ORIGINAL RESEARCH

The Prediction Effect of HbA_{1c} on Nosocomial Infection in Diabetic Patients was Analyzed Based on Decision Curve and Dose Response

Yizhen Li, MM; Peng Zhou, BM; Fengqin Nie, MM; Mei Xia, BM; Qilin Yan, BM

ABSTRACT

Objective • To analyze the predictive efficacy of HbA_{1c} on nosocomial infection in diabetic patients.

Methods • 566 patients with diabetes who received treatment in our hospital from January 2021 to January 2023 were selected as the study objects. All patients received relevant treatment in the hospital. Patients with nosocomial infection during treatment were included in the occurrence group, and those without nosocomial infection were included in the non-occurrence group. The level of HbA_{1c} and other laboratory indicators before admission were compared between the two groups of patients [gender, hypertension, age, body mass index (BMI), length of stay, primary caregiver, duration of disease, diabetes complications, antibiotic use, fasting blood glucose (FBG), invasive treatment, hemoglobin (HGB) and insulin resistance index (HO) MA-IR), to analyze the relationship between each index and the occurrence of hospital infection in diabetic patients, and to test the predictive value of HbA_{1c} level in the occurrence of hospital infection in diabetic patients.

Results • Among 566 patients with diabetes admitted to our hospital, 139 patients had nosocomial infection, accounting for 24.56%, and 427 patients did not have nosocomial infection, accounting for 75.44%. There were no differences in gender, hypertension, BMI, main caregiver, or HGB between the two groups ($P > .05$). Age, hospital stay, course of disease, FBG, HbA_{1c} and HOMA-IR in the occurrence group were higher than those in the non-occurrence group, and the proportion of diabetes complications, antibiotic use and invasive treatment was significantly higher than that in the non-occurrence group, with statistical significance ($P < .05$). Logistics regression analysis showed that old age, long hospital stay, long course of disease, diabetes complications, antibiotic use, high level of FBG, high level of HbA_{1c}, invasive treatment and high level of HOMA-IR were all risk factors for nosocomial infection in diabetic patients ($OR > 1$, $P < .05$). The ROC curve showed that the AUC of FBG and HbA_{1c} in predicting the occurrence of hospital infection in diabetic patients was 0.764 and 0.875, respectively, and the predictive energy of HbA_{1c} was higher than that of FBG.

Conclusion • HbA_{1c} level is correlated with the occurrence of hospital infection events in diabetic patients, and the correlation intensity with the occurrence of hospital infection events in diabetic patients presents a nonlinear dose-response relationship. Detection of HbA_{1c} levels in diabetic patients is conducive to predicting the probability of hospital infection events, and strict control of HbA_{1c} levels in diabetic patients is conducive to improving patient prognosis. (*Altern Ther Health Med.* [E-pub ahead of print.])

Yizhen Li, MM, Attending doctor; Hospital Infection Management Department, The People's Hospital of Wenjiang, Chengdu, China; Department of Endocrinology, The People's Hospital of Wenjiang, Chengdu, China. **Peng Zhou, BM**, Public health physician; **Qilin Yan, BM**, Associate chief nurse; Hospital Infection Management Department, The People's Hospital of Wenjiang, Chengdu, China. **Fengqin Nie, MM**, Attending doctor; **Mei Xia, BM**, Attending doctor; Department of Endocrinology, The People's Hospital of Wenjiang, Chengdu, China.

Corresponding author: Qilin Yan, BM
E-mail: 18011379063@163.com

INTRODUCTION

Diabetes is caused by insufficient insulin secretion or insulin use disorder. The main symptoms are polydipsia, polyuria, polyfood and weight loss. Patients with diabetes with a long course of the disease will face nerve, blood vessel, kidney and other important tissues and organs lesions, leading to cardiovascular disease, renal failure and even death.[1] According to research, diabetes is an important cause of nosocomial infection. In recent years, the incidence and mortality of nosocomial infection in patients with diabetes have been on the rise, which seriously affects the physical and mental health and quality of life of patients. Therefore, in order to reduce the incidence of nosocomial infection in diabetic patients and improve their prognosis, it is important to explore the indicators related to nosocomial infection in diabetic patients. At present, Fasting Blood Glucose (FBG) level is mainly measured as an index for clinical monitoring of diabetic patients, but there are many reasons for the fluctuation of FBG levels in the short term, and there may be some errors[3] in practice. HbA_{1c} is the product of non-enzymatic glycosylated glycosylation between hemoglobin and sugars in red blood cells and has certain continuity, stability, and irreversibility. In addition, HbA_{1c} is closely related to the life cycle of red blood cells. Therefore, HbA_{1c} can generally reflect the average blood glucose level[4] in 8-16 weeks. Based on this, this paper analyzes the relationship between various indicators and the occurrence of hospital infection events in diabetic patients through Logistics regression, analyzes the relationship between HbA_{1c} level and the occurrence risk of hospital infection events in diabetic patients through decision curve and dose-response, and tests the predictive value of HbA_{1c} level for the occurrence of hospital infection events in diabetic patients.

PATIENTS AND METHODS

General Information

A total of 566 diabetic patients admitted to our hospital from January 2021 to January 2023 were selected as the study objects, all of whom received relevant treatment in the hospital. Patients with nosocomial infection during treatment were included in the occurrence group, while those without nosocomial infection were included in the non-occurrence group.

Inclusion criteria

Inclusion criteria: (1) All patients met the diagnostic criteria in the 2018 ADA Standard Diabetes Guidelines;[5] (2) Complete clinical data; (3) good compliance and cooperation with doctors. (4) no drug allergy.

Exclusion criteria: (1) patients with renal failure; (2) patients with systemic infectious diseases, immune diseases and blood system; (3) patients with other malignant tumors; (4) patients with coagulation disorders.

Methods

Diagnosis criteria and grouping method of nosocomial infection in diabetic patients. In the course of treatment for all patients with diabetes, whether there is infection during hospitalization or infection after symptoms, signs, laboratory tests, imaging examinations and etiological examinations can determine hospital discharge. After the above examination, the occurrence of infection in patients (respiratory tract infection, pleural cavity infection, cardiovascular system infection and blood system infection, etc.) was taken as the end event, and the occurrence of nosocomial infection in diabetic patients was recorded as the occurrence group, and the occurrence of nosocomial infection in diabetic patients was recorded as the non-occurrence group.

Collection of clinical data. Gender, age, BMI, length of stay, primary caregiver, course of the disease, diabetes complications, antibiotic use and invasive treatment were recorded through the hospital patient data database. 5 ml of venous blood was collected from patients in the fasting state before admission, the temperature was set at 4°C, and centrifugation was performed at 3000 r/min for 10 min with a centrifugation radius of 10 cm. Serum was collected for testing. Serum fasting blood glucose (FBG), hemoglobin (HGB) levels, insulin resistance index (HOMA-IR) and glycosylated hemoglobin (HbA_{1c}) levels were detected by automatic biochemical analyzer selected from Jinan Xinying Biotechnology Co., LTD.

Statistical analysis

Statistic Package for Social Science (SPSS) 26.0 statistical software (IBM, Armonk, NY, USA) was used to test the normality of measurement data. The normality of measurement data was measured as "$\overline{x} \pm s$", an independent sample t test was used between groups, and paired t test was used within groups. % and n were used to represent the count data, χ^2 test was used, and the rank sum test was used for rank data. Logistic regression analysis was used to examine the relationship between each index and nosocomial infection events in diabetic patients. The receiver operating curve (ROC) was plotted, and the area under the curve (AUC) value was calculated to test and compare the predictive performance of HbA_{1c} and FBG in the occurrence of nosocomial infection in diabetic patients. The restricted cubic spline method combined with spline function and Logistics regression was used to analyze the relationship between independent variables and dependent variables. The best truncation value of HbA_{1c} level was taken as the reference value, and the dose-response relationship between HbA_{1c} level and hospital infection events in elderly patients with diabetes was analyzed by the restricted cubic spline method. The decision curve was drawn to analyze the predictive value of HbA_{1c} level for the occurrence of hospital infection events in elderly patients with diabetes. $P < .05$ was considered statistically significant. $P < .05$ was considered statistically significant.

RESULTS

Nosocomial infection in diabetic patients

Among 566 diabetic patients admitted to our hospital, 139 patients had nosocomial infection, accounting for 24.56%(139/566), and 427 patients did not have nosocomial infection, accounting for 75.44%(427/566). See Table 1.

There were no differences in gender, hypertension, BMI, main caregiver, or HGB between the two groups ($P > .05$). Age, hospital stay, course of disease, FBG, HbA_{1c} and HOMA-IR in the occurrence group were higher than those in the non-occurrence group, and the proportion of diabetes complications, antibiotic use and invasive treatment was significantly higher than that in the non-occurrence group, with statistical significance ($P < .05$). See Table 2.

Table 1. Nosocomial infections in diabetic patients

Groups	Number of cases (n)	Proportion (%)
Occurrence group	139	24.56
Group not occurring	427	75.44

Table 2. Clinical data of diabetic patients in the occurrence group and the non-occurrence group

Project		Occurrence Group (n = 139)	Non-occurrence group (n = 427)	Statistics	*P* value
Gender	male	82 (58.99)	266 (62.30)	$\chi^2 = 0.483$	.487
	female	57 (41.01)	161 (37.70)		
hypertension	is	50 (35.97)	143 (43.73)	$\chi^2 = 0.287$	.592
	no	89 (64.03)	284 (56.27)		
Age ($\bar{x} \pm s$, years)		54.02 ± 10.25	48.23 ± 8.41	$t = 6.665$	.000
BMI ($\bar{x} \pm s$, kg/m²)		23.65 ± 2.47	23.38 ± 2.29	$t = 1.834$	.237
Length of stay ($\bar{x} \pm s$, days)		55.46 ± 5.86	50.61 ± 4.57	$t = 10.101$	.000
Primary caregiver	Relatives	62 (44.60)	201 (47.07)	$\chi^2 = 0.257$	.612
	Other	77 (55.40)	226 (52.93)		
Duration of disease ($\bar{x} \pm s$, years)		7.26 ± 1.85	6.02 ± 1.54	$t = 7.832$	.000
Diabetes complications	There are	80 (57.55)	198 (46.37)	$\chi^2 = 5.248$	.022
	There is no	59 (42.45)	229 (53.63)		
Antibiotic use	There are	82 (58.99)	193 (45.20)	$\chi^2 = 7.987$	.005
	There is no	57 (41.01)	234 (54.80)		
FBG ($\bar{x} \pm s$, mmol/L)		9.64 ± 2.77	7.22 ± 1.89	$t = 11.585$	.000
HbA_{1c} ($\bar{x} \pm s$, %)		9.93 ± 2.62	6.18 ± 1.93	$t = 18.116$	.000
Invasive treatment	There are	85 (61.15)	201 (47.07)	$\chi^2 = 8.315$	.004
	There is no	54 (38.85)	226 (52.93)		
HGB ($\bar{x} \pm s$, g/L)		132.43 ± 12.51	131.36 ± 12.20	$t = 0.893$	.373
HOMA-IR ($\bar{x} \pm s$, pmol/L)		4.13 ± 1.12	3.22 ± 0.78	$t = 10.644$	.000

Logistics regression analysis of the relationship between each index and nosocomial infection events in diabetic patients takes the occurrence of nosocomial infection events in diabetic patients as the dependent variable (1= occurrence, 0= non-occurrence). Logistics regression analysis of various indicators of diabetic patients in Table 2 shows that old age, long hospital stay, long course of disease, diabetes complications, use of antibiotics, high FBG level, high HbA_{1c} level, invasive treatment and high HOMA-IR level are all risk factors for the occurrence of hospital infection events in diabetic patients ($OR > 1$, $P < .05$). See Table 3.

The predictive value of FBG and HbA_{1c} for the occurrence of hospital infection events in diabetic patients was taken as state variables (1= occurrence, 0= non-occurrence), FBG and HbA_{1c} were taken as state variables, and the ROC curve was drawn to show the results. The AUC of FBG and HbA_{1c} in predicting the occurrence of nosocomal infection in diabetic patients was 0.764 and 0.875, respectively, and the optimal cut-off value was 7.775 mmol/L and 7.975%, respectively. See Table 4, Figure 1.

Dose-response analysis of the intensity of association between HbA_{1c} and Nosocomial infection events in diabetic patients

With the optimal cut-off value of HbA_{1c} 7.975% as a reference value, the dose-response relationship between HbA_{1c} and nosocomial infection events in diabetic patients was analyzed by spline function and logistic regression restricted cubic spline method. As shown in Figure 2, the horizontal coordinate corresponds to the continuous change of HbAlc, and the vertical coordinate is its corresponding OR value. The continuous change of HbA_{1c} presents a nonlinear dose-response relationship with the occurrence of nosocomial infection events in diabetic patients ($P < .05$).

The predictive value of HbA_{1c} for nosocomial infection events in diabetic patients was analyzed based on decision curve.

The decision curve was drawn using the high risk threshold as the horizontal coordinate and the net rate of

Table 3. Logistics regression analysis of the relationship between various indicators and nosocomial infection events in diabetic patients

Items	*B*	Standard Error	*Wald*	*P* value	*OR*	95% confidence interval Lower bound	Upper limit
Gender	0.138	0.199	0.483	.487	0.871	0.589	1.287
hypertension	0.110	0.204	0.287	.592	1.116	0.748	1.665
Age	0.073	0.012	8.194	.000	1.130	1.090	1.591
BMI	0.049	0.042	1.396	.237	0.952	0.877	1.033
Length of stay	0.197	0.024	9.600	.000	1.128	1.047	2.860
Primary Caregiver	0.005	0.196	0.001	.979	0.995	0.667	1.462
Course of disease	0.476	0.068	9.435	.000	1.261	1.014	1.709
Complications of Diabetes	0.545	0.197	7.612	.006	1.724	1.171	2.538
Antibiotic use	0.651	0.198	10.795	.001	1.918	1.301	2.829
FBG	0.491	0.054	8.715	.000	1.312	1.255	2.680
HbA_{1c}	0.788	0.072	19.344	.000	1.955	1.395	3.524
Invasive Treatment	0.554	0.201	4.582	.004	1.336	1.125	2.318
HGB	0.007	0.008	0.797	.372	0.993	0.978	1.009
HOMA-IR	0.128	0.131	7.159	.000	1.324	1.250	2.418

Table 4. Predictive value of FBG and HbA_{1c} for nosocomial infection events in patients with diabetes

Items	AUC	Cut-off indicates the value	95%CI	*P* value	Specificity	Sensitivity	Jorden index
FBG	0.764	The tendency for 7.775 L	0.712-0.815	.000	0.748	0.635	0.383
HbA_{1c}	0.875	7.975%	0.840-0.910	.000	0.763	0.845	0.608

Figure 1. Predictive value of FBG and HbA_{1c} for hospital infection events in patients with diabetes

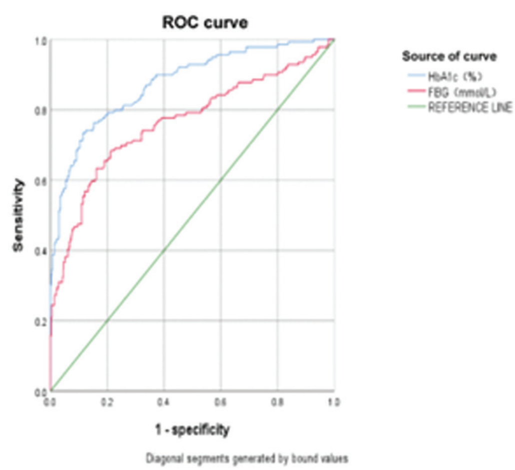


Figure 2. Dose-response analysis of the intensity of association between HbA_{1C} and NOsocomial infection events in diabetic patients

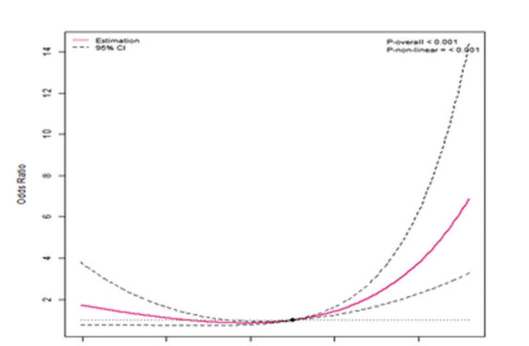
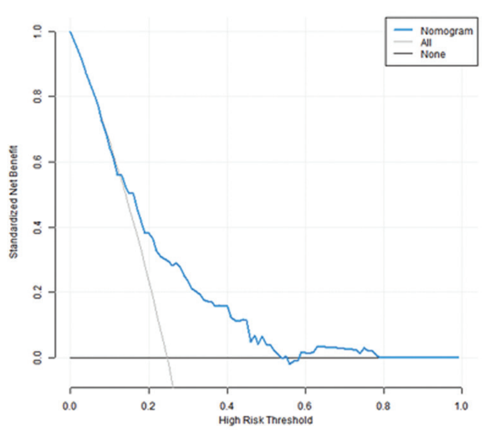


Figure 3. Decision curve analysis of the predictive value of HbA_{1c} for nosocomial infection events in diabetic patients



return as the vertical coordinate. When the high-risk threshold was 0.0-0.45, the net rate of return was > 0, which had clinical significance, and the high-risk threshold was negatively correlated with the net rate of return, indicating that HbA_{1c} had important predictive value for the occurrence of hospital infection events in diabetic patients (Figure 3).

DISCUSSION

Diabetes is caused by insufficient insulin secretion or insulin utilization disorders, resulting in metabolic disorders and a significant decline in disease resistance in the body, and then infection, in which high blood sugar is the main sign[6] of diabetes. Although pre-diabetes has symptoms such as polydipsia, polyuria, polyphagia and weight loss, it is easy to ignore because these symptoms are not specific. When diabetes is detected, the body has suffered great damage which affects the treatment and prognosis.[7] In addition, studies have shown that patients with diabetes are faced with nerve, blood vessel, kidney and other important tissue and organ lesions during treatment, and hospital infections occur, leading to cardiovascular disease, renal failure and even death, so the prognosis of patients with diabetes is now an important medical issue.[8] Relevant studies have pointed out that patients with diabetes are prone to nosocomial infection when receiving treatment, affected by multiple factors such as autoimmune regulation ability, treatment mode and treatment time.[9] In this study, among 566 patients with diabetes admitted to our hospital, 139 patients suffered from nosocomial infection, with an incidence rate of 24.56%, suggesting that patients with diabetes have a higher risk of nosocomial infection during treatment. Therefore, it is of great importance to study various clinical indicators of diabetes and identify the influencing factors of nosocomial infection for reducing the incidence of nosocomial infection in diabetic patients and improving the prognosis of patients.

As the product of a non-enzymatic glycosylation reaction between hemoglobin and sugars in red blood cells, HbA_{1c} has certain continuity, stability and irreversibility. Currently, HbA_{1c} level is often used to evaluate the prognosis[10] of diabetes patients. Studies have pointed out that the HbA_{1c} level in diabetic patients with good prognosis is significantly lower than that in diabetic patients with poor prognosis, and a moderate reduction of HbA_{1c} level in diabetic patients can reduce the incidence[11] of hospital infection. In this study, the level of HbA_{1c} in the group with nosocomial infection was (9.93±2.62)%, which was significantly higher than that in the group without nosocomial infection (6.18±1.93)%, which is consistent with the above results, indicating that HbA_{1c} level is related to the occurrence of nosocomial infection in diabetic patients. To confirm the results of this study, Logistics regression analysis of clinical data of diabetic patients was conducted in this paper. The results showed that old age, long hospital stay, long course of disease, diabetes complications, use of antibiotics, high FBG level, high HbA_{1c} level, invasive treatment and high HOMA-IR level were all risk factors for nosocomial infection in diabetic patients ($OR > 1$, $P < .05$), and HbA_{1c} level had the largest risk factor value. The reasons are as follows: the high blood sugar level in diabetic patients leads to the decline of the body's immunity, thus increasing the nosocomial infection[12] of diabetic patients. Among the co-infections in diabetic patients, respiratory tract infections and urinary system infections are the most common. The lung defense ability of diabetic patients is low, which leads to the decrease of the swallowing ability of lung phagocytes to foreign bacteria and viruses, thus leading to the abnormal production of lung surface-active substances and affecting the microcirculation[13] between lung tissues. In addition, a large number of bacteria and viruses gather in the bronchus and lungs to multiply and spread, causing respiratory tract infections.[14] Diabetes patients with high urine sugar is conducive to the growth of urinary tract bacteria and then pyelonephritis;[15] In addition, urinary tract infection can also lead to elevated urinary sugar, forming a vicious circle between the two, and then aggravate the condition[16] of diabetes patients. HbA_{1c}, as the product of a non-enzymatic glycation reaction between hemoglobin and sugars in red blood cells, has certain continuity, stability and irreversibility. Its level can reflect the glucose level in patients and the average blood glucose level[17] of 8-16 weeks. When the blood sugar in the human body continues to rise, it will not only damage the important organs of the body, resulting in the decline of disease resistance, but also inhibit the function of granulocytes, resulting in the decline of leukocyte phagocytosis and the reduction[18] of antibody production. In addition, the level of HbA_{1c} is positively correlated with the level of blood sugar, and the higher the level of HbA_{1c}, the more serious[19] the damage to vital organs.

In addition, in this study, the ROC curve showed that the AUC of FBG and HbA_{1c} in predicting the occurrence of hospital infection in diabetic patients was 0.764 and 0.875, respectively, which further confirmed that the detection of HbA_{1c} level had certain predictive value in the occurrence of hospital infection in urinary patients. There were many reasons for the fluctuation of FBG level in the short term. There may be some errors in the actual operation, making the prediction efficiency of FBG lower than that of HbA_{1c}.[20] This study also combined the HbA_{1c} data with the incidence of hospital infection events in diabetic patients through the restricted cubic spline model and continuously presented a nonlinear dose-response relationship, indicating that different HbA_{1c} levels were associated with the probability of adverse cardiovascular events in elderly AMI patients after PCI. In the analysis of the decision curve, within the threshold range of 0.0-0.45, HbA_{1c} level has a certain value in predicting the occurrence of hospital infection in diabetic patients, and the smaller the value of HbA_{1c} level in this range, the higher the net benefit rate, suggesting that HbA_{1c} level has important clinical significance in predicting the occurrence of hospital infection in diabetic patients.

In summary, HbA_{1c} level is associated with the occurrence of hospital infection in diabetic patients, and the correlation intensity with the occurrence of hospital infection in diabetic patients presents a nonlinear dose-response relationship. Detection of HbA_{1c} levels in diabetic patients is conducive to predicting the probability of occurrence of hospital infection, and strict control of HbA_{1c} levels in diabetic patients is conducive to improving patient prognosis. In the future, HbA_{1c} may be used as one of the therapeutic targets to reduce the risk of nosocomial infection in diabetic patients.However, this study still has limitations. For example, the number of cases that can be included is small, and all the cases are from the same area and hospital, which leads to the limited inclusion of some factors and the limited prediction model, and the research results may be biased. In the future, it is necessary to further expand the scope of the study and extend the research cycle to verify the results of this study.

ETHICAL COMPLIANCE

This study was approved by the ethics committee of The People's Hospital of Wenjiang. Signed written informed consent were obtained from the patients and/or guardians.

CONFLICT OF INTEREST

The authors have no potential conflicts of interest to report relevant to this article.

AUTHOR CONTRIBUTIONS

YL and QY designed the study and performed the experiments, PZ and FN collected the data, PZ, FN and MX analyzed the data, YL and QY prepared the manuscript. All authors read and approved the final manuscript.

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