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Original Study

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Correlation between the invasive fungal infection among and their blood glucose levels

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Abstract: The purpose of this study was to study the association of deep fungal infection with glucose levels in critically ill intensive care unit (ICU) patients. Fasting blood glucose level was measured for 108 critically ill ICU patients in the morning. After analyzed according to the Spearman method found deep fungal infections in patients with the rise in blood glucose levels and the ratio increases, a positive correlation between the two. Deep infection in critically ill ICU patients and their blood glucose levels was closely related, and therefore, there should a focus on controlling blood sugar levels in patients.

Keywords: ICU, critically ill patients, deep fungal

The prevalence of fungal infection in critically ill intensive care unit (ICU) patients increases gradually with glucose metabolic disorders, resulting in the decline of their body resistance and invasive surgical interventions [1]. ICU patients are often severely ill, and invasive fungal infection is prevalent, which may further increase the difficulty of treatment. Controlling the blood glucose levels (BGLs) of ICU patients but neglecting the specific level range has been reported to reduce the risk of fungal infection [2]. Therefore, this paper investigated and analyzed the correlation between the prevalence of invasive fungal infection and BGL in critically ill ICU patients and presented some conclusions.

1 Materials and methods

1.1 Clinical data

From August 2015 to August 2017, 108 critically ill ICU patients in our hospital were enrolled as study subjects (58 males and 50 females). The age range was 21–68 years, with an average age of 54.2 ± 3.2 years. The patients had the following underlying health problems: cerebral vascular accidents (35 cases), pulmonary disease (30 cases), advanced cancers (24 cases), cardiovascular diseases (13 cases), drug poisoning (3 cases), multi-organ function failures (2 cases), and other diseases (1 case). The inclusion criteria included (1) length

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of stay at the ICU ≥2 days and (2) age of patient >20 years. The exclusion criteria were (1) diabetes mellitus and (2) invasive fungal infection prior to admission to the ICU. We obtained fasting venous blood samples from the patients to determine their BGLs in the morning. The patients were grouped as follows: (1) Group A: BGL ≤ 6.1 mmol/L; (2) Group B: 6.1 mmol/L^{w} BGL ≤ 10.0 mmol/L; and (3) Group C: BGL > 10.0 mmol/L. The characteristics of the patients in these groups were as follows: Group A – 18 patients, 10 males and 8 females; 1.25:1 sex ratio; and age range of 21–65 years with an average age of 53.5 ± 2.5 years; Group B – 52 cases, 28 males and 24 females; 1.17:1 sex ratio; and age range of 22–64 years with an average age of 52.7 ± 2.2 years; and Group C – 38 cases, 20 males and 18 females; 1.11:1 sex ratio; and age range of 24–68 years with an average age of 55.1 ± 0.7 years. The differences among the three groups in terms of sex ratio, age, and underlying health problems are statistically insignificant ($P > 0.05$). However, the data series is comparable.

1.2 Research methods

The general information of each patient in each group was counted and recorded separately, and their fasting BGLs were detected every morning on the basis of insulin dosage and usage. Subcutaneous or intravenous injection or intravenous drip was recorded. These groups were compared in terms of invasive fungal infection. Specimens, mainly including (1) sputum, (2) blood, (3) urine, (4) indwelling catheter liquid, (5) drainage liquid, and (6) wound secretion, were all derived from the body fluids of patients. All the sampling procedures were strictly followed for aseptic operations. The diagnostic criteria for fungal infection conform to the *Diagnostic Standards for Nosocomial Infections of the Ministry of Health of the People's Republic of China (Trial)*.

1.3 Statistical methods

SPSS 13.0 statistical software was used for analysis. Data were compared by using the Chi-square test. The measurements were expressed by ($\bar{x} \pm s$), and the t-test was conducted. The between-group comparison was conducted by Analysis of Variance and the correlation analysis was performed by Spearman. The differences were statistically significant when $P < 0.05$.

2 Results

2.1 Between-group comparison in the severity

The differences among the three groups in terms of age, BMI, body temperature, or heart rate were statistically insignificant ($P > 0.05$) as shown in Table 1.

Tab. 1: Between-Group Comparison in Terms of Severity (e.g., $\bar{x} \pm s$)

Group	Number of Cases	Age	BMI (kg/m^2)	Body Temperature (ºC)	Heart Rate (Beats Per Minute)
Group A	18	53.5 ± 2.5	23.32 ± 3.73	36.3 ± 1.3	110.2 ± 25.5
Group B	52	52.7 ± 2.2	23.68 ± 3.55	36.0 ± 1.1	98.9 ± 24.3
Group C	38	55.1 ± 0.7	23.72 ± 3.14	36.2 ± 1.5	102.5 ± 21.2
F value	-	1.486	0.138	1.105	1.321
P value	-	0.225	0.845	0.223	0.179

2.2 Between-group comparison of the prevalence of invasive fungal infection

The prevalence rates of invasive fungal infection in Groups A, B, and C were 5.56% (1/18), 28.85% (15/52), and 50.00% (19/38), respectively, and the prevalence in Group B was substantially less than that in Group C, having a statistically significant difference (P < 0.05; see Table 2).

Tab. 2: Between-Group Comparison of the Prevalence of Invasive Fungal Infection (cases, %)

Group	Number of Cases	Number of Cases	Prevalence
Group A	18	1	5.56*$^{\Delta}$
Group B	52	15	28.85$^{\Delta}$
Group C	38	19	50.00*
F value	4.656		
P value	0.027		
Group A *vs* Group B	χ^2 value	4.114	
	P value	0.043	
Group A *vs* Group C	χ^2 value	10.509	
	P value	0.001	
Group B *vs* Group C	χ^2 value	4.180	
	P value	0.041	

Note: Compared with Group B, *P < 0.05; compared with Group C, $^{\Delta}P$ < 0.05.

2.3 Analysis on the correlation between the prevalence of invasive fungal infection and the BGL

After using the Spearman's correlation coefficient, we found that the prevalence of invasive fungal infections increased with BGL, and both were positively correlated (r = 0.863, P = 0.000).

Tab. 3: Correlation between the Prevalence of Invasive Fungal Infection and BGL

Indicator	Invasive Fungal Infection	
	r-value	*P* value
BGL	0.863	0.000

3 Discussion

Clinically, glucose metabolic disorders frequently occur in critically ill ICU patients. However, in recent years, invasive fungal infection in hospitals has become increasingly prevalent, demonstrating a yearly increase [3]. According to relevant statistics [4], candidiasis ranks sixth among the causes of hospital-acquired infections and has the highest mortality rate. This finding shows that fungi have become an important pathogen of nosocomial infections [5]. By studying the situation of invasive fungal infection in our critically ill ICU patients and analyzing its correlation with the BGLs, this paper is designed to provide some theoretical basis for the clinical infection control among ICU patients.

In the present study, the differences among the three groups in terms of age, BMI, body temperature, or heart rate are nonsignificant. Moreover, the prevalence of invasive fungal infection in Group A is 5.56%, which is evidently lower than that in Group B (28.85%) and Group C (50.00%). Furthermore, Spearman's correlation coefficient indicated that the prevalence of invasive fungal infection increases with BGL, and both are positively correlated. The results are in line with the findings of Li *et al.* [6], suggesting that the prevalence of fungal infection among critically ill ICU patients is closely related to their BGLs. This finding can be primarily attributed to the following factors. (1) Critically ill ICU patients are usually in a state of stress, and their bodies secrete increased levels of stress hormones, such as glucagon, catecholamine, cortisol, and growth hormone. Stress can promote the release of various inflammatory factors, such as large quantities of TNF–IL-1 and IL-6 with insulin resistance, leading to the formation of hyperglycemia, which can weaken the defense response of the body, reduce the chemotaxis and phagocytosis of polymorphonuclear leukocytes, and ultimately increase the incidence of infection. The resulting infection can further aggravate the symptoms of stress hyperglycemia, forming a vicious circle and producing poor prognosis [7]. (2) Improved BGL is beneficial for the expression of activated B or T cells, the establishment and maintenance of the immune system, and the reduction of nosocomial infections by accelerating recovery from inflammations. The BGLs of patients of Group C are higher than 10.0 mmol/L. Among the critically ill ICU patients, the proportion of fungal infection is up to 50% primarily because blood osmotic pressure increases with high BGL, and this increase inhibits the phagocytic functions of neutrophils, reduces the ability of the body to resist infection, and causes abnormalities in the immune system, thereby promoting the spread of fungal infection and adding value to deep organizations [8]. Bueno [9] investigated the situation of fungal infection among ICU patients and reported that their BGLs should be monitored. This finding also supports this paper.

Notably, although the lowest proportion of patients with deep infection was obtained when BGL ≤ 6.1mmol/L, protecting such patients from hypoglycemia should be considered. Based on many years of experience, we found that the clinical situation worsens at low BGL. Therefore, BGL should be considered when protecting patients from fungal infection. Critically ill patients are safe when their BGLs are within the range of 4.5–8.3 mmol/L, and this range should be the most reasonable in clinical practice.

Overall, the occurrence of intensive fungal infection among critically ill ICU patients is closely related to their BGLs; therefore, the BGLs of patients should be controlled and clinically monitored.

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