

Candida Colonization as a Risk Marker for Invasive Candidiasis in Intensive Care Unit

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Abstract:

Background: Invasive candidiasis is a serious complication among critically ill patients, with delayed diagnosis often contributing to poor outcomes. Colonization by *Candida* species is increasingly recognized as a precursor to invasive infection.

Methods: This retrospective study was conducted in mixed medical–surgical ICUs of Patna Medical College and Hospital over a 2-year period. Medical and microbiological records of 200 adult patients admitted for more than 48 hours were reviewed. Colonization was assessed from surveillance cultures (oral cavity, respiratory tract, urine, rectum, and catheter tips). The colonization index (CI) was calculated, and invasive candidiasis was diagnosed based on isolation of *Candida* from blood or other sterile sites.

Results: *Candida* colonization was found in 120 (60%) of the 200 patients. Compared to 4 (5%) of non-colonized patients, 36 (30%) of colonized individuals experienced invasive candidiasis. Patients without invasive disease had a mean CI of 0.3 ± 0.1 , while those with invasive illness had a mean CI of 0.7 ± 0.2 . *Candida albicans* accounted for 40% of all isolated species, with *tropicalis* (30%), *glabrata* (15%), *parapsilosis* (10%), and *krusei* (5%), the next most prevalent species. Broad-spectrum antibiotic exposure (OR 3.5, 95% CI 1.8–6.9), central venous catheterization (OR 2.8, 95% CI 1.4–5.3), and colonization index > 0.5 (OR 5.1, 95% CI 2.3–10.9) were independent risk factors for invasive candidiasis. Patients with invasive candidiasis had an ICU death rate of 45%, while those without it had a mortality rate of 20%.

Conclusions: *Candida* colonization, particularly at multiple sites and with a colonization index ≥ 0.5 , was strongly associated with invasive candidiasis in ICU patients. Routine colonization surveillance may help identify high-risk patients and guide timely antifungal interventions.

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Introduction

Invasive candidiasis has emerged as a leading cause of bloodstream infections in critically ill patients and represents a major clinical challenge in ICUs. Despite improvements in antifungal therapy and critical care practices, mortality remains high, frequently reported between 30% and 50%. The difficulty of timely diagnosis is a central factor contributing to poor outcomes, as clinical manifestations are often nonspecific and blood cultures lack both sensitivity and rapid turnaround. These limitations delay initiation of appropriate antifungal treatment, which is closely linked to survival. Identifying patients at greatest risk before invasive infection occurs is therefore of considerable importance, particularly in settings with limited resources where the disease burden is substantial and delayed recognition may have serious consequences.

Candida species normally inhabit the human gastrointestinal, respiratory, and genitourinary tracts as part of the commensal flora. In healthy individuals, this colonization rarely progresses to disease. However, critically ill patients are frequently exposed to risk factors such as central venous catheters, broad-spectrum antibiotics, urinary catheters, mechanical ventilation, corticosteroids, or immunosuppressive agents. These interventions alter the microbial balance and increase mucosal permeability, allowing *Candida* species to proliferate and translocate into the bloodstream. Surveillance cultures and calculation of a colonization index (CI) have been proposed as practical tools for predicting progression to invasive candidiasis. A CI value of 0.5 or higher has been associated in prior studies with a significantly

increased likelihood of invasive disease, highlighting its potential role in risk stratification.

Epidemiological trends also underline the need to study colonization dynamics in ICU populations. While *Candida albicans* has historically been the predominant pathogen, recent data show a growing prevalence of species that are non-*albicans* *C. tropicalis*, *C. glabrata*, and *C. parapsilosis*. These species are often less susceptible to commonly used antifungals, complicating empiric therapy and antifungal stewardship. Reports from India, in particular, indicate a rising dominance of *C. tropicalis* in ICU-related infections. Against this background, local data are essential to inform clinical decision-making and guide preventive strategies. The present retrospective study was conducted in the mixed medical–surgical ICUs of Patna Medical College and Hospital, Patna, Bihar, with the aim of evaluating Colonization of *Candida* as an indicator of invasive candidiasis, examining species distribution, identifying associated risk factors, and assessing its impact on patient outcomes.

Methods

Study design and setting: Retrospective observational study in the mixed medical–surgical ICUs of Patna Medical College, Patna, Bihar, over a 2-year period (January 2021 to December 2022).

Study population: 200 consecutive adult patients admitted for more than 48 hours were included.

Inclusion criteria:

- Age ≥ 18 years
- At least one surveillance culture performed during ICU stay

Exclusion criteria:

- Prior antifungal therapy before ICU admission
- Incomplete medical records

Data collection: Clinical records were reviewed for age, sex, comorbidities, device use (central venous catheters, urinary catheters, ventilators), exposure to antibiotics, immunosuppressants, length of stay, and ICU outcomes. Microbiology records were reviewed for site of colonization, *Candida* species, and blood/sterile site cultures.

Definitions:

- Colonization: Isolation of *Candida* species from non-sterile sites (urine, respiratory tract, oral cavity, rectum, catheter tips).
- Colonization index (CI): Ratio of colonized sites to total sites sampled. $CI \geq 0.5$ was considered high risk.
- Invasive candidiasis: Isolation of *Candida* from sterile sites or blood, with compatible clinical features.

Statistical analysis: Descriptive statistics summarized demographics and microbiological findings. Associations were tested with chi-square and t-tests. Logistic regression identified independent predictors. A p-value < 0.05 was considered significant.

Results

Among 200 ICU patients studied, the median age was 56 years (range 19–84), with men comprising nearly two-thirds of the cohort; diabetes mellitus (30%), chronic kidney disease (18%), and malignancy (12%) were the most common comorbidities. *Candida* colonization was observed in 120 patients (60%), most frequently from urine (40%) and respiratory samples (30%). Invasive candidiasis occurred in 40 patients (20%), with a significantly higher incidence in those with colonization (36 of 120; 30%) compared with those without (4 of 80; 5%). The mean colonization index was 0.7 ± 0.2 in patients who developed invasive infection versus 0.3 ± 0.1 in those who did not ($p < 0.01$). Species analysis showed *Candida albicans* in 40% of isolates, while non-*albicans* species together accounted for 60% of cases, led by *C. tropicalis* (30%), followed by *C. glabrata* (15%), *C. parapsilosis* (10%), and *C. krusei* (5%). On multivariate regression, exposure to broad-spectrum antibiotics (OR 3.5, 95% CI 1.8–6.9), central venous catheterization (OR 2.8, 95% CI 1.4–5.3), and $CI \geq 0.5$ (OR 5.1, 95% CI 2.3–10.9) were identified as independent predictors of invasive candidiasis. Mortality was significantly higher among patients with invasive disease (45% vs. 20%, $p = 0.002$), and their mean ICU stay was also prolonged (21 ± 7 days vs. 14 ± 5 days).

Table 1: Demographic and Clinical Characteristics of the Study Population (N = 200)

Characteristic	Value
Median age (years, range)	56 (19–84)
Male : Female ratio	130 : 70 (1.8:1)
Diabetes mellitus	60 (30%)
Chronic kidney disease	36 (18%)
Malignancy	24 (12%)
<i>Candida</i> colonization	120 (60%)
Invasive candidiasis overall	40 (20%)

Table 2: Candida Species Distribution Among Colonized and Invasive Cases

Species	Colonization (%)	Invasive candidiasis (%)
<i>Candida albicans</i>	40	40
<i>C. tropicalis</i>	30	30
<i>C. glabrata</i>	15	15
<i>C. parapsilosis</i>	10	10
<i>C. krusei</i>	5	5

Table 3: Independent Predictors of Invasive Candidiasis

Risk Factor	Odds Ratio (OR)	95% Confidence Interval	p-value
Broad-spectrum antibiotics	3.5	1.8–6.9	<0.01
Central venous catheter	2.8	1.4–5.3	<0.05
Colonization index ≥ 0.5	5.1	2.3–10.9	<0.001

Discussion

This retrospective analysis from the mixed medical–surgical ICUs of Patna Medical College and Hospital demonstrates that *Candida* colonization is both frequent and clinically important in critically ill patients. More than half of the individuals admitted for longer than 48 hours showed colonization at one or more body sites, and nearly one-third of those colonized progressed to invasive candidiasis. In contrast, invasive infection developed in only a minority of non-colonized patients. These findings emphasize that colonization is not a neutral event but rather an early warning sign for subsequent invasive disease, underscoring the value of surveillance in high-risk ICU populations.

The predictive role of the colonization index (CI) was clearly evident in this cohort. Patients with a CI of 0.5 or greater had a significantly higher likelihood of progressing to invasive infection, confirming the utility of this threshold in an Indian ICU setting. Earlier work from European centers first proposed this cut-off, and subsequent reports have validated its use across diverse populations. Our findings reinforce the idea that systematic colonization surveillance, coupled with CI calculation, can be applied practically in routine ICU care to stratify risk and identify patients who may benefit from closer monitoring or early intervention.

Species distribution patterns observed in this study add further insight into local epidemiology. Even while *Candida albicans* was still the most commonly isolated species, a greater proportion of colonization and invasive illness was caused by non-*albicans* *Candida* as a whole. Among these, *C. tropicalis* was particularly prominent, followed by *C. glabrata* and *C. parapsilosis*. This pattern is consistent with other Indian studies but differs from Western countries, where *C. glabrata* has become dominant. The rise of non-*albicans* *Candida* is clinically significant because several of these species exhibit reduced susceptibility to azole antifungals, which are commonly used for empirical treatment. These findings highlight the importance of local

surveillance to inform empirical therapy and antifungal stewardship strategies.

The analysis of clinical risk factors confirmed that exposure to broad-spectrum antibiotics, use of central venous catheters, and high colonization indices were independently associated with invasive candidiasis. Each of these factors contributes in a distinct way: antibiotics alter the balance of commensal flora and facilitate fungal overgrowth, invasive catheters provide a portal of entry, and the CI captures the overall burden of colonization. These results emphasize that invasive candidiasis arises from a complex interplay of host, microbial, and treatment-related factors. Preventive measures should therefore include rational antibiotic use, meticulous catheter care, and incorporation of colonization monitoring into infection control policies.

Patient outcomes in this cohort underline the severity of invasive candidiasis. Mortality among affected individuals approached 45%, more than double the mortality in non-invasive cases. In addition, patients with invasive disease experienced longer ICU stays, reflecting greater illness complexity and treatment burden. These findings are consistent with international reports, where mortality rates remain unacceptably high despite advances in antifungal therapy. The observed impact on both survival and resource utilization underscores the need for earlier recognition and targeted strategies to prevent progression from colonization to invasive infection.

This study provides valuable insights but also has limitations that must be acknowledged. Its retrospective design depends on the completeness and accuracy of existing records, and antifungal susceptibility testing was not available for all isolates, limiting our ability to comment on resistance trends. Furthermore, as a single-center study, results may not be generalizable to all ICUs, particularly those with different patient demographics or practices. Nonetheless, the relatively large sample size, systematic colonization data, and focus on an Indian ICU population

strengthen the relevance of the findings. Future research should aim to validate colonization indices prospectively across multiple centers, incorporate fungal biomarkers and molecular diagnostics to enhance predictive accuracy, and evaluate the cost-effectiveness of implementing colonization surveillance as a standard component of ICU care.

Conclusions

In this 2-year retrospective study of 200 ICU patients, *Candida* colonization, particularly at multiple body sites and with a colonization index ≥ 0.5 , was closely linked to the emergence of invasive candidiasis. Colonization surveillance represents a valuable tool for identifying high-risk patients and may inform early antifungal strategies to reduce morbidity and mortality in critically ill populations.

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