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Risk factors and clinical outcome of geriatric patients with Vibrio vulnificus septicemia: A retrospective hospital-based study

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Abstract

Background

Vibrio vulnificus septicemia is associated with high mortality, with the majority of patients dying within the first 48 hours. Only a limited number of studies have evaluated mortality prediction models in patients with *V. vulnificus* septicemia, and none have specifically examined prognostic factors in geriatric populations. The aim of this study is to evaluate the performance of various clinical scoring systems in predicting mortality among patients with *V. vulnificus* septicemia, with particular focus on the prognosis of geriatric patients.

Methods

This retrospective study included 19 patients diagnosed with *V. vulnificus* septicemia at a single medical center in Taiwan between January 2012 and December 2020. Seven clinical scoring systems were evaluated for their ability to predict mortality. Demographic characteristics and physiological parameters upon ED arrival were analyzed using hazard modeling.

Results

Nineteen patients with *V. vulnificus* septicemia were identified, including 14 males (73.7%) and 5 females (26.3%). The geriatric group had a significantly higher 30-day mortality compared with the non-geriatric group ($p = 0.0021$). Among the seven scoring models evaluated, the Rapid Emergency Medicine Score (REMS, AUROC 0.917) and the Mortality in Emergency Department Sepsis Score (MEDS, AUROC 0.798) demonstrated the strongest discriminatory performance. Both REMS ≥ 6 ($p = 0.029$) and MEDS ≥ 10 ($p = 0.0039$) were significantly associated with increased 30-day mortality.

Conclusion

Geriatric patients are more vulnerable to *V. vulnificus* septicemia, which is associated with higher mortality compared with younger adults. REMS and MEDS are scoring models based on clinically available data and showed good discriminatory ability. REMS and MEDS are suggested to facilitate rapid risk stratification in the ED.

Introduction

Vibrio vulnificus is an aquatic Gram-negative, halophilic, motile bacillus, growing in water temperatures above 13°C and flourishing in temperatures above 20°C [1]. The geographic hotspots of *V. vulnificus* were discovered in East Asia and the east coast of the US, including Taiwan, a subtropical island in the western Pacific [2, 3]. The most common routes of infection were an open wound exposure to seawater

and foodborne transmission after consuming undercooked seafood (especially oyster and shellfish) [4]. Clinical manifestations of *V. vulnificus* include cutaneous infection (45%), septicemia (43%), and gastroenteritis (5%) [5]. High-risk populations are more vulnerable to infection, including patients with chronic liver disease, diabetes mellitus, end-stage renal disease, malignancy, immunosuppressant, and steroid usage [6]. A substantial mortality burden has been reported, with rates reaching 60–70% among patients with septicemia, and increasing to as high as 90% in those who develop hypotension within the first 12 hours of admission. Delayed initiation of antimicrobial therapy beyond 72 hours can lead to 100% mortality [7, 8].

Several clinical scoring systems have been developed to predict mortality among patients admitted to intensive care units (ICU) or emergency departments (ED), including the Acute Physiology and Chronic Health Evaluation II (APACHE II), Rapid Acute Physiology Score (RAPS), Rapid Emergency Medicine Score (REMS), Mortality in Emergency Department Sepsis Score (MEDS), and Modified Early Warning Score (MEWS) [9–13]. However, these systems were primarily validated for predicting mortality in patients with diverse medical conditions—such as myocardial infarction, sepsis, or stroke—or in septic patients with infections caused by common community-acquired pathogens. Their predictive value in patients infected with *V. vulnificus* remains unclear. Although Chen *et al.* and Kuo *et al.* reported that the APACHE II and REMS scores are useful for predicting mortality in patients with *V. vulnificus* infection, these studies enrolled adult patients based on positive blood, wound, and/or stool cultures [14, 15]. Few studies have specifically investigated *V. vulnificus* septicemia and its clinical outcome in geriatric populations. Therefore, this study aimed to evaluate the clinical outcomes of patients with *V. vulnificus* septicemia, with a particular focus on prognostic factors in geriatric patients.

Methods

Study Design and Setting

This single-center, retrospective observational study was conducted at a 1520-bed public, academic medical center in central Taiwan. This study was approved by the Joint Institutional Review Board of Taichung Veterans General Hospital (TCVGH) (approval number: CE23126B). The review board waived the requirement for informed consent because the study's retrospective design would not pose additional risk to patients.

Study participants and inclusion criteria

We identified 19 adult patients (aged ≥ 18 years) who were hospitalized at TCVGH for *V. vulnificus* septicemia through the ED between January 2012 and December 2020. *V. vulnificus* septicemia was defined as the isolation of *V. vulnificus* from at least one set of positive blood cultures. Geriatric patients were defined as those aged 65 years or older, while non-geriatric patients were defined as those younger than 65 years.

Data collection

Patient demographic and clinical characteristics were obtained from electronic medical records. Data on the following clinical characteristics were collected: age, sex, vital signs, complete blood count, clinical biochemical parameters, arterial or venous blood gas, exposure history, initial empirical antibiotics selection, and length of stay. All cases were classified as either primary or secondary septicemia according to the patients' exposure history. Cases without an identifiable portal of entry were defined as primary septicemia. Patients with a history of recent consumption of raw or undercooked seafood were considered to have secondary septicemia associated with primary gastroenteritis. Those with preexisting wounds exposed to seawater or marine organisms, or with recent injuries sustained while handling seafood, were classified as having secondary septicemia associated with primary wound infection [16]. Clinical score, including RAPS, REMS, MEDS, and MEWS, Worthing Physiological System (WPS), and National Early Warning Score (NEWS), qSOFA were calculated (Table S1-S7) [9–13, 17]. The primary outcome was the 30-day mortality rate.

Statistical analysis

Continuous variables are denoted as mean ± standard deviation (SD) values, and categorical variables are denoted as frequency and percentage values. Independent two-sample Mann-Whitney U tests and Fisher's exact tests were used for between-group comparisons of continuous and categorical variables, respectively. The differences in overall survival (OS) between groups were determined by Kaplan–Meier analysis, and the p-value was determined by the Mantel-Haenszel test. Univariate and multivariate analyses were performed using a Cox proportional hazards model to identify correlations between various clinical factors and the risk of disease-related mortality; the results are presented as hazard ratios (HRs) with 95% confidence intervals (CIs). The performance of the clinical scoring models in predicting mortality was assessed using the receiver operating characteristic (ROC) curve analysis. Discriminatory power, defined as the capacity of each model to differentiate between survivors and non-survivors, was quantified by the area under the curve of an ROC curve (AUROC). The optimal cutoff value for mortality prediction was determined as the score that maximized Youden's index (sensitivity + specificity − 1) for each scoring system. All analyses were conducted in SPSS. 22.0 for Windows (IBM Corp., 2019) and Taipei Medical University R Data Analysis & Guiding System (http://rweb.tmu.edu.tw/index.php). A p-value of < 0.05 was considered statistically significant.

Results

Baseline characteristics of study population

A total of 19 patients with *V. vulnificus* bacteremia were included in this study, comprising 14 males (73.7%) and 5 females (26.3%), with a mean age of 60.4 ± 17.4 years (range, 33–90 years). Among them, 7 patients (36.8%) were classified as geriatric (≥ 65 years), and 12 (63.2%) as non-geriatric (< 65 years). There were no significant differences between the geriatric and non-geriatric groups in terms of initial vital signs at ED presentation, symptoms, comorbidities, or sources of infection. Notably, the geriatric group had significantly higher REMS (8.71 ± 3.73 vs. 4.42 ± 1.16, $p < 0.01$) and MEDS (10.14 ± 2.91 vs.

5.42 ± 4.76, $p < 0.05$) scores compared with the non-geriatric group. In addition, the geriatric group showed a significantly higher requirement for urgent hemodialysis (42.85% vs. 0%, $p < 0.05$). The demographic characteristics were summarized in Table 1.

Table 1
Demographic data of 19 patients with Vibrio vulnificus septicemia stratified by geriatric (≥ 65 years) and non-geriatric (< 65 years) subgroup

Clinical variables	Non-geriatric patients (n = 12)	Geriatric patients (n = 7)	*p*-Value
Sex, male	11 (91.66%)	3 (42.85%)	0.038*
Age (years)	50.25 ± 9.27	80.43 ± 9.00	< 0.001**
Vital signs			
Systolic blood pressure (mmHg)	123.58 ± 23.43	139.86 ± 45.34	0.299
Diastolic blood pressure (mmHg)	66.00 ± 16.40	67.57 ± 19.24	0.773
Mean arterial pressure (mmHg)	84.92 ± 17.46	91.71 ± 26.65	0.536
Heart rate (/min)	119.83 ± 19.07	101.86 ± 24.94	0.083
Respiratory rate (/min)	20.00 ± 1.13	20.29 ± 4.68	0.384
Body temperature (°C)	38.17 ± 1.36	37.80 ± 1.31	0.432
Comorbidities			
Coronary arterial disease	2 (16.66%)	1 (14.28%)	1.000
Heart failure	4 (33.33%)	2 (28.57%)	1.000
Diabetes mellitus	2 (16.66%)	2 (28.57%)	0.603
Alcoholism	4 (33.33%)	0 (0%)	0.245
Liver cirrhosis	4 (33.33%)	1 (14.28%)	0.603
Obstructive lung disease	1 (8.33%)	0 (0%)	1.000
Transplant	0 (0%)	1 (14.28%)	0.368
Cancer	2 (16.66%)	2 (28.57%)	0.603
Major complication			
Shock	4 (33.33%)	2 (28.57%)	1.000
Urgent hemodialysis	0 (0%)	3 (42.85%)	0.036*

Mann-Whitney U test and Fisher exact test. *$p < 0.05$, **$p < 0.01$, Statistically significant. Continuous data are expressed as mean ± SD. Categorical data are expressed as numbers and percentages. Abbreviations: MEDS, Mortality in Emergency Department Sepsis Score; MEWS, Modified Early Warning Score; NEWS, National Early Warning Score; qSOFA, quick Sepsis Related Organ Failure Assessment; RAPS, Rapid Acute Physiology Score; REMS, Rapid Emergency Medicine Score; WPS, Worthing Physiological System

Clinical variables	Non-geriatric patients (n = 12)	Geriatric patients (n = 7)	*p*-Value
Vasopressor	4 (33.33%)	3 (42.85%)	1.000
Source of infection			0.143
Primary septicemia	2 (16.66%)	4 (57.14%)	
Primary wound infection	8 (66.66%)	3 (42.85%)	
Primary gastroenteritis	2 (16.66%)	0 (0%)	
Clinical scoring model			
REMS (points)	4.42 ± 1.16	8.71 ± 3.73	0.002*
RAPS (points)	2.25 ± 1.86	2.14 ± 2.73	0.967
MEWS (points)	4.08 ± 2.39	3.86 ± 3.72	0.482
MEDS (points)	5.42 ± 4.76	10.14 ± 2.91	0.036*
NEWS (points)	5.58 ± 2.23	7.43 ± 4.12	0.384
WPS (points)	2.67 ± 1.83	4.29 ± 3.20	0.261
qSOFA (points)	0.42 ± 0.67	0.86 ± 0.69	0.196

Mann-Whitney U test and Fisher exact test. *$p < 0.05$, **$p < 0.01$, Statistically significant. Continuous data are expressed as mean ± SD. Categorical data are expressed as numbers and percentages. Abbreviations: MEDS, Mortality in Emergency Department Sepsis Score; MEWS, Modified Early Warning Score; NEWS, National Early Warning Score; qSOFA, quick Sepsis Related Organ Failure Assessment; RAPS, Rapid Acute Physiology Score; REMS, Rapid Emergency Medicine Score; WPS, Worthing Physiological System

Laboratory investigations, management, and outcome of study population

There were no significant differences between the two groups in complete blood count, venous blood gas analysis, serum electrolytes, lactate, or serum C-reactive protein (CRP) levels. In contrast, blood urea nitrogen (BUN) levels were significantly higher in the geriatric group (40.33 ± 23.64 mg/dL vs. 17.45 ± 14.29 mg/dL, $p < 0.01$), whereas serum glutamic pyruvic transaminase (GPT) levels were significantly lower (17.14 ± 6.57 U/L vs. 40.90 ± 19.74 U/L, $p < 0.05$). Moreover, there's no difference between the two groups in empirical antibiotic use, ICU admission rate, and length of stay. The geriatric subgroup had a higher mortality rate (71.42% vs. 8.33%, $p < 0.01$). A summary of laboratory findings is presented in Table 2.

Table 2
Laboratory data, initial management, and outcome of 19 patients with V. vulnificus septicemia stratified by geriatric (≥ 65 years) and non-geriatric (< 65 years) subgroup

Clinical variables	Non-geriatric patients (n = 12)	Geriatric patients (n = 7)	*p*-Value
Complete blood cells			
WBC (cells/mm^3)	11216.67 ± 8006.96	8484.29 ± 4493.12	0.592
ANC (cells/mm^3)	9880.73 ± 7428.00	6697.06 ± 3866.93	0.432
Hb (g/dL)	12.58 ± 2.16	11.21 ± 1.88	0.277
PLT (10^3 cells/μL)	160.58 ± 103.85	163.43 ± 67.57	0.837
Biochemistry			
BUN (mg/dL)	17.45 ± 14.29	40.33 ± 23.64	0.005**
Creatinine (mg/dL)	1.07 ± 0.43	1.89 ± 0.96	0.681
BUN/Creatinine	16.35 ± 8.74	19.20 ± 6.94	0.462
Na (mEq/L)	135.17 ± 4.30	135.14 ± 4.06	0.967
K (mEq/L)	3.85 ± 0.87	4.50 ± 1.13	0.120
Total bilirubin (mg/dL)	3.36 ± 3.27	5.99 ± 10.72	0.440
GPT (U/L)	40.90 ± 19.74	17.14 ± 6.57	0.010*
LDH (U/L)	295.60 ± 98.38	353.00 ± 141.42	0.571
CRP (mg/dL)	3.21 ± 5.66	4.11 ± 3.42	0.227
Lactate (mg/dL)	38.89 ± 15.50	38.64 ± 17.86	1.000
Glucose (mg/dL)	148.00 ± 78.97	128.71 ± 74.62	0.417
Maximum of CK (U/L)	197.44 ± 167.09	1323.60 ± 2277.42	0.147
Venous blood gas			
pH	7.39 ± 0.07	7.34 ± 0.09	0.285
PvO_2 (mmHg)	53.25 ± 27.57	53.13 ± 26.64	1.000
$PvCO_2$ (mmHg)	22.46 ± 2.56	22.57 ± 3.08	0.813

Mann-Whitney U test and Fisher exact test. *$p < 0.05$, **$p < 0.01$, Statistically significant. Continuous data are expressed as mean ± SD. Categorical data are expressed as numbers and percentages. Abbreviations: ANC, absolute neutrophil count; BUN, blood urea nitrogen; CK, creatine kinase; CRP, C-reactive protein; GPT, glutamate pyruvate transaminase; Hb, hemoglobin; ICU, intensive care unit; LDH, lactate dehydrogenase; PLT, platelet; WBC, white blood cell

Clinical variables	Non-geriatric patients (n = 12)	Geriatric patients (n = 7)	*p*-Value
Complete blood cells			
HCO_3^- (mEq/L)	(2.40) ± 2.73	(2.89) ± 2.99	0.791
Empirical antibiotics			0.613
Cephalosporins	4 (33.33%)	4 (57.14%)	
Cephalosporins + Tetracyclines	5 (41.66%)	1 (14.28%)	
Cephalosporins + Quinolone	1 (8.33%)	1 (14.28%)	
Others	2 (16.66%)	1 (14.28%)	
Surgery	7 (58.33%)	3 (42.85%)	0.650
ICU admission	3 (25%)	3 (42.85%)	0.617
Length of stay (days)	18.25 ± 13.94	10.86 ± 11.60	0.167
30-day mortality	1 (8.33%)	5 (71.42%)	0.009**

Mann-Whitney U test and Fisher exact test. *$p < 0.05$, **$p < 0.01$, Statistically significant. Continuous data are expressed as mean ± SD. Categorical data are expressed as numbers and percentages. Abbreviations: ANC, absolute neutrophil count; BUN, blood urea nitrogen; CK, creatine kinase; CRP, C-reactive protein; GPT, glutamate pyruvate transaminase; Hb, hemoglobin; ICU, intensive care unit; LDH, lactate dehydrogenase; PLT, platelet; WBC, white blood cell

Discriminatory ability of clinical scoring models

Seven clinical scoring models, including RAPS, REMS, MEDS, MEWS, NEWS, WPS, and qSOFA, were evaluated for their ability to predict mortality in patients with *V. vulnificus* septicemia (Fig. 1). An AUROC of greater than 0.7 was considered to indicate acceptable discriminative ability. Among these models, REMS (AUROC, 0.917) and MEDS (AUROC, 0.798) demonstrated acceptable discrimination and were selected for further analysis. Based on Youden's index, the optimal cutoff values were determined to be REMS ≥ 6 and MEDS ≥ 10. At a cutoff of REMS ≥ 6, the model achieved a sensitivity of 85.7%, specificity of 75.0%, positive predictive value (PPV) of 66.7%, and negative predictive value (NPV) of 90.0%. At a cutoff of MEDS ≥ 10, the sensitivity, specificity, PPV, and NPV were 51.7%, 91.7%, 80.0%, and 78.6%, respectively (Table 3).

Table 3
Diagnostic performance of REMS and MEDS for mortality of V. vulnificus septicemia

Score (cutoff)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
REMS ≥ 6	85.7	75.0	66.7	90.0
MEDS ≥ 10	51.7	91.7	80.0	78.6
Abbreviations: PPV, positive predictive value; NPV, negative predictive value				

Prognosis impact among geriatric patients, and survival rate of REMS and MEDS

The overall mortality of 19 patients with *V. vulnificus* septicemia was 31.57% (6/19) (Fig. 2A). The geriatric group had a higher 30-day mortality than the non-geriatric group (HR = 17.02, 95% CI = 2.797–103.50, $p = 0.0021$) (Fig. 2B). At cutoffs of REMS ≥ 6 and MEDS ≥ 10, both REMS ≥ 6 (HR = 6.223, 95% CI = 1.205–32.15, $p = 0.029$) and MEDS ≥ 10 (HR = 19.4, 95% CI = 2.589–145.4, $p = 0.0039$) were significantly associated with increased 30-day mortality (Figs. 2C and 2D).

Predictive factors for disease-related mortality in patients with *V. vulnificus* septicemia

Univariate Cox proportional hazards regression analysis (n = 19) identified several clinical variables potentially associated with disease-related mortality, including age, the need for urgent hemodialysis, serum potassium level, and acidosis (Table 4). Variables with *p*-values < 0.20 in the univariate analysis were subsequently entered into a multivariate Cox regression model to account for potential interdependence among covariates [18]. In the final multivariate model, only heart rate > 100/min remained an independent predictor of disease-related mortality (HR = 448.83, 95% CI = 1.75–1.15×10^5, $p = 0.031$) (Table 5).

Table 4
Univariate Cox proportional hazards model analyzing correlation between clinicopathological features and disease-related mortality in patients with V. vulnificus septicemia (n = 19)

Parameters	Hazard ratio (HR)	95% CI	*p*-Value
Demographic data			
Sex (female as reference)	4.45	0.88–22.4	0.070
Age (< 65 y/o as reference)	13.77	1.59-119.52	0.017*
Initial vital signs			
MAP (≧ 65 mmHg as reference)	1.04	0.12–8.96	0.97
Heart rate (> 100 bpm as reference)	0.314	0.063–1.563	0.157
Respiratory rate (> 20/min as reference)	0.569	0.115–2.820	0.489
Body temperature (> 38°C as reference)	0.389	0.071–2.140	0.278
Comorbidities			
Coronary arterial disease	1.224	0.143–10.505	0.854
Heart failure	1.087	0.199–5.951	0.923
Diabetes mellitus	2.314	0.420-12.753	0.335
Alcoholism	0.657	0.077–5.636	0.702
Liver cirrhosis	0.479	0.056–4.104	0.501
Obstructive lung disease	3.975	0.444–35.612	0.217
Cancer	0.791	0.092–6.777	0.830
Major complication			
Shock	2.366	0.473–11.846	0.295
Urgent hemodialysis	9.053	1.753–46.745	0.009**
Vasopressor	3.584	0.652–19.693	0.142
Complete blood cells			
WBC (< 10000 cells/mm^3 as reference)	0.138	0.016–1.183	0.071
ANC (< 7000 cells/mm^3 as reference)	0	0-Inf.	0.999
Hb (< 12 g/dL as reference)	0.830	0.167–4.116	0.820
*$p < 0.05$, **$p < 0.01$, Statistically significant.			

Parameters	Hazard ratio (HR)	95% CI	*p*-Value
Demographic data			
PLT (< 150 10^3 cells/μL as reference)	1.300	0.262–6.444	0.749
Biochemistry			
BUN (< 20 mg/dL as reference)	0	0-Inf.	0.999
Creatinine (< 1 mg/dL as reference)	0	0-Inf.	0.999
Na (> 135 mEq/L as reference)	1.254	0.253–6.222	0.782
K (< 5.5 mEq/L as reference)	16.476	2.654-102.267	0.003**
Total bilirubin (< 1 mg/dL as reference)	0.376	0.062–2.280	0.287
GPT (< 40 U/L as reference)	0	0-Inf.	0.999
CRP (< 1 mg/dL as reference)	1.560	0.285–8.554	0.609
Lactate (< 20 mg/dL as reference)	0	0-Inf.	0.999
Glucose (< 100 mg/dL as reference)	1.049	0.122–9.007	0.965
CK (< 160 U/L as reference)	0	0-Inf.	0.999
Venous blood gas			
pH (< 7.3 as reference)	10.553	1.842–30.449	0.008**
$PaCO_2$ (< 40 mmHg as reference)	-	- -	-
BE (> -1.9 as reference)	2.344	0.429–12.821	0.326
Surgery (no surgery as reference)	1.677	0.306–9.178	0.551
*p < 0.05, **p < 0.01, Statistically significant.			

Table 5
Multivariate Cox proportional hazards model analyzing correlation between clinicopathological features and disease-related mortality in patients with V. vulnificus septicemia (n = 19) †

Parameters	Hazard ratio (HR)	95% CI	*p*-Value
Sex (female as reference)	68.45	$0.16–2.99\times10^{4}$	0.173
Age (< 65 y/o as reference)	3.12×10^{6}	$0.002->10^{10}$	0.142
Heart rate (> 100 bpm as reference)	448.83	$1.75–1.15\times10^{5}$	0.031*
Vasopressor	6.96×10^{4}	$0->10^{10}$	0.332
K (< 5.5 mEq/L as reference)	8.95×10^{6}	$2\times10^{-4}->10^{10}$	0.199

**p* < 0.05, Statistically significant. † All parameters with a p value of < 0.2 in the univariate analysis were included in the multivariate analysis. The final model was determined through stepwise selection performed on the basis of the Akaike information criterion.

Discussion

V. vulnificus, a rod-shaped Gram-negative bacterium belonging to the family *Vibrionaceae*, demonstrates temperature-dependent growth. Environmental studies have demonstrated that *V. vulnificus* growth becomes detectable at temperatures above 15°C, with a marked increase in abundance and associated infection risk at temperatures exceeding 25°C [19]. According to data from the Central Weather Bureau in Taiwan, the average seawater temperature in central Taiwan was above 18°C throughout the year and above 25°C from May to October, providing a favorable environment for *V. vulnificus* to proliferate [20]. The geographic characteristics and easy access to coastal areas increase the risk of exposure to *V. vulnificus*.

In a previous study by Chen et al., 85 patients with severe *V. vulnificus* infection admitted to the ICU were analyzed, with an ICU mortality rate of 40% and an APACHE II score ≥ 20 associated with a 41-fold increased risk of death [14]. However, 30% of their cohort did not have septicemia, while 82% of non-survivors did, indicating that inclusion of patients with limited infection (gastroenteritis or soft tissue involvement) may have diluted the risk of mortality for those with *V. vulnificus* septicemia. The complexity of the APACHE II score, which requires multiple laboratory parameters, limits its practicality in the ED.

In addition, Kuo et al. studied 171 patients with *V. vulnificus* infection, reporting a 34% mortality rate in those with septicemia, which is similar to the present study [15]. The REMS, which is simpler and based on readily available clinical data, had an AUROC of 0.895 for mortality prediction. Their data is similar to the APACHE II (AUROC of 0.945) in the study by Chen et al. and the REMS (AUROC of 0.917) in our data. Nevertheless, the optimal REMS cutoff for mortality prediction was ≥ 8 in the study by Kuo et al., compared with ≥ 6 in our study. This discrepancy may reflect differences in cohort composition, as 31%

of Kuo's cohort had limited infection, thereby raising the mortality prediction threshold. Still, REMS offers a practical alternative to APACHE II for rapid risk stratification in the emergency setting, with predictive accuracy comparable to APACHE II not only in nonsurgical ED patients but also in patients with *V. vulnificus* septicemia [21].

In our study, geriatric patients demonstrated significantly higher disease-related mortality. An Australian epidemiological study showed that increasing age was associated with a higher incidence of bloodstream infections caused by *Vibrio* species, with the median age of *V. vulnificus* septicemia at 68 years [22]. However, this study only revealed a trend of higher incidence with aging and did not address whether other covariates confounded the relationship with age. Nevertheless, the authors concluded that increasing age is associated with a higher risk of septicemia. In contrast, a large U.S. surveillance study using multivariate logistic regression identified age > 30 years as an independent risk factor for mortality after adjusting for other covariates, including liver disease, race, and transmission route [1]. This finding supports the perspective that age independently contributes to mortality risk in overall *V. vulnificus* infection, while the risk in *V. vulnificus* septicemia is not presented in their study.

REMS and MEDS showed acceptable discriminatory ability, with optimal cutoffs of REMS ≥ 6 and MEDS ≥ 10 associated with significantly higher mortality rates. Although age ≥ 65 years was not identified as an independent risk factor for mortality in the multivariate analysis, among the seven clinical scoring systems we evaluated, only REMS and MEDS incorporate age as a scoring component. Due to the clinical complexity and multiple comorbidities in geriatric patients, age alone may be confounded by other clinical factors, but still inevitably influences survival. To predict mortality in patients with *V. vulnificus* septicemia, clinicians need to generate a clinical gestalt—that is, evaluate the patient as a whole rather than relying on any single clinical factor—while remaining alert to and recognizing the increased vulnerability of the geriatric population to *V. vulnificus* infection. In our study, REMS ≥ 6 and MEDS ≥ 10 serve as tools to increase clinical awareness of poor outcomes and facilitate early risk stratification.

This study has some limitations. First, the rarity of *V. vulnificus* septicemia and the single-center nature of the study restricted data enrollment. A nationwide, multicenter study would be necessary to validate these findings and provide more robust epidemiological data. In addition, tachycardia (heart rate > 100 beats per minute) was significantly associated with increased mortality, consistent with prior evidence that tachycardia is an independent predictor of poor outcomes in sepsis [23]. Nevertheless, the confidence interval was extremely wide (HR = 448.83, 95% CI = 1.75–1.15×10^5, p = 0.031), likely reflecting the small cohort size. We should cautiously interpret this data and regard tachycardia as a clinical warning sign rather than a significant prognostic factor.

Conclusions

This is the first study to investigate the clinical outcome of *V. vulnificus* septicemia in geriatric patients. Age ≥ 65 years were associated with higher mortality compared with younger adults, emphasizing the

vulnerability in geriatric patients to *V. vulnificus* infection. This is also the first study exclusively focusing on *V. vulnificus* septicemia rather than a mixed cohort including limited disease, which may underestimate mortality. Among seven scoring models, REMS ≥ 6 and MEDS ≥ 10 showed good discriminatory ability (AUROC of 0.917 and 0.798, respectively), and are recommended for rapid risk stratification and mortality prediction in the ED setting.

Declarations

Supplementary Materials

The following supporting information is in Tables S1-S7: Scoring systems [9-13,17].

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Author Contributions

C.-H.H. and S.-Y.H. wrote the main manuscript; M.-S.H., S.-C.H., T.-C. C., and S.-Y.H. reviewed and revised the main manuscript; C.-H.H., S.-Y.H., C.-Y.H., C.-A.T., and C.-H.S. prepared the figures and tables. All authors have read and agreed to the published version of the manuscript. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement

The data are available upon reasonable request to the corresponding author. Readers can access the data and material supporting the study's conclusions by contacting Sung-Yuan Hu at song9168@pie.com.tw.

Institutional Review Board Statement

The human study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board of Taichung Veterans General Hospital (IRB file code CE23126B).

Informed Consent Statement

Informed consent was waived because of this study's retrospective and observational nature.

Conflicts of Interest

The authors declare no conflict of interest.

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Figures

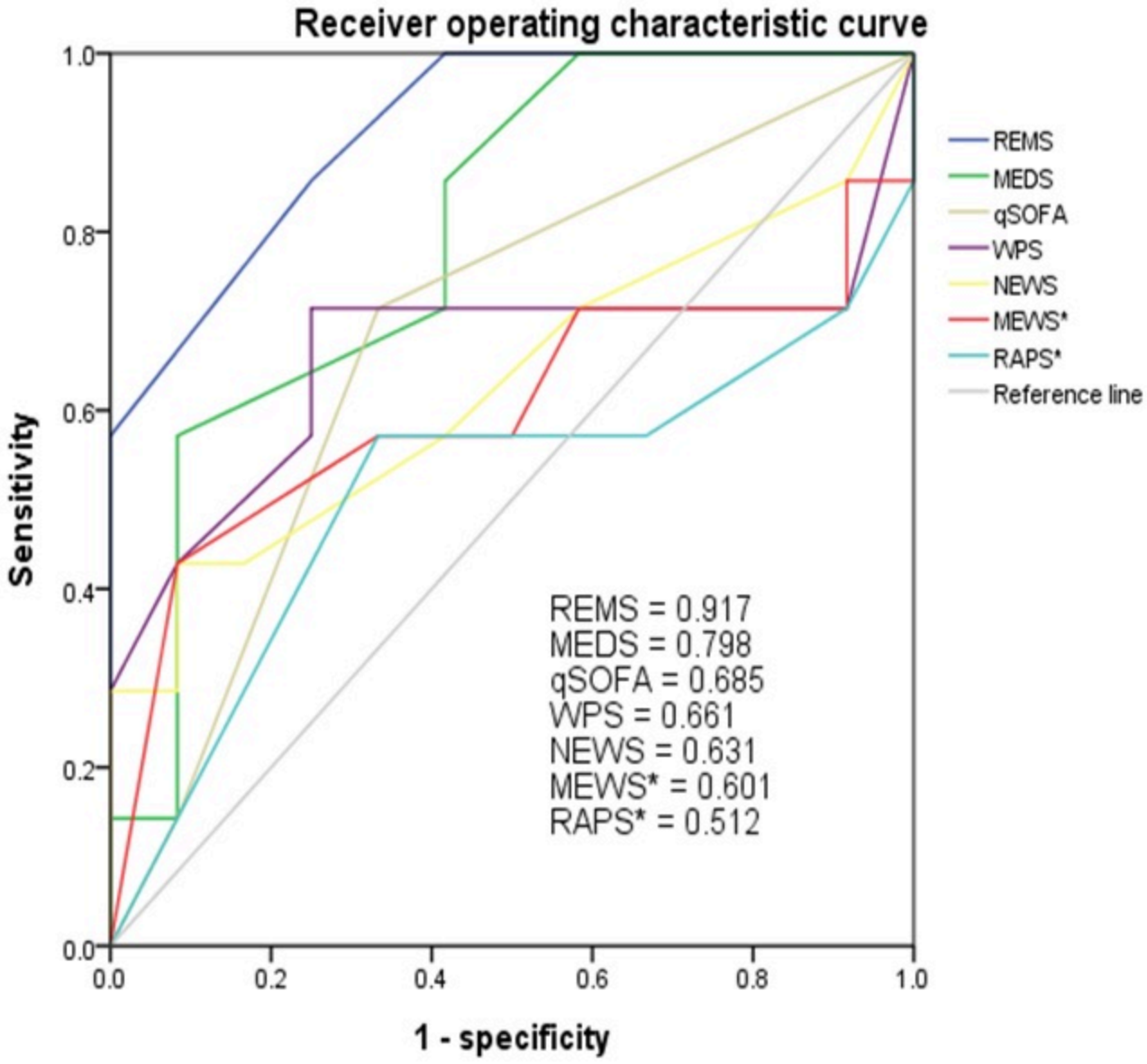


Figure 1

The AUC of ROC of REMS (0.917), MEDS (0.798), qSOFA (0.685), WPS (0.661), NEWS (0.631), MEWS (0.601), and RAPS (0.512) showed the predictive performance of 30-day mortality risk for patients with *Vibrio vulnificus* septicemia. AUC, Area under curve; MEDS, Mortality in Emergency Department Sepsis Score; MEWS, Modified Early Warning Score; NEWS, National Early Warning Score; RAPS, Rapid Acute

Physiology Score; REMS, Rapid Emergency Mortality Score; qSOFA, quick Sequential Organ Failure Assessment; WPS, Worthing Physiological Scoring System.

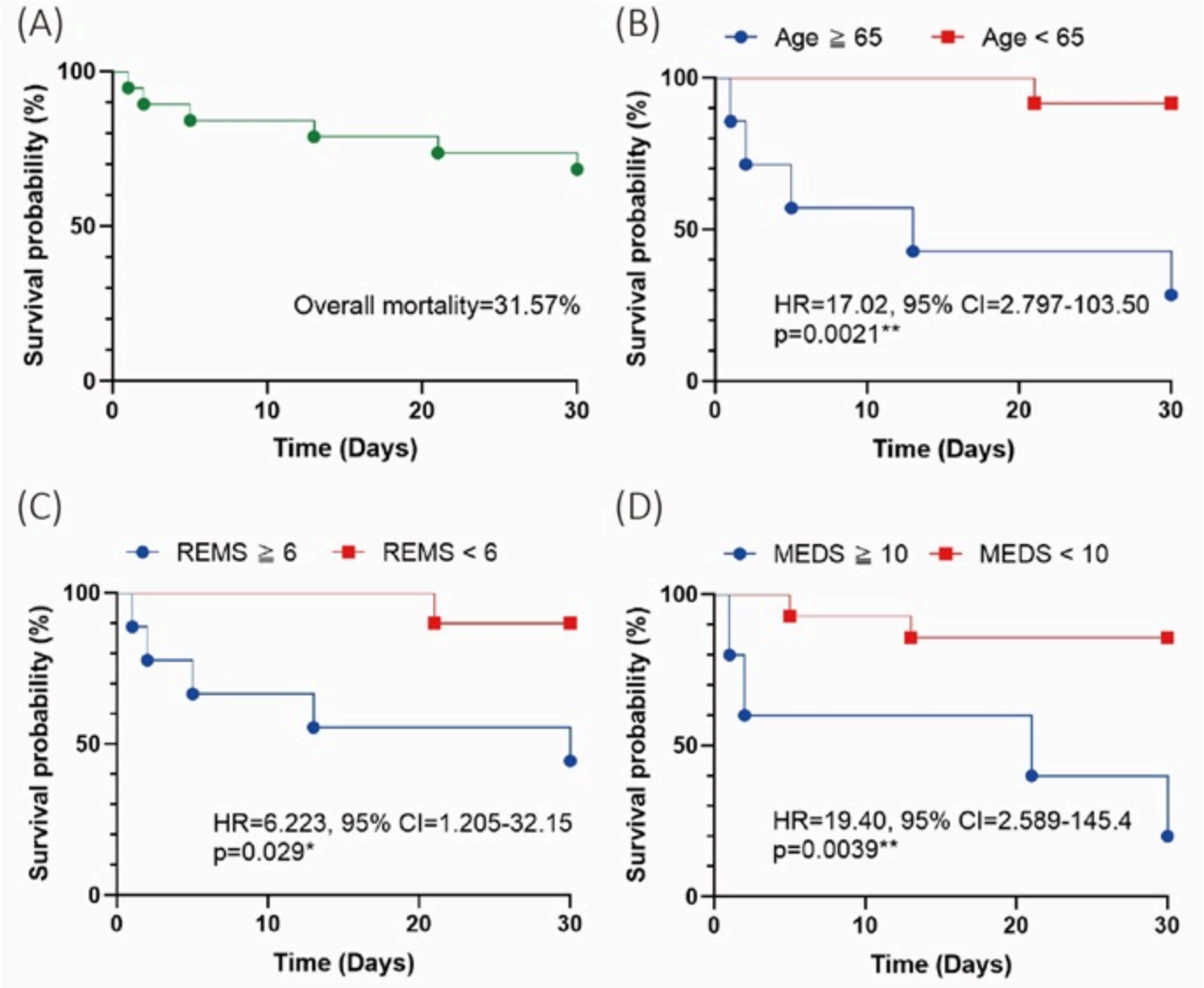


Figure 2

The overall mortality of 19 patients with *V. vulnificus* septicemia was 31.57% (2A). The geriatric group had a higher 30-day mortality than the non-geriatric group (HR = 17.02, 95% CI = 2.797-103.50, p = 0.0021) (2B). At cutoff points of REMS ≥6 and MEDS ≥10, both REMS ≥6 (HR = 6.223, 95% CI=1.205-32.15, p = 0.029) and MEDS ≥10 (HR = 19.4, 95% CI = 2.589-145.4, p = 0.0039) were significantly associated with increased 30-day mortality (2C and 2D).CI, Confidence Interval; HR: Hazard Ratio; MEDS, Mortality in Emergency Department Sepsis; REMS, Rapid Emergency Mortality Score.

Supplementary Files

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- VibrioSupplementary115.05.24.docx