

Activities of fluconazole in combination with terbinafine against non-*albicans* *Candida* species isolated from the patients with recurrent vulvovaginal candidiasis in comparison with ciclopirox olamine

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Original Article

Abstract

Introduction: Recent epidemiological studies show that episodes due to non-*albicans* species of *Candida* (*C*) such as *Candida tropicalis*, *C. glabrata*, *C. krusei*, *C. parapsilosis* appear to be increasing in recurrent vulvovaginal candidiasis (RVVC). Increased use of the current antifungal drugs cause drug resistance among *Candida* species. In order to gain suitable antifungal therapy for this disease, we investigated the activity of synergism of fluconazole and terbinafine comparing with cyclopirox olamine, against non-*albicans* *Candida* species isolated from recurrent candidal vaginitis.

Methods: This study was carried out on 44 strains of non-*albicans* *Candida* species that were isolated from patients with recurrent vulvovaginal candidiasis. Antifungal susceptibility testing of fluconazole and terbinafine alone and combination of these drugs on non-*albicans* species were determined by Clinical and Laboratory Standard Institute (CLSI) microdilution method (document M27-A2).

Results: The mean of MICs of fluconazole, terbinafine and cyclopirox olamine was 93.8, 104.7 and 18 µg/ml, respectively, after 48 hours of incubation. FICs of fluconazole in combination with terbinafine were shown ineffective and additive in 42 isolates (95.5%), synergism and relative-synergism were obtained in two isolates (4.5%). Additionally, the mean of cyclopirox olamine MFCs (32 µg/ml) had the most effective and the mean of terbinafine MFCs (177 µg/ml) showed the lowest effectiveness on non-*albicans* isolates (P>0.05).

Conclusion: Most of isolates were resistant against fluconazole and terbinafine, and combination of these drugs did not affect clinical isolates. But cyclopirox olamine with the lowest mean of MICs and MFCs showed the highest activity in non-*albicans* isolates.

Key words: Candidiasis – Terbinafine - Cyclopirox

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Introduction:

Vulvovaginal Candidiasis (VVC) is a disease caused by abnormal growth of yeasts in the female genital tract (1,2). It is one of the most common problems of women during their sexually active years (3). The prevalence of VVC has increased during recent years (1). Almost 75% of women experience at least an episode of this disease during lifetime (4). However, about 5-10% of the patients complain about complicated candidiasis which is featured severe and recurrent. This kind of VVC is called Recurrent Vulvovaginal Candidiasis (RRVC) where patients are infected at least 4 episodes in a year (5,6). This disease is characterized by yellowish discharge with milky color and grey pseudo membrane on mucosa of vagina. Moreover, it may be associated with eczematous reaction with mild to severe erythema, pustule and ulcer (7, 8). Although *Candida albicans* accounts for 80-90% of vaginal candidiasis, most of researches have reported increase of non-albicans species *Candida* particularly *glabrata* which is probably due to widely use of antibiotics for a long time and also short time use of azoles and antifungal drugs (28, 29). *C. glabrata* shortly acquire resistance against azoles (30). Nowadays, prophylactic fluconazole for high risk patients has resulted in the reduction of albicans-induced infections and increased incidence of non-albicans induced infections such as *C. glabrata* and *C. krusei* (30). Ten to thirty-three percent of RRVC are caused by non-albicans species like *C. glabrata*, *C. tropicalis*, *C. krusei* and *C. parapsilosis* (31). This type of the disease infects about 6 million women per annum (32).

Different treatments have been introduced for candida-induced vaginitis during 2 last decades. The most common options are azoles which are prescribed either topically in various concentrations and formula or systematically (33). Since susceptibility of various species of candida against antifungal drugs including azoles vary, non-albicans candidiasis requires more investigations (34,35).

Hence, given the importance of the subject, the present study was designed to study the susceptibility of various species of non-albicans candida isolated from the patients with RRVC to fluconazole and terbinafine individually and in combination with each other and also to evaluate the results in comparison with the effects of

ciclopirox olamine – as a new synthetic drug with exclusive properties including broad spectrum antibacterial and antifungal properties as well as anti-inflammatory properties for treatment of cutaneous infections (17).

Methods:

The entire procedure of this experimental study was evaluated based on the agenda of the Clinical and Laboratory Standard Institute for yeasts (CLSI M27-A2) (11). This study included 44 strains of non-albicans *Candida* species that were isolated from patients with recurrent vulvovaginal candidiasis. For standardization and processing of the stages of the procedure, a standard strain of *C. krusei* (ATCC 6258) was used at the initial stages.

Medicines used in the study included fluconazole (070209/90) donated by Tehran Daru Company, terbinafine supplied by Behvazan Company, and ciclopirox olamine by USP ROCKVILLE (American).

Appropriate basic concentrations of fluconazole, terbinafine and ciclopirox olamine were prepared using Dimethyl sulfoxide (DMSO) supplied by Merck (Germany) as a solvent

Culture Media Preparation

- A) Liquid Culture Media Preparation: to prepare liquid culture media (Subaru broth), the instructions of the manufacturing was followed (12, 13)
- B) Solid Culture Media Preparation: to prepare solid culture media, the instruction of the manufacturing company was followed (10-12).

Drug sensitivity Testing

Fungal specimen culture: the identified species of candida were cultured on Subaru Dextrose Agar at 30°C for 24 hours to produce fungal colonies. Then the fungal colonies were used for yeast suspension preparation.

Yeast suspension preparation: to prepare a candida yeast suspension with concentration of 1×10^3 cells in 1 ml, a colony grown on the Subaru Dextrose Agar was added to 1 ml of sterile physiologic serum. An appropriate cell suspension was obtained through a spectrophotometer at 530 nm wavelength adjusted by 90% translucency

which is equal to 1×10^6 cells in 1 milliliter. Then the solution was diluted 1000 times (13,14).

Preparation of pharmaceutical solution: initially, 0.0128 gram of the medicines was weighted (fluconazole, terbinafine and ciclopirox olamine) using a sensitive balance scale. Then each item was dissolved in 10 ml of DMSO. It was kept at the laboratory temperature for 30 minutes to get it completely dissolved following which a 1280 $\mu\text{g/ml}$ solution was obtained. Then to prepare a solution for measuring MIC, 1 ml of the stock solution of the drug under the study was diluted by 9 ml of sterile Subaru culture media (final concentration: 128 $\mu\text{g/ml}$). To prepare consecutive concentrations from 128 to 1 $\mu\text{g/ml}$, they were diluted by Subaru (13,15).

The procedure of the test: at the beginning, 50 μl of the consecutive concentrations of fluconazole was added to the wells at 8 horizontal rows of a sterilized gated 96-well micro plate with U-bottom-shape. Then an additional 50 μl of terbinafine was added to the wells at 8 vertical rows. Hence, the concentration of the drug in the first horizontal and vertical row was 128 and in the 8th row 1 $\mu\text{g/ml}$. Then 100 μl of the above medicines and ciclopirox olamine – which had been prepared in consecutive concentrations – were individually added to 9 other wells to assess the MIC of the medicines. Finally, 100 μl of the fungal suspension was added to all the wells (except one well to which only Subaru broth was added as negative control). And for positive control, 100 μl of fungal suspension was added to another well in which there was Subaru broth. The lid of the micro plate was closed. The plate was shaken for 3-5 minutes. It was then incubated for 48 hours and checked after 48 hours. This process was repeated 3 times for each case. The average

was considered as MIC. The FIC obtained from the combination of the medicines was calculated as per the formula and the results were interpreted in the following way: synergistic if $\text{FIC} \leq 0.5$, relative synergistic if $0.5 < \text{FIC} < 1$, additive effect if $\text{FIC} = 1$, ineffective if $1 < \text{FIC} < 4$ and antagonism if $\text{FIC} > 4$ (11,13,14)

$$\text{FIC} = \frac{\text{MIC of the 2nd combined medicine}}{\text{MIC of the 2nd medication alone}} + \frac{\text{MIC of the 1st combined medicine}}{\text{MIC of the 1st medication alone}}$$

The analysis of the findings of the study was performed by SPSS software (Version 16). The statistical tests used to determine the relationships between variables including Chi-square, Fisher's exact, logistic regression by GEE parametric method and paired tukey's test. P-value less than 0.05 was considered as significant.

Results:

The mean of MICs of fluconazole, terbinafine and ciclopirox olamine was 93.8, 104.7 and 18 $\mu\text{g/ml}$, respectively, after 48 hours of incubation. FIC of the medicines was additive and ineffective in 42 cases (95.5%) while it was synergistic and relatively synergistic in 2 cases (4.5%). Moreover, studying the fungicidal effects of the medicines revealed that the mean of MFC of ciclopirox olamine, terbinafine and fluconazole was 32, 177 and 154 $\mu\text{g/ml}$ respectively.

The results showed that the range of MIC for fluconazole on 29 isolates of *C. glabrata* – which were under study – was $\text{MIC} = 32\text{-}128 \mu\text{g/ml}$ (Table 1), $\text{MIC}_{50} = 128 \mu\text{g/ml}$ and $\text{MIC}_{90} = 128 \mu\text{g/ml}$.

Table 1. Range of the MIC of the medicines based on $\mu\text{g/ml}$

Species	Number of Species	MIC Fluconazole	MIC Terbinafine	MIC Ciclopirox Olamine
<i>glabrata</i>	29	32-128	64-128	8-128
<i>kefyr</i>	10	32-128	64-128	8-64
<i>krusei</i>	3	128	128	8
<i>parapsilosis</i>	2	64-128	64	8-32

Table 2. Frequency of FIC based on the various species after 48 hours

Species	Synergistic and relative synergistic effect	Additive effect and ineffectiveness	Total
glabrata	2 (6.9%)	27 (93.1%)	29 (100%)
Others	0%	15 (100%)	15 (100%)
Total	2 (4.5%)	42 (95.5%)	44 (100%)

According to NCCLS, $MIC \leq 8 \mu\text{g/ml}$ considered sensitive, $MIC = 16-32 \mu\text{g/ml}$ dose-dependent and $MIC \geq 64 \mu\text{g/ml}$ was resistant. Hence, out of 29 strains of *C. glabrata*, 25 cases (86.2%) were resistant to fluconazole and 4 cases (13.8%) were dose-dependent.

Studying dual combined medicines after 48 hours through paired tukey's test showed that there was a significant difference between "ciclopirox olamine" and "terbinafine and fluconazole" while there was no significant difference between terbinafine and fluconazole. In other words, the mean of MIC for both terbinafine and fluconazole is equal and the mean of MIC for ciclopirox has the minimum value.

Studying the FIC of the combined medicines after 24 hours on the candida strains isolated from RRVC revealed that 1 case (2.3%) had synergistic effect, 5 cases (11.4%) relative synergistic effect, 2 cases (4.5%) additive effect and 36 cases (81.8%) were ineffective. After 48 hours the rates changed to 2 cases (4.5%) with relative synergism, 3 cases (6.8%) with additive effect and 39 cases (88.6%) without effect (Figure 1).

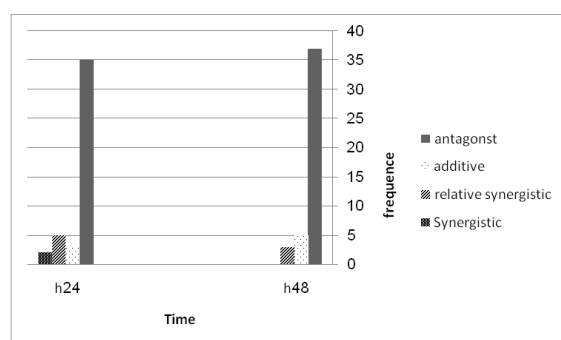


Figure 1. Frequency of synergistic, relative synergistic and additive effects

Conclusion:

Epidemiologic studies show that RRVC infections are mainly caused by the species resistant to antifungal medicines (9). Therefore, tendency

towards finding new antifungal combinations increased.

Mahmodirad et al studied 191 species of candida isolated from 175 patients with VVC referred to Mahdiah hospital from 2006 to 2008. They found that out of 135 strains of *C. glabrata*, 11 strains (31.4%) were resistant, 6 cases (17.1%) were sensitive and 18 cases (51.4%) were dose-dependent sensitive to fluconazole. They reported the range of $MIC = 0.5-64 \mu\text{g/ml}$. The obtained results are somewhat consistent with our study (17).

The results of the present study is consistent with the results of another study by Pfaller et al (2011) who studied 120 strains of *C. glabrata* reported range of $MIC = 0.5-128 \mu\text{g/ml}$, $MIC_{50} = 8 \mu\text{g/ml}$ and $MIC_{90} = 31 \mu\text{g/ml}$ (18).

Ozcelik et al (2006) introduced all of 8 strains of *C. kefyr* isolated from a variety of clinical specimen with a range of $MIC: \leq 3-4 \mu\text{g/ml}$ sensitive to fluconazole (20).

Badie et al reported 7 strains of *C. kefyr* isolated from mouth and vagina of patients suffering from AIDS with a range of $MIC = 0.25-1 \mu\text{g/ml}$, $MIC_{50} = 0.25 \mu\text{g/ml}$ and $MIC_{90} = 0.5 \mu\text{g/ml}$ (19).

Researchers reported the range of specimen isolated from vagina differently: Padua et al (2003) $MIC_{90} = 0.5-64 \mu\text{g/ml}$, Sojakova et al (2004) $MIC = 4 \mu\text{g/ml}$ and Mahmodirad $MIC = 0.5-16 \mu\text{g/ml}$ (16,17,22).

All of 3 strains of *C. krusei* had $MIC = 128 \mu\text{g/ml}$. Therefore, both their MIC_{50} and MIC_{90} are also $128 \mu\text{g/ml}$. According to NCCLS, all of isolates are resistant to fluconazole.

Sataha et al (2010) studying 2 strains of *C. krusei* isolated from mouth of patients with AIDS obtained range of $MIC = 4-64 \mu\text{g/ml}$ and $MIC_{50} = 8 \mu\text{g/ml}$ (27).

In the same study, it was suggested that the range of MIC for terbinafine obtained from 29 strains of *C. glabrata* ranged from 64 to $128 \mu\text{g/ml}$ (Table 1).

MIC₅₀ and MIC₉₀ is equal to 128 $\mu\text{g/ml}$. Out of 10 cases of *C. kefyr* under study, 7 cases (70%) showed MIC=128 $\mu\text{g/ml}$ and 3 cases (30%) had MIC=64 $\mu\text{g/ml}$ for terbinafine. MIC₅₀ and MIC₉₀ were also equal to 128 $\mu\text{g/ml}$. Both cases of *C. parapsilosis* isolates showed MIC= 64 $\mu\text{g/ml}$ to terbinafine. Therefore, MIC₅₀ and MIC₉₀ are also equal to 64 $\mu\text{g/ml}$. All of three isolates of *C. krusei* showed MIC=128 $\mu\text{g/ml}$ to terbinafine. In this case, MIC₅₀ was also equal to MIC₉₀ (128 $\mu\text{g/ml}$).

In the present study, comparison of the MFC mean of the medicine showed that ciclopirox olamine with mean MFC of 32 $\mu\text{g/ml}$ had the minimum value and the maximum fungicidal effect. However, terbinafine with mean MFC of 177 $\mu\text{g/ml}$ had the maximum value and the minimum fungicidal effect. Studying the effect of MIC and MFC of the medicines showed that fluconazole with mean MIC of 93 $\mu\text{g/ml}$ inhibited growth of fungus and with mean MFC of 154 $\mu\text{g/ml}$ had fungicidal effect. In other words, mechanism of action is dose-dependent: fungistatic at lower dosage and fungicide at higher dosage. Sharifinia et al also showed that fluconazole was dose-dependent which is consistent with the present study (27).

Evaluating the effect of MIC and MFC regarding terbinafine revealed that this drug with mean MIC of 104 $\mu\text{g/ml}$ and mean MFC of 177 was fungistatic and its fungicidal effects were dose-dependent.

Ciclopirox olamine with mean MIC of 18 $\mu\text{g/ml}$ and mean MFC of 32 $\mu\text{g/ml}$ was fungistatic. Because it is fungistatic at low dosage, it turns fungicide at higher dosage.

Ciclopirox olamine in comparison with other medicines was more effective on isolates of non-albicans candidiasis. It was fungistatic with lower MIC. Fluconazole and terbinafine were less effective and most of the isolates were resistant to them.

The present study revealed that combination of fluconazole and terbinafine was not so effective on the isolates and their combination was not synergistic on isolates.

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بررسی اثر همبست فلوکونازول و تربینافین در مقایسه با اثر سیکلوپیروکس اولامین بر روی گونه های کاندیدای غیر آلبیکنس در بیماران وولوواژنیت عود کننده کاندیدیایی

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چکیده

مقدمه: اخیراً مطالعات اپیدمیولوژیک نشان داده است که عوامل کاندیداهای غیر آلبیکنس مانند: کاندیدا تروپیکالیس، کاندیدا گلابراتا، کاندیدا کروزه ای و کاندیدا پاراپسیلوزیس در ایجاد بیماری وولوواژنیت عودکننده کاندیدیایی (RVVC) رو به افزایش است. تجویز طولانی مدت داروهای متداول سبب ایجاد مقاومت دارویی می شوند. در این مطالعه، اثر توأم فلوکونازول با تربینافین و مقایسه اثر آنها با سیکلوپیروکس اولامین بر روی گونه های غیر آلبیکنس جدا شده از وولوواژنیت عود کننده کاندیدیایی بررسی گردید.

روش کار: این مطالعه یک روش تجربی آزمایشگاهی است که بر روی ۴۴ ایزوله کاندیدیای غیر آلبیکنس جدا شده از بیماران وژنیت کاندیدیایی عود کننده انجام شد و اثر داروهای فلوکونازول و تربینافین به تنهایی و در همبست با یکدیگر و مقایسه آنها با اثر سیکلوپیروکس اولامین به روش استاندارد میکرودابیلوشن (CLSI M27-A2) مورد ارزیابی قرار گرفتند. **نتایج:** میانگین MIC فلوکونازول، تربینافین و سیکلوپیروکس اولامین بعد از ۴۸ ساعت گرماگذاری به ترتیب ۰/۹۲/۱، ۱۰۴/۷ و ۱۸ میکروگرم بر میلی لیتر بدست آمد و FIC داروها به صورت ۴۲ (۹۵/۵٪) مورد اثر افزایشی و بی اثر و ۲ (۴/۵٪) میانگین MFC=۳۲ میکروگرم بر میلی لیتر بیشترین اثر و تربینافین با میانگین MFC= ۱۷ میکروگرم بر میلی لیتر کمترین اثر دیده شد (P < ۰/۰۵).

نتیجه گیری: اکثر ایزوله ها نسبت به داروهای فلوکونازول و تربینافین مقاوم بودند و همبست کردن آنها نیز تأثیر چندانی نداشت ولی سیکلوپیروکس اولامین دارای بیشترین اثر بوده و میزان MIC و MFC کمتری را دارا می باشد.

کلیدواژه ها: کاندیدیاز - تربینافین - سیکلوپیروکس

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