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Prognostic role of intermountain risk score (IMRS) in intensive care unit patients with a diagnosis of COVID-19

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Abstract. – OBJECTIVE: In this study, we aimed to assess the predictive value of Intermountain Risk Score (IMRS) in intensive care unit (ICU) patients with COVID-19.

PATIENTS AND METHODS: Our retrospective study included the data of 194 patients who were admitted to the COVID-19 ICU of a tertiary care center. COVID-19 diagnoses were made by a positive result from a real-time reverse-transcriptase (RT) polymerase chain reaction (PCR) assay of nasal and pharyngeal swab specimens. Patients who had negative RT-PCR results or who were not admitted to ICU and patients under 18 years old were excluded from the study. Complete blood count, biochemistry panel, and blood gas analysis results were gathered and compiled.

RESULTS: 194 ICU patients with COVID-19 (PCR positive) were included in the study. The patients were divided into two groups according to IMRS (if IMRS was <15 in women and <17 in men, patients were included in the non-high-risk group, while patients with IMRS ≥15 in women and ≥17 in men were defined as a high-risk group). Multivariate regression analysis was performed to predict in-hospital mortality. The IMRS [OR: 1.17 (1.08-1.27) p<0.001)] was found to predict in-hospital mortality.

CONCLUSIONS: In this study, we showed that the IMRS score at admission can predict in-hospital mortality in intensive care unit patients with a diagnosis of COVID-19.

Key Words:
IIntermountain risk score (IMRS), COVID-19, Intensive care unit (ICU).

Introduction

Since December 2019, Coronavirus 19 (COVID-19) has caused a global pandemic that has resulted in millions of deaths worldwide[1]. The disease has a broad spectrum that can range from minor infection to varying degrees of pneumonia and acute respiratory failure leading to sepsis and death[2]. Because of the high morbidity and mortality rates of COVID-19 infection, it is essential to identify critically ill individuals who require more close monitoring. As a result, a useful and easily accessible risk prediction index is required for routine clinical practice in identifying individuals who are at higher risk.

There are well-known risk factors related to COVID-19 mortality, including old age, immunosuppression, chronic disorders (hypertension, diabetes mellitus, chronic renal failure, etc.), and cancer[3-8]. COVID-19 illness can influence biochemistry and complete blood count parameters. In addition, prior studies[8-14] revealed that several biochemical and hematological abnormalities were related to disease severity, lung involvement, and death. Thus, a scoring system that is created by combining biochemical and hematological variables might better predict the probability of death.

The Intermountain Risk Score (IMRS) is derived from a baseline metabolic profile and a complete blood count. The ability of IMRS to predict mortality and morbidity in various diseases has been demonstrated in the literature, including in patients with trauma, atrial fibrillation, heart failure, and those undergoing transaortic valve implantation[15-23]. Moreover, in COVID-19 patients, a high IMRS is a predictor of hospitalization and mortality[24]. However, there is insufficient evidence in the literature to assess the predictive usefulness of IMRS in the high-risk COVID-19 group, such as those who are admitted

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to the intensive care unit (ICU). Therefore, the purpose of this study was to assess the predictive value of IMRS in ICU patients with COVID-19.

Patients and Methods

Patient Selection

This single-center, retrospective study included COVID-19 adult patients who were admitted to the University of Health Sciences Sultan Abdulhamit Han Education and Research Hospital Intensive Care Unit between 25/03/2020 and 15/10/2021. A positive result from a real-time reverse-transcriptase (RT) polymerase chain reaction (PCR) test of nasal and pharyngeal swab specimens was used to confirm a COVID-19 diagnosis. Patients with negative RT-PCR findings, those who were not admitted to the ICU, as well as those under the age of 18, were excluded from the research. In total, the study involved 194 individuals. The demographic, clinical characteristics, and laboratory parameters of the participants during their hospitalization were obtained from the hospital's electronic medical records.

Laboratory Analysis

Blood samples were obtained on the first day of ICU admission. Immediately after sampling, complete blood count parameters were determined by a hematology analyzer ABX Pentra DX 120 (HORIBA Medical, Montpellier, France). Biochemical parameters were measured by the Roche Cobas Integra 800 (Roche Diagnostic Limited, Basel, Switzerland) device. These blood values were obtained retrospectively from the hospital system to calculate the IMRS.

Calculation of IMRS

The IMRS is calculated using various laboratory and complete blood count parameters. These parameters are as follows: hematocrit, white blood cell (WBC) count, platelet count, mean corpuscular volume, mean corpuscular hemoglobin concentration (MCHC), red cell distribution width (RDW), mean platelet volume (MPV), sodium, potassium, calcium, bicarbonate, glucose, and creatinine. By using these parameters, the IMRS can be calculated *via* a website that has been utilized in previous studies[25] (available at: https://intermountainhealthcare.org/IMRS/). The MRS values ranged from -5 to 28 for women and -1 to 28 for men. Because of the small sample of patients in our study compared to previous studies in literature, patients were divided into two groups, non-high risk (Group-1) and high risk (Group-2), while previous studies included three risk groups. If the IMRS was <15 in women and <17 in men, patients were included in the non-high-risk group, while patients with IMRS ≥15 in women and ≥17 in men were defined as a high-risk group. A flowchart of patient selection is given in Figure 1.

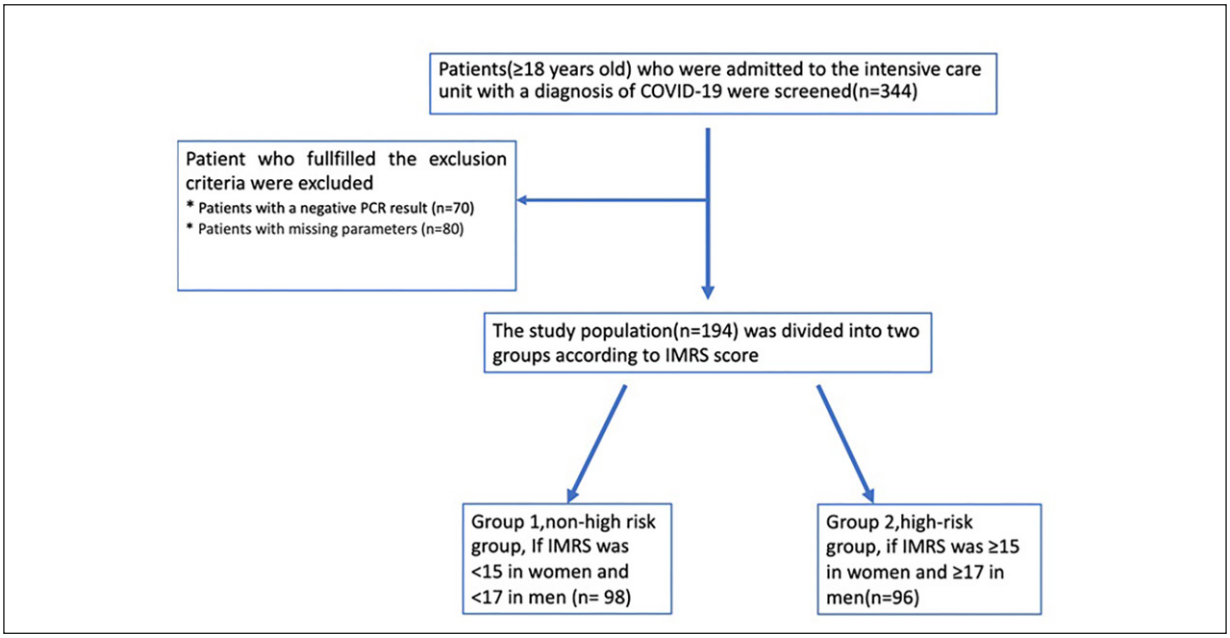

Figure 1. Consort-flow diagram for patient selection.

The ICU Admission Criteria

The patients were admitted to the ICU according to the following criteria: I-) meeting criteria for acute respiratory distress syndrome or O_2 >6 liters per minute to maintain SpO_2 >92% (or rapid escalation of oxygen requirement), II-) Respiratory rate >30 per minute, III-) Systolic blood pressure <90 mmHg, mean arterial pressure <65 mmHg, tachycardia and other signs of shock, IV-) Arterial blood gas with pH <7.3 or partial CO_2 pressure >50 mmHg or above patient's baseline, lactate >2 mmol/Liter, V-) Concerning clinical appearance. The decision of ICU admission was based on the criteria by Brigham and Women's Hospital COVID-19 guidelines, which were updated on December 20, 2020[26].

Outcomes

The primary outcome was defined as all-cause in-hospital mortality in this study.

Statistical Analysis

Continuous variables were presented as mean (SD) or median (IQR), or median interquartile range (25^{th} to 75^{th}) according to data distribution, and as absolute numbers and percentages for categorical variables. The distribution was tested by Shapiro-Wilk test. Differences between patient outcomes were studied by *t*-test for independent groups or by Wilcoxon rank test if the non-parametric analysis was required. A study of differences between groups of categorical data was carried out by Chi-square statistics. The mortality probability in patients admitted to ICU was analyzed by the logistic regression analysis. We used stepwise logistic regression, and variables with $p<0.05$ were included in the multivariable model. All Intervals of confidence (CI) were established at 95% and the two-tailed significance level was established to be <0.05. Statistical data analysis was performed using the R v4.01 (Vienna, Austria) with "rms" and "hmisc" packages.

Results

Patients were divided into two groups according to their risk status. Group-1 included non-high-risk patients (n=98), while group-2 included high-risk patients (n=96).

Comparison of basal characteristics and baseline blood parameters at admission are given in Table I. Patients in the high-risk groups were older (61.7±14.4 *vs.* 76.9±10.7, $p<0.001$) and included fewer male patients (67.3% *vs.* 47.9%, $p=0.006$). The high-risk group demonstrated a higher frequency of hypertension, chronic renal failure, lower hemoglobin, and hematocrit levels, higher RDW, and higher IMRS ($p<0.001$ for all). Higher congestive heart failure presence, more chronic obstructive pulmonary disease, lower bicarbonate levels, higher glucose, and higher leucocyte values were observed in the high-risk group ($p=0.01$, 0.04, 0.006, 0.02 and 0.04, respectively). High-risk patients required more intubation and demonstrated more in-hospital mortality ($p<0.001$ for both).

Univariable logistic regression analysis for the prediction of in-hospital mortality is given in Table II. The parameters included in the univariate logistic regression analysis were the presence of hypertension, diabetes mellitus, chronic renal disease, congestive heart failure, chronic obstructive pulmonary disease, history of stroke, male gender, age, WBC count, hemoglobin count, platelet count, creatinine level, glucose level, and IMRS. According to the analysis, the presence of chronic renal failure, older age and higher IMRS predicted in-hospital mortality ($p=0.04$, <0.001 and <0.001, respectively). Then, these parameters were evaluated by multivariable logistic regression analysis (Table III). The IMRS independently predicted in-hospital mortality between these parameters ($p=0.02$).

The relationship of IMRS with the possibility of in-hospital mortality was given with a marginal effect plot. When the adjustment with other parameters of multivariable logistic regression was made, the possibility of in-hospital mortality was 25% when IMRS is 5. The possibility of in-hospital death showed an increase with an increasing IMRS. As a result, it reaches 90% while IMRS is 25 (Figure 2). The ratio of death was 75% for the high-risk group, while this ratio reduced to 51% in the low-risk group (Figure 3, $p<0.001$).

Discussion

COVID-19 has caused a global pandemic that has resulted in millions of deaths all over the world. The infection has a wide spectrum that can progress from a mild illness to acute respiratory failure resulting in sepsis and death[2]. COVID-19 can lead to some changes in hematological and biochemical parameters and the primary reason for this is thought to be inflammation. Inflammation is a key factor in the progression and severity

Table I. Basal characteristics, laboratory parameters and outcomes.

Variable	Total group, (n: 194)	Non-high-risk group, (n: 98)	High-risk group (n: 96)	*p*-value
Age	69.2 ± 14.4	61.7 ± 13.6	76.9 ± 10.7	< 0.001
HT	117 (60.3)	45 (45.9)	72 (75)	< 0.001
DM	66 (34)	28 (28.6	39 (38.3)	0.10
CKD	42 (21.6)	12 (12.2)	30 (31.2)	0.001
CHF	51 (26.3)	16 (16.3)	35 (36.5)	0.01
Stroke history	15 (7.7)	4 (4.1)	11 (11.5)	0.06
Asthma	8 (4.1)	6 (6.1)	2 (2.1)	0.16
COPD	28 (14.4)	9 (9.2)	19 (19.8)	0.04
Gender (male)	108 (57.7)	66 (67.3)	46 (47.9)	0.006
Intubation	124 (63.9)	51 (52)	73 (76)	< 0.001
NIMV	79 (40.9)	36 (37.1)	43 (44.8)	0.28
Death	122 (62.9)	50 (51)	72 (75)	< 0.001
WBC	10.8 ± 7.4	9.4 ± 7.4	11.9 ± 7.3	0.04
Hematocrit	33.7 ± 6.8	36.4 ± 30.9	33.7 ± 6.8	< 0.001
Hemoglobin	11.2 ± 2.3	12.1 ± 2.1	10.3 ± 2.1	< 0.001
Platelet	235 ± 106	232 ± 111	238 ± 102	0.70
MPV	10.1 ± 1.4	10.1 ± 1.2	10.0 ± 1.5	0.47
MCV	86.6 ± 7.3	87.1 ± 7.3	86.1 ± 7.3	0.34
RDW	14.7 ± 2.2	13.9 ± 1.8	15.5 ± 2.2	< 0.001
Creatinine	1.9 ± 2 [0.2-11.2]	1.7 ± 2 [0.5-11.2]	2.1 ± 1.9 [0.2-11.2]	0.13
Glucose	150 ± 77	137 ± 60	163 ± 89	0.02
Bicarbonate	23.8 ± 6	24.9 ± 5.2	22.6 ± 6.6	0.006
Sodium	136.6 ± 5.6	136.2 ± 5.5	136.9 ± 5.8	0.42
Calcium	8.6 ± 0.9	8.7 ± 0.9	8.5 ± 0.8	0.08
Potassium	4.3 ± 0.8	4.3 ± 0.7	4.4 ± 0.9	0.48
IMRS	15.2 ± 4.3	11.9 ± 2.9	18.6 ± 2.6	< 0.001

HT, hypertension; DM, Diabetes Mellitus; CKD, chronic kidney disease; CHF, Chronic heart failure; COPD, Chronic obstructive pulmonary disease; WBC, White blood cell count; IMRS, Intermountain Risk Score, NIMV: Non-invasive mechanical ventilation, MPV, Mean platelet volume; MCV, Mean corpuscular volume; RDW, Red cell distribution width.

of COVID-19. Exaggerated immune response and inflammation can lead to cytokine storm, which may trigger more severe disease involvement. Besides that, elevated WBC as a result of intense inflammation was associated with disease severity and higher mortality in prior studies[4,7-11,14,27-30].

Table II. Location of the brain lesions at conventional MRI performed after 3 months of stroke.

Variable	Odds ratio	Confidence interval, 95%	*p*-value
HT	1.25	0.69-2.26	0.46
DM	0.95	0.51-1.76	0.87
CKD	2.20	1.01-4.81	0.04
CHF	0.89	0.46-1.71	0.72
Stroke	1.68	0.52-5.50	0.39
COPD	1.93	0.78-4.8	0.16
Gender (male-referans)	0.66	0.37-1.19	0.17
Age	1.04	1.01-1.06	< 0.001
WBC	0.97	0.93-1.01	0.13
Hemoglobin	0.89	0.78-1.02	0.10
Platelet	0.99	0.98-1.01	0.06
Creatinine	1.09	0.92-1.28	0.32
Glucose	1.00	0.99-1.01	0.33
IMRS	1.17	1.08-1.27	< 0.001

HT, hypertension; DM, Diabetes Mellitus; CKD, chronic kidney disease; CHF, Chronic heart failure; COPD, Chronic obstructive pulmonary disease; WBC, White blood cell; IMRS, Intermountain Risk Score.

Table III. Multivariable logistic regression for in-hospital mortality.

Variable	Odds ratio	Confidence interval, 95%	*p*-value
Age	1.02	0.99-1.04	0.18
CKD	1.55	0.67-3.60	0.30
IMRS	1.12	1.02-1.23	0.02

CKD, Chronic kidney disease; IMRS, Intermounatain Risk Score.

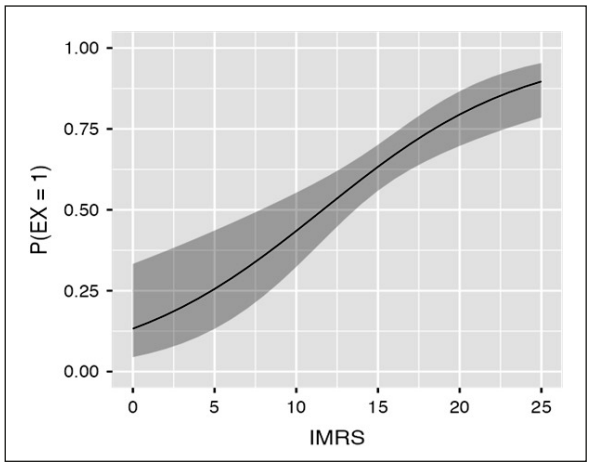

Figure 2. Marginal effect plot to show the relationship between IMRS and in-hospital mortality.

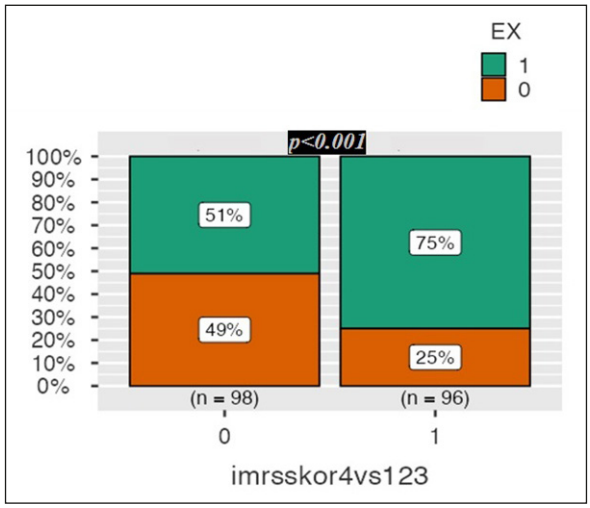

Figure 3. Ratio of in-hospital mortality is given for non-high-risk and high-risk groups separately.

On the other hand, in patients with neutrophilia as well as eosinophilia and lymphopenia, it was associated with the progression of the inflammatory response and mortality.

Platelet count is an important parameter in many classification systems that are utilized to evaluate disease severity. The presence of thrombocytopenia in COVID-19 infection correlates with the severity of the disease, and it indicates the presence of consumptive coagulopathy. The mechanism by which Coronavirus interferes with the hematopoietic system is still unclear. However, it can be assumed that there are three cascading mechanisms to explain thrombocytopenia in SARS-CoV-2 infections: I-) cessation of platelet production by direct infiltration of the bone marrow, II-) destruction of platelets by the body's defense mechanism, and III-) aggregation of platelets in the lungs with microthrombus formation and greater consumption of platelets[9,12,31].

Advanced age, male gender, high MCHC, high RDW, MPV, high creatinine, and decreased hemoglobin were found to be associated with mortality in COVID-19 patients in different studies[7,9,10,13,14,16,28,31,32].

The IMRS is a score that is created using different biochemical and hematological parameters. The IMRS provides a compound risk score by including various risk factors and parameters. Therefore, it might be applied to evaluate the general risk condition of a patient. Previously, this index was demonstrated[15-25,33] to have an adequate predictive value for mortality in patients with various diseases. Furthermore, the IMRS was also tested in COVID-19 patients, and practical results were obtained in terms of mortality and morbidity[25]. However, the predictive value of this index has not been evaluated in COVID-19 patients who are admitted to the ICU. Our study results revealed that this easily applicable index might be used to predict in-hospital mortality in ICU patients with COVID-19.

The IMRS is an inexpensive, practical, and easily obtainable risk scoring system that can be used for risk stratification in ICU patients with COVID-19, according to our study findings. As the risk prediction in ICU patients with COVID-19 is essential for clinicians in evaluating them more precisely, an applicable risk scoring system can help clinicians to take appropriate management actions for such patients.

Limitations

Firstly, the retrospective nature of this single-center study was the main limitation. Secondly, the relatively small sample size was another limitation. Lastly, future studies, including larger data sets, are needed to test the results of our study.

Conclusions

The IMRS is a useful score that can be easily calculated from routine blood tests. In this study, we showed that the IMRS at admission could predict in-hospital mortality in ICU patients with a diagnosis of COVID-19.

Conflict of Interest

The Authors declare that they have no conflict of interests.

Funding

The current study received no financial support.

Ethics Approval

Written permission was obtained from the Sağlık Bilimleri University Hamidiye Ethics Committee (22-46 dated 26.05.2022). This study was conducted in conformity with the Declaration of Helsinki.

Informed Consent

Before starting the study, all the patients were informed of the study, and the voluntary ones were included in the study.

Authors' Contribution

The concept of this study was developed by Dr. Başak ÇAKIR GÜNEY, Dr. Tufan ÇINAR, Dr. Doğancan ÇENELİ and Dr. Mustafa KAPLAN. The study designation was made by Dr. Başak ÇAKIR GÜNEY, Dr. Tufan ÇINAR and Dr. Mustafa KAPLAN. The literature review was done by Dr. Başak ÇAKIR GÜNEY, Dr. Doğancan ÇENELİ, Dr. Nurgül TÜKEL, Dr. Zeliha SERİNDAĞ, Dr. Betül DOĞANTEKİN, Dr. Süha ASAL, Dr. Emine SINLIK, Dr. Özge ATIŞ. The data collection was made by Dr. Başak ÇAKIR GÜNEY, Dr. Doğancan ÇENELİ, Dr. Nurgül TÜKEL, Dr. Zeliha SERİNDAĞ, Dr. Betül DOĞANTEKİN, Dr. Süha ASAL, Dr. Emine SINLIK, Dr. Özge ATIŞ. The statistical analysis of data made by Dr. Ali KARAGÖZ The writers of the article are Dr. Başak ÇAKIR GÜNEY and Dr. Doğancan ÇENELİ. Critical Review was made by Dr. Başak ÇAKIR GÜNEY and Dr. Doğancan ÇENELİ.

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