

# MHR and CRP/Albumin Ratio Correlate with Wagner Grade in Diabetic Foot Ulcers: A Chinese Retrospective Study with Pathogen Analysis

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**Background:** Assessing the severity of diabetic foot ulcers (DFU) is critical for prognosis and treatment. While the Wagner classification is widely used, it lacks systemic inflammatory and nutritional assessment. Composite markers like the monocyte-to-high-density lipoprotein cholesterol ratio (MHR) and C-reactive protein-to-albumin ratio (CAR) may fill this gap. Furthermore, regional data on pathogen distribution in China are essential for guiding antibiotic therapy.

**Aim:** To investigate the correlation of MHR and CAR with Wagner grades in Chinese DFU patients, identify independent predictors for severity, and analyze pathogen distribution and drug resistance patterns across different grades.

**Patients and Methods:** A retrospective analysis was conducted on 136 DFU patients hospitalized from January 2022 to May 2024. Patients were categorized into three groups based on Wagner grades: Grade 1–2 ( $n=17$ ), Grade 3 ( $n=42$ ), and Grade 4–5 ( $n=77$ ). Clinical data, MHR, and CAR were analyzed. Spearman correlation and ordinal logistic regression determined associations with severity. Receiver operating characteristic (ROC) curves evaluated the predictive value of MHR and CAR for severe infection (Wagner 4–5). Pathogen profiles were analyzed per group.

**Results:** MHR ( $r=0.451$ ,  $P<0.001$ ) and CAR ( $r=0.521$ ,  $P<0.001$ ) were significantly and positively correlated with Wagner grades. Logistic regression identified serum albumin ( $OR=0.88$ , 95%  $CI$ : 0.82–0.95,  $P=0.002$ ) and HDL-C ( $OR=0.11$ , 95%  $CI$ : 0.02–0.68,  $P=0.017$ ) as independent protective factors against higher Wagner grades. For predicting severe infection, the optimal cut-off values were 0.775 for MHR ( $AUC=0.760$ ) and 2.04 for CAR ( $AUC=0.777$ ). Among 183 isolated strains, *Staphylococcus aureus* (24.59%) was predominant. Notably, as Wagner grades increased, the prevalence of Gram-negative bacteria (e.g. *Escherichia coli*, *Pseudomonas aeruginosa*) and mixed infections rose significantly ( $P<0.01$ ).

**Conclusion:** MHR and CAR are valuable biological markers for assessing DFU severity in the Chinese population. Albumin and HDL-C serve as independent protective factors. The study reveals a grade-dependent shift in pathogen spectra toward Gram-negative bacteria and mixed infections, providing region-specific evidence for optimizing empirical antibiotic strategies.

**Keywords:** diabetic foot ulcer, Wagner classification, monocyte to high-density lipoprotein cholesterol ratio, C-reactive protein to albumin ratio, pathogenic bacteria

## Introduction

The rising prevalence of diabetes mellitus has made diabetic foot ulcer (DFU) a challenging complication worldwide.<sup>1</sup> Characterized by prolonged healing, high recurrence, and significant disability and mortality rates, DFU imposes a heavy economic burden on healthcare systems and patients.<sup>2–4</sup> Accurate severity assessment is paramount for formulating individualized treatment plans.

Currently, the Wagner classification system is the clinical standard for staging DFU based on ulcer depth and extent. A recent systematic review has confirmed that the Wagner scale demonstrates appropriate reliability for evaluating diabetic foot wounds, with weighted kappa values ranging from 0.41 to 0.55 for inter-observer agreement.<sup>5</sup> However, this anatomical-based system has

limitations: it fails to adequately reflect the patient's systemic inflammatory status, metabolic derangements, and nutritional reserves, which are critical determinants of healing potential and amputation risk.

Recent research suggests that composite inflammatory markers may offer superior prognostic value. The monocyte-to-high-density lipoprotein cholesterol ratio (MHR) reflects the balance between pro-inflammatory monocytes and anti-inflammatory HDL-C, which exerts protective effects through anti-inflammatory, antioxidant, and immunomodulatory functions<sup>6</sup>. Elevated MHR has been independently associated with type 2 diabetes and cardiovascular disease.<sup>7–9</sup> Similarly, the C-reactive protein-to-albumin ratio (CAR) integrates acute-phase inflammation with nutritional status<sup>10</sup> and has been validated as a strong predictor of early mortality.<sup>11</sup> Although these markers are cost-effective and accessible, their correlation with DFU severity—specifically within the Chinese population—remains understudied.

Furthermore, the complexity of wound infection directly impacts prognosis. Pathogen distribution and antibiotic resistance patterns in DFU vary significantly by geography.<sup>12</sup> However, data describing how pathogenic flora evolve across different Wagner grades in Chinese patients are scarce. Understanding these regional characteristics is crucial for guiding empirical anti-infective therapy.

Therefore, this study aims to: (1) analyze the correlation between MHR/CAR levels and Wagner grades in Chinese DFU patients; (2) evaluate their predictive value for severe infection; and (3) explore the distinct distribution and resistance profiles of pathogens across different grades. This study seeks to provide region-specific clinical evidence to optimize DFU assessment and treatment.

## Patients and Methods

### Study Design and Population

This retrospective study enrolled 136 patients with DFU hospitalized in the Department of Diabetic Foot at a tertiary care hospital from January 2022 to May 2024.

### Inclusion Criteria

- (1) Diagnosis of DFU according to the 2024 Chinese consensus on the diagnosis and treatment of diabetic foot ulcer complicated with lower extremity vasculopathy;<sup>13</sup>
- (2) Positive wound bacterial cultures;
- (3) Complete clinical and laboratory data.

### Exclusion Criteria

- (1) Ulcers of non-diabetic etiology;
- (2) Concurrent infections at other sites (eg., pneumonia, urinary tract infection);
- (3) Co-existing inflammatory conditions such as malignancies or autoimmune diseases.

### Grouping

Patients were categorized into three groups based on the Wagner classification system:<sup>14</sup>

Wagner Grade 1–2 Group (n=17): Superficial or deep ulcers without abscess or osteomyelitis.

Wagner Grade 3 Group (n=42): Deep ulcers with abscess or osteomyelitis.

Wagner Grade 4–5 Group (n=77): Localized or whole-foot gangrene.

### Data Collection

Clinical data (gender, age, diabetes duration) were retrieved from electronic medical records. Peripheral blood samples collected upon admission were analyzed for: white blood cell (WBC) count, monocytes, hemoglobin (Hb), albumin (ALB), C-reactive protein (CRP), and HDL-C.

Composite indicators were calculated as follows:

$$\text{MHR} = \text{Monocyte count } (\times 10^9/\text{L}) / \text{HDL} - \text{C } (\text{mmol/L})$$

$$\text{CAR} = \text{CRP (mg/L)} / \text{ALB (g/L)}$$

## Microbiological Analysis

Deep wound secretions or tissue specimens were collected aseptically using sterile swabs after debridement. Specimens were immediately cultured on Columbia blood agar and China Blue plates (Autobio, Zhengzhou, China) at 35°C for 24–72 h. Identification and antimicrobial susceptibility testing (AST) were performed using the BD Phoenix™ M50 system. Results were interpreted according to CLSI 2025 standards.<sup>15</sup> Anaerobic cultures were not performed due to the lack of anaerobic culture facilities in our laboratory.

## Statistical Analysis

Data were analyzed using SPSS 22.0 (IBM Corp, Armonk, NY) and WHONET 5.6. Normal distribution was tested using the Shapiro–Wilk method. Continuous variables were presented as mean  $\pm$  standard deviation ( $\bar{x} \pm s$ ) or median (interquartile range, IQR). Group comparisons used one-way ANOVA or Kruskal–Wallis tests. Categorical data were compared using the  $\chi^2$ -test. Spearman rank correlation assessed relationships between serum markers and Wagner grades. Ordinal logistic regression identified independent factors associated with higher grades. ROC curves evaluated the predictive value of MHR and CAR for severe infection (Wagner 4–5); the reported cut-off values were derived from the original data without cross-validation, and external validation is warranted in future studies. A P-value  $< 0.05$  was considered statistically significant. The small sample size in the Wagner grade 1–2 group (n=17) is acknowledged as a limitation, which may affect the statistical power of subgroup comparisons.

For the analysis of pathogen distribution, each isolate was counted individually to reflect the complete microbiological profile, which is standard practice in diabetic foot ulcer microbiology studies. We acknowledge that this approach may violate the assumption of statistical independence for some comparisons. Therefore, the results are presented primarily as descriptive data to guide clinical expectations, without formal statistical inference within patients.

## Results

Clinical Characteristics and Serum Markers Demographic baselines (gender, age, diabetes duration) were comparable across groups ( $P > 0.05$ ). However, disease severity markers differed significantly. The Wagner 4–5 group exhibited significantly higher WBC, monocytes, CRP, MHR, and CAR levels, and lower Hb, ALB, and HDL-C levels compared to Grade 1–2 and Grade 3 groups ( $P < 0.05$ ) (Table 1).

**Table 1** Clinical Characteristics of DFU Patients by Wagner Grade

Characteristic	Wagner Grade 1–2 (n=17)	Wagner Grade 3 (n=42)	Wagner Grade 4–5 (n=77)	P-value
Gender (M/F)	10/7	25/17	52/25	0.507
Age (years)	63.9 $\pm$ 12.2	60.4 $\pm$ 10.4	62.8 $\pm$ 11.4	0.229
Duration of Diabetes (years)	13.5 (8, 20)	12 (8, 20)	12 (8, 20)	0.256
Duration of Diabetic Foot (days)	30 (15, 62)	31 (15, 93)	38 (15, 120)	0.032
Glycated Hemoglobin (%)	8.64 $\pm$ 1.71	9.05 $\pm$ 2.14	9.50 $\pm$ 2.19	0.765
Hemoglobin (g/L)	121.6 $\pm$ 23.8 <sup>a</sup>	116.6 $\pm$ 23.0 <sup>a</sup>	100.4 $\pm$ 23.0	<0.001
Sodium (mmol/L)	139.5 $\pm$ 4.2 <sup>a</sup>	139.0 $\pm$ 4.4 <sup>a</sup>	135.9 $\pm$ 4.5	<0.001
Chloride (mmol/L)	103.5 $\pm$ 4.7 <sup>a</sup>	102.4 $\pm$ 4.5 <sup>a</sup>	100.4 $\pm$ 4.6	0.005
White Blood Cells ( $\times 10^9$ /L)	6.9 $\pm$ 5.9	9.5 $\pm$ 5.7	12.8 $\pm$ 5.6	<0.001
Monocytes ( $\times 10^9$ /L)	0.55 $\pm$ 0.35	0.64 $\pm$ 0.34	0.81 $\pm$ 0.35	0.002
HDL-C (mmol/L)	1.11 $\pm$ 0.28	1.00 $\pm$ 0.33	0.76 $\pm$ 0.33	<0.001
MHR	0.57 (0.31, 0.68)	0.61 (0.39, 0.78)	0.96 (0.68, 1.46)	<0.001
CRP (mg/L)	13.6 $\pm$ 22.7	53.6 $\pm$ 61.6	97.6 $\pm$ 78.6	<0.001
Albumin (g/L)	34.4 $\pm$ 4.2	31.9 $\pm$ 5.2	27.4 $\pm$ 6.0	0.018

(Continued)

**Table 1** (Continued).

Characteristic	Wagner Grade 1–2 (n=17)	Wagner Grade 3 (n=42)	Wagner Grade 4–5 (n=77)	P-value
CAR	0.07 (0.02, 0.63)	1.07 (0.34, 2.34)	2.92 (1.35, 5.76)	<0.001
Hematocrit (%)	35.6 ± 5.2	34.1 ± 5.4	28.9 ± 6.2	0.59
[HCT-ALB]	5.1 (3.8, 6.5)	3.8 (1.7, 7.3)	3.8 (1.6, 6.3)	0.081

Notes: Data are presented as mean ± SD or median (IQR). <sup>a</sup> OR 0.05 compared to the Wagner grade 4–5 group.

## Correlation Analysis

Spearman analysis revealed strong positive correlations between Wagner grade and inflammatory markers: CAR ( $r=0.521$ ), CRP ( $r=0.491$ ), MHR ( $r=0.451$ ), and WBC ( $r=0.450$ ) (all  $P < 0.001$ ). Conversely, negative correlations were observed with ALB ( $r=-0.455$ ) and HDL-C ( $r=-0.451$ ) (Table 2).

## Independent Predictors of Severity

Ordinal logistic regression indicated that traditional inflammatory markers (WBC, CRP) and the composite ratios (MHR, CAR) were not independent predictors when adjusted for other variables. However, serum albumin ( $OR=0.88$ , 95%  $CI$ : 0.82–0.95,  $P=0.002$ ) and HDL-C ( $OR=0.11$ , 95%  $CI$ : 0.02–0.68,  $P=0.017$ ) emerged as independent protective factors. Specifically, a 1 mmol/L increase in HDL-C reduced the risk of a higher Wagner grade by approximately 89%.

## Predictive Value for Severe Infection

For predicting severe infection (Wagner Grade 4–5), ROC analysis showed:

MHR:  $AUC = 0.760$  (95%  $CI$ : 0.662–0.830), cut-off 0.775.

CAR:  $AUC = 0.777$  (95%  $CI$ : 0.699–0.855), cut-off 2.04.

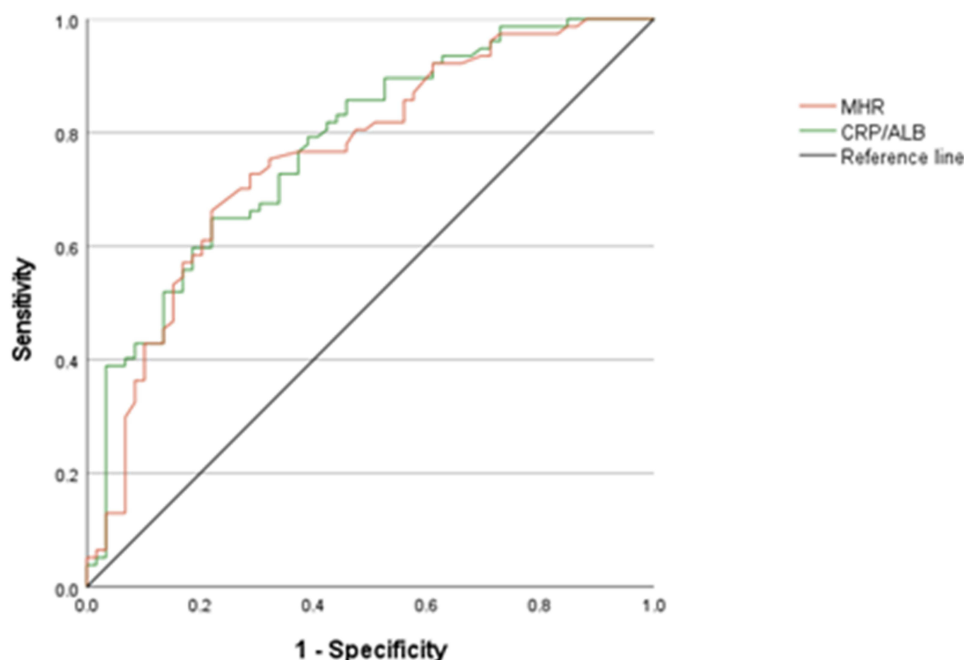
Both markers demonstrated moderate predictive accuracy (Figure 1).

## Pathogen Distribution and Shift

There were no patients with grade 0 diabetic foot infection. The distribution of pathogens varied significantly across Wagner grades. The total number of isolates exceeded the number of patients, as multiple isolates were obtained from some individuals (Table 3). We isolated a total of 183 strains, with the predominant pathogens being *Staphylococcus aureus* (24.59%). As Wagner grades increased, the prevalence of Gram-negative bacteria (eg., *Escherichia coli*, *Pseudomonas aeruginosa*) and mixed infections rose significantly ( $P < 0.01$ ). No statistically significant differences were found among groups for other pathogens ( $P > 0.05$ ) (Figure 2).

**Table 2** Correlation Between Clinical Indicators and Wagner Grade (Spearman's Rho)

Indicator	r-value	P-value
Duration of Diabetic Foot	0.225	0.009
Sodium	-0.367	<0.001
Chloride	-0.279	0.001
Hemoglobin	-0.401	<0.001
White Blood Cells	0.45	<0.001
Monocytes	0.305	<0.001
HDL-C	-0.451	<0.001
MHR	0.451	<0.001
CRP	0.491	<0.001
Albumin	-0.455	<0.001
CAR	0.521	<0.001



**Figure 1** Receiver operating characteristic (ROC) curves of MHR and CAR for predicting severe diabetic foot infection (Wagner grade 4–5). The diagonal reference line ( $y = x$ ) represents the performance of a random classifier (area under the curve [AUC] = 0.5); curves that lie above this line indicate better-than-random discriminative ability. The calculated AUC values were 0.760 for MHR and 0.777 for CAR, suggesting moderate predictive accuracy.

## Antibiotic Resistance Profiles

$G^+$  Bacteria: *S. aureus* and coagulase-negative staphylococci showed 100% susceptibility to vancomycin, teicoplanin, and linezolid, but high resistance to penicillin and clindamycin. The MRSA detection rate was 24.44%, with no significant difference across Wagner grades ([Supplementary Table S1](#)).

$G^-$  Bacteria: *E. coli* and *P. aeruginosa* demonstrated high resistance to third-generation cephalosporins but remained highly sensitive to carbapenems (imipenem/meropenem) and amikacin ([Supplementary Table S2](#)).

Subgroup Analysis by Wagner Grade: When resistance profiles were analyzed according to DFU severity, no significant differences were observed in the resistance rates of *S. aureus* ([Table 4](#)) or *E. coli* ([Table 5](#)) across Wagner grade groups ( $P > 0.05$  for all antibiotics tested). This suggests that while the distribution of pathogens shifts with increasing Wagner grade (as shown in [Tables 3](#) and [6](#)), the antibiotic resistance patterns of these key pathogens remain relatively stable across different stages of infection.

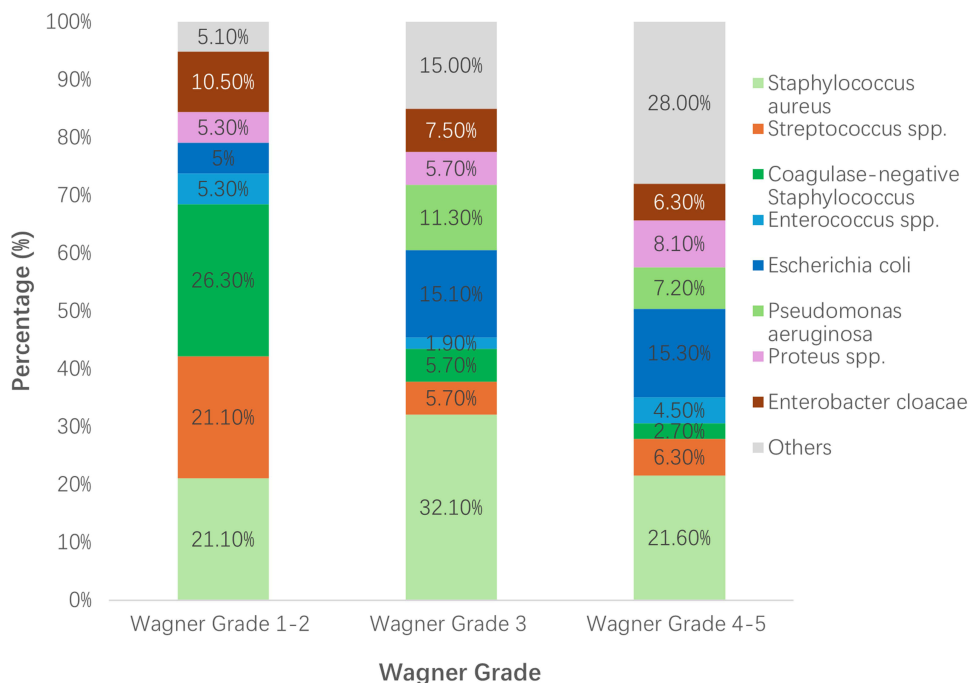
## Discussion

This study investigated the role of MHR and CAR in Chinese patients with diabetic foot ulcers (DFU) and found a significant positive correlation between these biomarkers and Wagner grades. However, in multivariate analysis, neither MHR nor CAR emerged as independent predictors. This finding reveals the complex relationship between inflammatory

**Table 3** Distribution of Pathogen Types by Wagner Grade [n (%)]

Pathogen Type	Wagner Grade 1–2 (n=19)	Wagner Grade 3 (n=53)	Wagner Grade 4–5 (n=111)	P-value
Gram-positive bacteria	14 (73.68)	24 (45.28)	40 (36.04)	0.008
Gram-negative bacteria	5 (26.32)	28 (52.83)	68 (61.26)	0.017
Fungi	0	1 (1.89)	3 (2.70)	1.000
Total	19 (100)	53 (100)	111 (100)	

**Note:** Percentages are column percentages within each Wagner grade group.



**Figure 2** Composition of major bacterial species isolated from diabetic foot ulcers, stratified by Wagner grade (1–2, 3, and 4–5). The stacked bar chart shows the proportional distribution of each pathogen within each grade group. Pathogens that accounted for less than 5% of isolates in all groups are combined into the category “Others”. A clear shift from Gram-positive bacteria (e.g., *Staphylococcus aureus*) toward Gram-negative organisms (e.g., *Escherichia coli*, *Pseudomonas aeruginosa*) is observed as Wagner grade increases, together with a rise in mixed infections.

markers and the pathological process of DFU, suggesting that when assessing DFU severity, we should not rely on a single indicator but rather combine multiple clinical parameters for comprehensive evaluation.

### Interpretation of MHR and CAR as Non-independent Predictors

Although MHR and CAR were significantly correlated with Wagner grade in univariate analysis, they lost significance after adjustment for albumin and HDL-C. This is likely due to the fact that both composite ratios are mathematically derived from their components (monocytes, HDL-C, CRP, albumin). The strong protective effects of HDL-C and albumin may overshadow the combined signal of the ratios. Additionally, the relatively small sample size, particularly

**Table 4** Resistance Rates of *S. aureus* to Antimicrobial Agents by Wagner Grade (%)

Antimicrobial Agent	Grade 1–2 (n=4)	Grade 3 (n=17)	Grade 4–5 (n=24)	P-value
Penicillin G	100	100	91.67	0.588
Vancomycin	0	0	0	–
Teicoplanin	0	0	0	–
Rifampicin	0	0	0	–
Chloramphenicol	0	5.88	4.17	1
Tetracycline	25	29.41	8.33	0.154
Ciprofloxacin	0	23.53	8.33	0.249
Levofloxacin	0	17.65	12.5	0.823
Clindamycin	75	82.35	58.33	0.308
Erythromycin	100	82.35	62.5	0.263
Doxycycline	0	5.88	8.33	1
Oxacillin	25	41.18	12.5	0.108
Gentamicin	25	5.88	4.17	0.297
Minocycline	0	0	0	–
Trimethoprim/sulfamethoxazole	25	35.29	25	0.787

**Note:** Resistance rates are percentages. P-values from  $\chi^2$ -test or Fisher’s exact; “–” indicates no variation (all 0%).

**Table 5** Resistance Rates of *E. coli* to Antimicrobial Agents by Wagner Grade (%)

Antimicrobial Agent	Grade 1-2 (n=1)	Grade 3 (n=8)	Grade 4-5 (n=17)	P-value
Piperacillin/tazobactam	0	0	0	–
Imipenem	0	0	0	–
Meropenem	0	0	0	–
Cefepime	0	37.5	35.29	1
Amikacin	0	0	0	–
Tobramycin	0	50	35.29	0.795
Gentamicin	0	50	17.65	0.207
Ciprofloxacin	0	62.5	64.71	0.632
Levofloxacin	0	62.5	58.82	0.648
Ceftazidime	0	37.5	58.82	0.411
Aztreonam	0	37.5	52.94	0.824
Ceftriaxone	0	50	64.71	0.507
Cefoxitin	0	12.5	41.18	0.339
Ampicillin/sulbactam	0	25	52.94	0.305
Cefazolin	0	62.5	76.47	0.239
Cefuroxime	0	62.5	70.59	0.465
Trimethoprim/sulfamethoxazole	0	50	64.71	0.507
Amoxicillin/clavulanic acid	0	37.5	52.94	0.824
Ampicillin	0	100	88.24	0.08

**Note:** Resistance rates are percentages. P-values from  $\chi^2$ -test or Fisher's exact; "–" indicates no variation (all 0%).

**Table 6** Distribution of Major Pathogens by Wagner Grade [n (%)]

Pathogen (Total Isolates)	Wagner Grade 1-2 (n=19)	Wagner Grade 3 (n=53)	Wagner Grade 4-5 (n=111)	P-value
Staphylococcus aureus (45)	4 (8.89)	17 (37.78)	24 (53.33)	<0.001
Streptococcus spp. (14)	4 (28.57)	3 (21.43)	7 (50.00)	0.353
Coagulase-negative Staphylococcus (11)	5 (45.46)	3 (27.27)	3 (27.27)	0.721
Enterococcus spp. (7)	1 (14.29)	1 (14.29)	5 (71.42)	0.052
Escherichia coli (26)	1 (3.85)	8 (30.77)	17 (65.38)	<0.001
Pseudomonas aeruginosa (14)	0 (0)	6 (42.86)	8 (57.14)	0.003
Proteus spp. (13)	1 (7.69)	3 (23.08)	9 (69.23)	0.002
Enterobacter cloacae (13)	2 (15.38)	4 (30.77)	7 (53.85)	0.144

**Note:** Percentages are calculated as the proportion of each pathogen's total isolates that were found in each Wagner grade group. For example, 8.89% of all *S. aureus* isolates came from grade 1-2 patients.

in the lower Wagner grades, may have limited our power to detect an independent effect.<sup>5,14</sup> Future studies with larger cohorts are needed to clarify whether MHR and CAR provide incremental value beyond their individual components.

## Comparison of ROC Thresholds with Literature

The optimal cut-off values for predicting severe infection (Wagner 4-5) were 0.775 for MHR and 2.04 for CAR. To our knowledge, no prior study has reported MHR or CAR cut-offs specifically for DFU severity in a Chinese population. Our MHR cut-off is slightly higher than the threshold of 0.51 reported for identifying type 2 diabetes risk in a general population,<sup>9</sup> which may reflect the greater inflammatory burden in DFU patients. The CAR cut-off is comparable to the value of 2.29 reported by Keskinçilic Yağız et al for predicting major amputation in DFU patients,<sup>16</sup> supporting its clinical relevance. External validation of these thresholds is warranted.

## Protective Roles of HDL-C and Albumin

Furthermore, our study confirmed the independent protective roles of HDL-C and albumin in DFU patients. HDL-C not only has anti-inflammatory and antioxidant effects but also modulates immune cell function, mitigating excessive inflammation

caused by both Gram-negative and Gram-positive bacteria.<sup>6,17,18</sup> Albumin reflects the patient's nutritional status; hypoalbuminemia is associated with poor healing and worse prognosis in DFU.<sup>19</sup> Therefore, clinical management should focus not only on local wound care but also on systemic nutritional support and lipid regulation to improve healing rates.

## Pathogen Distribution and Clinical Implications

In terms of pathogen distribution, we found that the detection rate of Gram-negative bacteria (eg., *Escherichia coli*, *Pseudomonas aeruginosa*) significantly increased with higher Wagner grades. This finding is consistent with previous studies<sup>20–22</sup> and suggests regional differences in DFU pathogen profiles, highlighting the importance of tailoring antibiotic strategies according to disease severity. Moreover, mixed infections were common in severe DFU cases, indicating that empirical antibiotics targeting only Gram-positive bacteria may be insufficient for high-risk patients.<sup>12</sup>

## Limitations

Several limitations should be acknowledged. This was a single-center retrospective study with a relatively small sample size, especially in the Wagner grade 1-2 group (n=17), which may introduce selection bias and limit statistical power.<sup>5,14</sup> Causality cannot be inferred due to the cross-sectional design. The Wagner classification, while widely used, does not fully capture vascular status or systemic health.<sup>5,14</sup> Additionally, potential confounders such as glycemic control, ulcer duration, osteomyelitis, and renal function were not included in the regression model. Our ROC cut-offs were derived without cross-validation and require external validation in independent cohorts.

## Conclusion and Future Directions

In summary, this study provides new insights into the clinical utility of MHR and CAR as adjunctive tools for DFU severity assessment, while highlighting the important protective roles of HDL-C and albumin. Large-scale, multicenter prospective studies are needed to externally validate our findings and to determine optimal antibiotic strategies targeting region-specific pathogen spectra, thereby offering more precise guidance for the management of DFU patients.

## Data Sharing Statement

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

## Ethical Approval And Institutional Review Board Approval

The study was approved by the Medical Ethics Committee of the 82nd Group Army Hospital (Approval No. 2022064). All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

## Consent To Participate

Informed consent was waived by the ethics committee due to the retrospective nature of the study.

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## Author Contributions

Juan Song and Ting Liu contributed equally to this work and share first authorship.

Juan Song: Conceptualization, Methodology, Formal analysis, Writing-original draft, Writing -review & editing, Supervision, Project administration.

Ting Liu: Methodology, Investigation, Data curation, Formal analysis, Writing-review & editing.

Ying Yu: Investigation, Resources, Validation, Writing-review & editing.

Ke Sun: Investigation, Resources, Validation, Writing-review & editing.

Liu Zheng: Investigation, Data curation, Writing-review & editing.

All authors gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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## Disclosure

The authors declare no conflict of interest.

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