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FULL PAPER

Bayesian estimation of post-test probability of *Candida glabrata* fungemia by means of serum creatinine

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SUMMARY

Fungemia is a life-threatening condition associated with high mortality; the most frequently isolated genus is *Candida*. *Candida glabrata* is of particular concern because of its increasing resistance to azoles. We evaluated common lab tests accessible by almost all healthcare professionals to estimate the post-test probability of recovery of *C. glabrata* from a blood culture collected by venipuncture, positive for fungi identified by microscopic examination. Patients with blood cultures positive for *C. glabrata* had significantly higher median values of serum creatinine (*P*=0.006), and a value of ≥1.45 mg/dL was the best cut-off in discriminating *C. glabrata* from other *Candida* spp., with 0.67 [95% Confidence Interval (CI): 0.49-0.85] sensitivity and 0.75 (95% CI: 0.66-0.84) specificity; Youden's J statistic: 0.42. The receiver operator characteristic curve analysis showed an area under the curve of 0.718 (95% CI: 0.603-0.833); *P*=0.001. Therefore, given a pre-test probability of 24% and applying the Bayes' theorem, the post-test probability of *C. glabrata* fungemia with creatinine values ≥1.45 mg/dL increased to 45.8%.
In conclusion, we showed how the probability of recovery of *C. glabrata* from blood cultures collected by venipuncture and positive for fungi can be better estimated using concurrent creatinine values.

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INTRODUCTION

Fungemia is a life-threatening condition associated with high mortality (Hirano *et al*., 2015); the most frequently isolated genus is *Candida* (Pfaller & Diekema, 2007). Blood cultures (BC) are still considered the gold standard for identification of microorganisms that are causal agents of sepsis (Carroll *et al*., 2019). Among the genus *Candida*, the four main species recovered from BC are *Candida albicans*, *Candida glabrata*, *Candida parapsilosis*, and *Candida tropicalis* (Pfaller & Diekema, 2007). *C. glabrata* is a species of particular concern because of its increasing resistance to fluconazole and other azoles (Fidel *et al*., 1999; Pfaller *et al*., 2012). Identification of fungi is time consuming and implementation of rapid diagnostic methods for identification of *Candida* spp. from positive BC is essential, since even a 12-hour delay in antifungal therapy is an independent factor associated with hospital mortality (Morrell *et al*., 2005; Garey *et al*., 2006). For this reason, since 2015 our Microbiology Laboratory rapidly identifies the causative agents of all fungemia by a multiplex Real-Time PCR directly from positive bottles, anticipating the identification of yeasts by at least 24 hours and checking the possibility of bacterial coinfection.
As part of normal routine in all Microbiology Laboratories, a microscopic examination of a Gram-stained aliquot of a positive BC is always performed (Carroll *et al*., 2019). It has already been reported that the finding of branched pseudohyphae from positive BC is mainly associated to recovery of *C. albicans* and can be used to presumptively exclude the presence of *C. glabrata* (Harrington *et al*., 2007; Doymaz *et al*., 2010). On the other hand, *C. parapsilosis* and *C. tropicalis* can also form branched pseudohyphae (Harrington *et al*., 2007; Trofa *et al*., 2008).
In the light of the above, since branched pseudohyphae cannot be found in all Gram-stained smears from BC positive for fungi and molecular methods are not readily available in all hospitals, we evaluated

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common lab tests accessible by almost all healthcare professionals as possible variables to estimate the probability of having a *C. glabrata* fungemia after a microscopic examination positive for fungi.
We chose to include only BC collected by peripheral venipuncture, to minimize the possible independent role of central lines in fungemia and therefore evaluate the relevance of both patients' comorbidities and organ damage evaluated by blood test abnormalities on the results of the Real-Time PCR without the central line as source of infection. Moreover, the use of a multiplex Real-Time PCR allowed us to exclude bacterial coinfection.

METHODS

Design of the study

This is an observational retrospective study including all BC positive for fungi collected by venipuncture from patients admitted to SS. Antonio e Biagio e C. Arrigo Hospital of Alessandria during the interval March 2015 - March 2022 and identified by means of a Real-Time PCR directly from the bottle. Urgent blood tests collected simultaneously with BC, such as complete blood count, kidney function, main electrolytes and C-reactive protein, along with clinical history from electronic health records, were also evaluated. Even though there is actual evidence of less reliability of usual differential time to positivity for candidemia (Park *et al*., 2014), a central line-associated bloodstream infection was defined as per Gahlot *et al.* (2014).
Inclusion criteria: all patients with BC collected by peripheral venipuncture and positive for fungi visualized by microscopic examination and subsequently identified by means of Real-Time PCR along with urgent blood tests and clinical history were included in the study. Only first episodes of fungemia were included. Exclusion criteria: bacterial coinfection; unavailability of concurrent urgent blood tests.

Blood Cultures

Blood cultures were obtained during febrile episodes. For each episode, at least two sets of BC were collected, each one composed of: for adult patients, one BACTEC® Lytic/10 Anaerobic/F bottle, and one BACTEC® Plus Aerobic/F bottle; for pediatric patients, one to two BACTEC® Peds Plus/F bottle (all bottled media from Becton Dickinson Diagnostic Instrument Systems, Sparks, MD, USA). Each set was subsequently incubated within 2 hours in the BACTEC FX® continuous-monitoring system for at least 5 days according to guidelines (Baron *et al*., 2005). Bottles reported as positive on the device were removed from the incubator, a microscopic examination of a Gram-stained aliquot of BC was performed and an aliquot was subcultured onto: Columbia agar supplemented with sheep blood (5%); Mac Conkey agar; Chocolate agar PolyViteX; Schaedler Agar supplemented with sheep blood (5%); Schaedler Neomycin Vancomycin agar supplemented with sheep blood (5%); Sabouraud Gentamicin Chloramphenicol 2 agar (all agar media from BioMérieux, Marcy-l'Étoile, France). If the microscopic examination was consistent with fungi, an aliquot of BC was processed for Real-Time PCR testing.

Real-Time PCR test

For the rapid identification of fungi, the commercially available FilmArray® Blood Culture Identification Panel (BioFire Diagnostics, Salt Lake City, UT, USA) was used, a nested multiplex PCR able to identify five species of *Candida*: *C. albicans*; *C. glabrata*; *Candida krusei*; *C. parapsilosis*; *C. tropicalis*; as well as some bacteria and three resistance mechanisms, in around one hour (Altun *et al*., 2013). First, the pouch was rehydrated with 300-µl rehydration solution, then a 200-µl aliquot of positive BC was transferred into a syringe containing sample dilution buffer and mixed. Finally, the diluted blood culture sample was inoculated into the pouch. The pouch was then loaded onto the FilmArray® device that automatically performs nested PCR amplification, real-time fluorescent detection and reporting.

Identification of fungi

Identification of fungi provided by the Real-Time PCR was subsequently confirmed by Vitek 2® system using Vitek 2® YST ID card (bioMérieux, Marcy l'Etoile, France) or, since September 2019, by matrix-assisted laser desorption ionization–time of flight mass spectrometry Vitek® MS (bioMérieux, Marcy l'Etoile, France). The *Candida* spp. not included in the Real-Time PCR panel were identified only by Vitek 2® and/or Vitek® MS.

Statistical methods

Categorical variables were expressed as absolute numbers and percentage, continuous variables as median and interquartile range (IQR). The Freeman-Halton extension of the Fisher exact probability test was used to examine the differences among frequencies. Median values were compared using the Mann-Whitney U test, the Kruskal-Wallis test or the Wilcoxon Signed Ranks Test, as appropriate. A correlation analysis was performed using Spearman's rank correlation coefficient. A Receiver Operator Characteristic (ROC) curve analysis was performed to look for possible thresholds of classifiers resulting significantly different by comparison of median values, and Youden's J statistic was applied to establish the optimal cut-off value. Sensitivity, specificity and positive likelihood ratio were calculated as described by Eusebi (2013). Bayes' theorem (*Equation 1*) was used to calculate both the post-test probability of a

C. glabrata fungemia in presence of values of the classifier above or equal to the cut-off and the post-test probability of a fungemia by other *Candida* spp. in presence of values of the classifier under the cut-off. The significance level was set at $P \leq 0.05$. The SPSS statistical package version 17.0 (SPSS Inc, Chicago, IL, USA) was used for some of the statistical analyses described above.

Equation 1:

$$P(A \mid B) = \frac{P(B \mid A) \times P(A)}{(B)}$$

Ethical considerations

The present study was designed as a secondary analysis of data collected as part of standard care and subjects included in the database were deidentified before access. No personal information was stored in the study database. No patient intervention occurred with the obtained results.

RESULTS

Descriptive

A total of 111 patients corresponding to the same number of *Candida* isolates were included in the study. No mixed fungemia were observed. Median age was 74 years (IQR: 64-81) and 83/111 (74.8%) were males. The BC were collected from: Internal Medicine 21/111 (18.9%); Intensive Care Unit 16/111 (14.4%); Geriatric Medicine 12/111 (10.8%); Emergency Medicine 11/111 (9.9%); General Surgery 8/111 (7.2%); Medical Oncology 6/111 (5.4%); Infectious Diseases 6/111 (5.4%); Long-Term Care 6/111 (5.4%); Cardiology 5/111 (4.5%); Nephrology 5/111 (4.5%); Pulmonology 5/111 (4.5%); Urology 4/111 (3.6%); Neurosurgery 2/111 (1.9%); Surgical Oncology 1/111 (0.9%); Otorhinolaryngology 1/111 (0.9%); Orthopedics 1/111 (0.9%); Psychiatry 1/111 (0.9%).

Candida species identified

The species recovered were: *C. albicans* 58/111 (52.3%); *C. glabrata* 27/111 (24.3%); *C. parapsilosis* 16/111 (14.4%); *C. tropicalis* 7/111 (6.3%); *Candida lipolytica* 2/111 (1.8%); *Candida krusei* 1/111 (0.9%). The number of isolates in relation to the year is represented in *Figure 1*. Of note, 10/27 (37%) of *C. glabrata* isolates were recovered during 2021.

Candida species identified and demographic variables

Comparing age median values and gender in relation to the recovery rate of *Candida* spp., we found that patients with BC positive for *C. glabrata* were significantly older: *C. albicans* 74.5 years (IQR: 63.3-80.3) *vs C. glabrata* 79 years (IQR: 68-85) *vs C. parapsilosis* 65 years (IQR: 47.5-70.8) *vs C. tropicalis* 67 years (IQR: 64-81), $P=0.018$. Conversely, no significant difference was found between males and females in relation to species of *Candida*: *C. albicans* 40/81 (49.4%) *vs C. glabrata* 20/81 (24.7%) *vs C. parapsilosis* 15/81 (18.5%) *vs C. tropicalis* 6/81 (7.4%), $P=0.211$. *Candida lipolytica* and *C. krusei* were excluded from the analysis due to small sample size.

Candida species identified and comorbidities

The comparison of frequencies of *Candida* spp. in relation to comorbidities is described in *Table 1*. *Candida lipolytica* and *C. krusei* were excluded from the analysis due to small sample size. The only significant association found was a higher frequency of *C. albicans* in stroke patients.

Candida species identified and organ damage evaluated by abnormalities of urgent blood tests

Table 2 describes the possible association between a *Candida* spp. and the organ damage suffered by the patient evaluated by urgent blood tests performed concurrently with BC collection. *Candida lipolytica* and *C. krusei* were excluded from the analysis due to small sample size. Of note, patients with BC positive for *C. glabrata* had significantly higher values of serum creatinine and sodium, as well as white blood cells and neutrophils. To investigate for possible re-

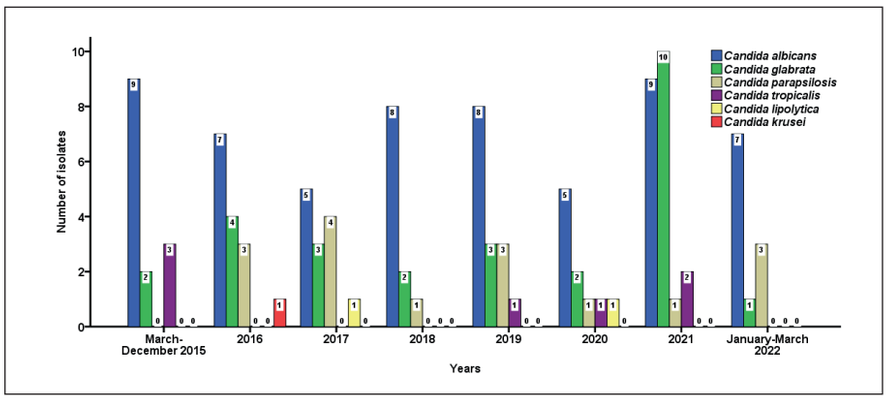

Figure 1 - *Number of Candida spp. recovered in relation to time.*

Table 1 - *Frequencies of main comorbidities according to Candida spp. recovered from blood culture. Candida albicans=58; Candida glabrata=27; Candida parapsilosis=16; Candida tropicalis=7.*

Comorbidities	*Candida albicans*	*Candida glabrata*	*Candida parapsilosis*	*Candida tropicalis*	*Whole sample*	*P*
COVID-19	4 (44.4)	2 (33.3)	3 (22.2)	0 (0)	9 (100)	0.791
Pneumonia	10 (35.7)	10 (35.7)	6 (21.4)	2 (7.1)	28 (100)	0.125
COPD	11 (55)	5 (25)	3 (15)	1 (5)	20 (100)	0.999
Mechanical ventilation	4 (33.3)	5 (41.7)	2 (16.7)	1 (8.3)	12 (100)	0.312
Urinary tract infection	6 (50)	3 (25)	3 (25)	0 (0)	12 (100)	0.657
NIDDM	14 (51.9)	7 (25.9)	5 (18.5)	1 (3.7)	27 (100)	0.882
Stroke	10 (43.5)	4 (17.4)	4 (17.4)	5 (21.7)	23 (100)	0.015
Acute myocardial infarction	6 (60)	2 (20)	1 (10)	1 (10)	10 (100)	0.821
Chronic kidney disease	9 (64.3)	3 (21.4)	2 (14.3)	0 (0)	14 (100)	0.878
Leukemia	1 (20)	2 (40)	2 (40)	0 (0)	5 (100)	0.154
Solid tumor	21 (63.6)	6 (18.2)	4 (12.1)	2 (6.1)	33 (100)	0.599
Central line	21 (53.8)	9 (23.1)	6 (15.4)	3 (7.7)	39 (100)	0.975
Major surgery	15 (55.6)	6 (22.2)	5 (18.5)	1 (3.7)	27 (100)	0.855
Diverticulitis	3 (37.5)	4 (50)	1 (12.5)	0 (0)	8 (100)	0.393

COVID-19: Coronavirus disease 2019; COPD: Chronic obstructive pulmonary disease; NIDDM: Non-insulin-dependent diabetes mellitus.
Values are expressed as: absolute numbers (%).

Table 2 - *Candida spp. and organ damage evaluated by urgent blood tests at the time of blood culture collection. Candida albicans=58; Candida glabrata=27; Candida parapsilosis=16; Candida tropicalis=7.*

Blood test	*Candida albicans*	*Candida glabrata*	*Candida parapsilosis*	*Candida tropicalis*	*Whole sample*	*P*
Creatinine (mg/dL)	1.1 (0.5-1.6)	1.8 (1.1-2.9)	0.7 (0.5-1.1)	0.8 (0.5-1.3)	1.1 (0.6-1.8)	0.006
Sodium (mEq/L)	140 (135.7-146.5)	145 (142-151)	138 (134.7-141.3)	146 (138-149)	141.5 (136-147.5)	0.002
Potassium (mEq/L)	3.8 (3.5-4.2)	3.9 (3.6-4.5)	4 (3.5.-4.4)	3.8 (3.3-4.3)	3.8 (3.5-4.3)	0.624
C-reactive protein (mg/dL)	14.1 (5.9-20.8)	15.6 (5.5-23.2)	8.9 (4.7-15.4)	7.4 (2.6-14.3)	14.1 (5.7-19.7)	0.167
White blood cells (cells×10^3/mcL)	9.8 (6.7-14.6)	11.6 (9.1-16.6)	8.4 (3.8-11.7)	8.7 (4.7-9.5)	9.9 (7.5-13.9)	0.013
Red blood cells (cells×10^6/mcL)	3.4 (3.1-3.9)	3.3 (3.1-3.7)	3.2 (2.8-3.6)	3.2 (3.0-4.1)	3.3 (3.1-3.8)	0.531
Hemoglobin (g/dL)	10.1 (9.3-11.3)	10 (9.1-11.3)	9.7 (8.7-10.5)	9.5 (8.6-10.3)	10 (9.2-11.1)	0.589
Hematocrit (%)	31 (29.1-36.3)	31.4 (27.8-35.3)	29.9 (27.4-31.8)	28.9 (27.1-35.7)	30.6 (28.2-35.2)	0.275
Platelet Count (cells×10^3/mcL)	198 (139.7-253)	240 (102-316)	257 (75-384.5)	168 (143-212)	214.5 (128.2-300)	0.647
Neutrophils (cells×10^3/mcL)	8 (5.7-13.3)	8.7 (7.7-11.8)	5.9 (2.5-9.8)	6.5 (3.2-8.3)	7.9 (5.6-11.6)	0.009
Eosinophils (cells/mcL)	70 (10-145)	30 (10-110)	65 (25-135)	80 (30-210)	60 (10-135)	0.274
Basophils (cells/mcL)	20 (10-40)	30 (20-80)	25 (20-40)	20 (10-50)	20 (10-40)	0.264
Lymphocytes (cells/mcL)	770 (517.5-995)	720 (390-1550)	920 (437.5-1510)	930 (410-1290)	785 (475-1180)	0.592
Monocytes (cells/mcL)	405 (225-542.5)	390 (260-720)	325 (172.5-502.5)	370 (290-420)	390 (230-547.5)	0.718

Values are expressed as: median (interquartile range).

nal failure already present at admission among patients with BC positive for *C. glabrata*, we compared creatinine values at admission with those measured at the time of BC collection (*Figure 2*). The comparison showed a significant difference: 1.1 mg/dL (IQR: 0.9-1.2) *vs* 1.8 mg/dL (IQR: 1.1-2.9); *P*<0.0001.

Candida species identified and outcome

The comparison of frequencies among *Candida* spp. and mortality did not show any significant association (*P*=0.358). Evaluating the positivity rates within the group of patients that died in Hospital (67/111; 60.4%) we had: *C. albicans* 37/67 (55.2%) *vs C. glabrata* 19/67 (28.4%) *vs C. parapsilosis* 7/67 (10.4%) *vs C. tropicalis* 4/67 (6%). Conversely, comparing the death rates within the species of Candida, we had: *C. albicans* 37/58 (63.8%) *vs C. glabrata* 19/27 (70.4%) *vs C. parapsilosis* 7/16 (43.8%) *vs C. tropicalis* 4/7 (57.1%). *Candida lipolytica* and *C. krusei* were excluded from the analysis due to small sample size.

Receiver-Operating Characteristic Analysis

A ROC analysis was performed to look for possible thresholds among the continuous variables found significantly different between two groups: *C. glabrata vs* other *Candida* spp. (*Figure 3*). The best cut-off value for creatinine in discriminating *C. glabrata* from other *Candida* spp. was ≥1.45 mg/dL; 0.67 (95% CI: 0.49-0.85) sensitivity; 0.75 (95% CI: 0.66-0.84) specificity; Youden's J statistic: 0.42. Likewise, the best discriminating value of neutrophil count was 7,365 cells/mcL; 0.82 (95% CI: 0.67-0.96) sensitivity; 0.55 (95% CI: 0.44-0.66) specificity; Youden's J statistic: 0.36.

Estimate of post-test probability of *Candida glabrata* fungemia

Therefore, having a pre-test probability of 24% of *C. glabrata* fungemia with a microscopic examination positive for fungi, applying Bayes' theorem, we calculated the post-test probability of *C. glabrata* fungemia with creatinine values ≥1.45 mg/dL:

Equation 2:

$$P(\text{Cg} \mid \text{Cr} \geq 1.45) = \frac{P(\text{Cr} \geq 1.45 \mid \text{Cg}) \times P(\text{Cg})}{P(\text{Cr} \geq 1.45 \mid \text{Cg}) \times P(\text{Cg}) + P(\text{Cr} \geq 1.45 \mid \text{oCs}) \times P(\text{oCs})}$$

$$= \frac{0.67 \times 0.24}{0.67 \times 0.24 + 0.25 \times 0.76} = \frac{0.161}{0.161 + 0.190} = \frac{0.161}{0.351} = 0.458$$

Cg: *Candida glabrata*; oCs: other *Candida* spp.; Cr: creatinine.

Estimate of post-test probability of fungemia by other *Candida* spp.

Conversely, from a pre-test probability of 76%, we calculated the post-test probability of fungemia by other *Candida* spp. with creatinine values <1.45 mg/dL:

Equation 3:

$$P(\text{oCs} \mid \text{Cr} < 1.45) = \frac{P(\text{Cr} < 1.45 \mid \text{oCs}) \times P(\text{oCs})}{P(\text{Cr} < 1.45 \mid \text{oCs}) \times P(\text{oCs}) + P(\text{Cr} < 1.45 \mid \text{Cg}) \times P(\text{Cg})}$$

$$= \frac{0.75 \times 0.76}{0.75 \times 0.76 + 0.33 \times 0.24} = \frac{0.57}{0.57 + 0.079} = \frac{0.57}{0.649} = 0.878$$

Cg: *Candida glabrata*; oCs: other *Candida* spp.; Cr: creatinine.

DISCUSSION

The main result of this study is the more accurate probability estimate of identifying a *C. glabrata* from a BC collected by venipuncture and positive for fungi, using the creatinine value measured at the time of BC collection (*Equation 2*). As already described by other authors (Harrington *et al.*, 2007; Doymaz *et al.*, 2010), the presence of branched pseudohyphae at mi-

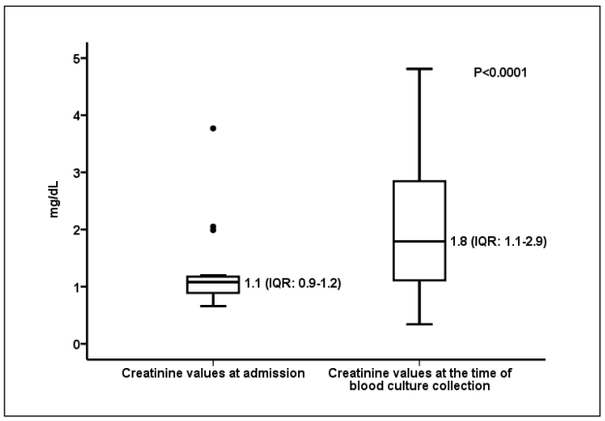

Figure 2 - *Comparison of creatinine median values at admission with those measured at the time of blood culture collection in the subgroup of patients with blood cultures positive for Candida glabrata.*

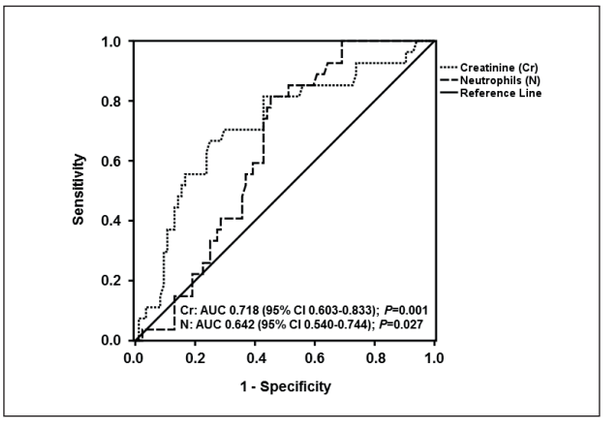

Figure 3 - *Receiver-Operating Characteristic Analysis of creatinine and neutrophils in predicting the presence of Candida glabrata vs other Candida spp. in blood cultures positive for fungi. CI: confidence interval.*

croscopic examination of Gram-stained blood smear makes the recovery of *C. glabrata* very unlikely. But starting from a pre-test probability of 24%, obtained from our local prevalence of *C. glabrata* fungemia from BC collected by venipuncture, if the creatinine value is ≥1.45 mg/dL, the post-test probability of recovering a *C. glabrata* increases to 45.8%. This result is also supported by a positive likelihood ratio of 0.67/0.25=2.68. By contrast, if the creatinine value is <1.45 mg/dL, the probability of recovering another *Candida* spp. increases from 76% to 87.8% (*Equation 3*). The finding of deterioration in renal function as a variable associated with *C. glabrata* fungemia is a result already described in the literature (Malani *et al.*, 2005; Ruan *et al.*, 2008). In particular, the higher creatinine median values found in our sample of patients with *C. glabrata* fungemia could be due not only to the older age found, a known risk factor for acute kidney injury (Coca, 2010), but also to some diseases already present before hospitalization but not considered in this study, e.g., autoimmune diseases, systemic hypertension or obesity, predisposing to renal failure, or to the therapy administered during hospitalization before blood culture collection. Unfortunately, all these variables were not evaluated and this will be the subject of a future study. The possibility of chronic kidney disease already present in all patients with BC positive for *C. glabrata* at admission to Hospital was already excluded by the data reported in *Table 1*; nevertheless, we performed the comparison of creatinine median values between admission and BC collection, which showed a significant difference. Therefore, among the 27 patients positive for *C. glabrata*, only three patients (11.1%) had values above 1.45 mg/dL at admission, suggesting that sepsis most likely caused renal function deterioration, as already reported by several authors (Wan *et al.*, 2003; Peerapornratana *et al.*, 2019). Even though the areas under the curve showed that creatinine had moderate discriminatory power, it was greater than neutrophil count (Swets, 1988). Indeed, for higher neutrophil count values, the line reaches values of random chance, indicating a bimodal association with the presence of *C. glabrata*. We chose not to include serum sodium values in the model due to the covariance with creatinine values (Spearman's rho: 0.242; P=0.008) and, since some patients positive for *C. tropicalis* had high values (*Table 2*) of serum sodium, it was conceivable that its discriminating power in predicting the recovery of *C. glabrata* was not superior to that of creatinine [AUC: 0.700 (95% CI: 0.597-0.803); P=0.002].

The prevalence of the *Candida* spp. found in this study is substantially similar to that of other authors (Marr, 2004; Pfaller & Diekema, 2007). Concerning demographic variables and *Candida* species recovered, the finding that patients positive for *C. glabrata* were significantly older has already been described (Malani *et al.*, 2005). The lack of a significant association between most comorbidities and a particular *Candida* spp. was somehow predictable, since the risk factors evaluated are described in the literature as associated to overall fungemia (Poissy *et al.*, 2020). The greater proportion of *C. albicans* recovered from stroke patients is an interesting result: indeed, a similar finding was described in a multicenter, retrospective, case–control study that evaluated 300 adult patients hospitalized in Internal Medicine wards. In that study, neurological disability (including cerebrovascular disease and hemiplegia) was found significantly associated with a greater risk of candidemia, and the proportion of *C. albicans* recovery was similar to that of the present study (Sozio *et al.*, 2018). The finding of a high prevalence of BC positive for *C. glabrata* (10/27; 37%) during 2021 is of interest because it could be related in some way to the SARS-CoV-2 pandemic. This issue also needs to be addressed.

With regard to mortality, we did not find any significant association with a specific *Candida* spp., and this matches the results of Blot *et al.* (2001) and Klevay *et al.* (2008), who found no differences in mortality between patients with *C. albicans* or *C. glabrata* fungemia.

This study has limitations: the probability estimate depends on prevalence; therefore, the results could not be applied to all settings and the prevalence of the disease evaluated is quite low (Bassetti *et al.*, 2013). Consequently, the sample size is small.

CONCLUSION

In conclusion, in this study we showed that the probability of recovery of *Candida glabrata* from blood cultures positive for fungi collected by venipuncture can be better estimated using concurrent serum creatinine values.

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