide collection of yeast and moulds collected from invasive infections. Int J Antimicrob Agents. 2014; 44(4):320-6.
16. Pfaller MA, Rhomberg PR, Messer SA, Jones RN, Castanheira M. Isavuconazole, micafungin, and 8 comparator antifungal agents' susceptibility profiles for common and uncommon opportunistic fungi collected in 2013: temporal analysis of antifungal drug resistance using CLSI species-specific clinical breakpoints and proposed epidemiological cutoff values. Diagn Microbiol Infect Dis. 2015; 82(4):303-13.
17. Lotfi N, Shokohi T, Nouranibaladezaei SZ, Nasrolahi Omran A, Kondori N. High recovery rate of non-*albicans Candida* species isolated from burn patients with candidemia in Iran. Jundishapur J Microbiol. 2015; 8(10):e22929.
18. National Committee for Clinical Laboratory Standards. Reference method for broth dilution antifungal susceptibility testing of yeasts: approved standard. 3rd ed. Wayne, PA: Clinical and Laboratory Standards Institute; 2008.
19. National Committee for Clinical Laboratory Standards. Reference method for broth dilution antifungal susceptibility testing of yeasts. 4th informational supplement. Wayne, PA: Clinical and Laboratory Standards Institute; 2012.
20. Zarrin M, Zarei Mahmoudabadi A. Invasive candidiasis; a review article. Jundishapur J Microbiol. 2009; 2(1):1-6.
21. Pfaller MA, Diekema DJ, Messer SA, Hollis RJ, Jones RN. *In vitro* activities of caspofungin compared with those of fluconazole and itraconazole against 3,959 clinical isolates of *Candida* spp., including 157 fluconazole-resistant isolates. Antimicrob Agents Chemother. 2003; 47(3):1068-71.
22. Mora-Duarte J, Betts R, Rotstein C, Colombo AL, Thompson-Moya L, Smietana J, et al. Comparison of caspofungin and amphotericin B for invasive candidiasis. N Engl J Med. 2002; 347(25):2020-9.
23. Pujol C, Pfaller MA, Soll DR. Flucytosine resistance is restricted to a single genetic clade of *Candida albicans*. Antimicrob Agents Chemother. 2004; 48(1):262-6.
24. Dodgson AR, Dodgson KJ, Pujol C, Pfaller MA, Soll DR. Clade-specific flucytosine resistance is due to a single nucleotide change in the FUR1 gene of *Candida albicans*. Antimicrob Agents Chemother. 2004; 48(6):2223-7.
25. Fothergill AW, Sutton DA, McCarthy DI, Wiederhold NP. Impact of new antifungal breakpoints on antifungal resistance in *Candida* species. J Clin Microbio J Clin Microbiol. 2014; 52(3):994-7.
26. Castanheira M, Messer SA, Rhomberg PR, Dietrich RR, Jones RN, Pfaller MA. Isavuconazole and nine comparator antifungal susceptibility profiles for common and uncommon *Candida* species collected in 2012: application of new CLSI clinical breakpoints and epidemiological cutoff values. Mycopathologia. 2014; 178(1-2):1-9.
27. Katiraee F, Khosravi AR, Khalaj V, Hajiabdolbaghi M, Khaksar AA, Rasoulinejad M. *In vitro* antifungal susceptibility of oral *Candida* species from Iranian HIV infected patients. Tehran Univ Med Sci. 2012; 70(2):96-103.
28. Badiee P, Alborzi A, Davarpanah MA, Shakiba E. Distributions and antifungal susceptibility of *Candida* species from mucosal sites in HIV positive patients. Arch Iran Med. 2010; 13(4):282-7.
29. Shokohi T, Bandalizadeh Z, Hedayati MT, Mayahi S. *In vitro* antifungal susceptibility of *Candida* species isolated from oropharyngeal lesions of patients with cancer to some antifungal agents. Jundishapur J Microbiol. 2011; 4(2):S19-26.
30. Gross NT, Arias ML, Moraga M, Baddasarow Y, Jarstrand C. Species distribution and susceptibility to azoles of vaginal yeasts isolated prostitutes. Infect Dis Obstet Gynecol. 2007; 2007:82412.
31. ElFeky DS, Gohar NM, El-Seidi EA, Ezzat MM, AboElew SH. Species identification and antifungal susceptibility pattern of *Candida* isolates in cases of vulvovaginal candidiasis. Alexandria J Med. 2015; 52(3):269-77.
32. Lass-Flörl C. The changing face of epidemiology of invasive fungal disease in Europe. Mycoses. 2009; 52(3):197-205.
33. Mukherjee PK, Sheehan D, Puzniak L, Schlamm H,

Ghannoum MA. Echinocandins: are they all the same? J Chemother. 2011; 23(6):319-25.
34. Ellis D. Amphotericin B: spectrum and resistance. J Antimicrob Chemother. 2002; 49(suppl 1):7-10.
35. Marr KA, White TC, van Burik JA, Bowden RA. Development of fluconazole resistance in *Candida albicans* causing disseminated infection in a patient undergoing marrow transplantation. Clin Infect Dis. 1997; 25(4):908-10.
36. Mori T, Matsumura M, Kanamaru Y, Miyano S, Hishikawa T, Irie S, et al. Myelofibrosis complicated by infection due to *Candida albicans*: emergence of resistance to antifungal agents during therapy. Clin Infect Dis. 1997; 25(6):1470-1.