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Investigation of the Value of MEW Score and Perfusion Index Parameters in Identifying Critically Ill Patients- A Prospective Study

MEW Skoru ve Perfüzyon İndeksi Parametrelerinin Kritik Hastaların Belirlenmesindeki Değerinin Araştırılması- Prospektif Bir Çalışma

[1]Agit Akgül, [2]Rezan Karaali, [3]Zeynep Karakaya

[1]Emergency Department, Prof.Dr. Cemil Taşcıoğlu City Hospital, Istanbul, Turkey
[2]Emergency Department, İzmir Atatürk Training And Research Hospital, Izmir, Turkey
[3]Emergency Department, İzmir Katip Çelebi University Atatürk Training and Resarch Hospital, Izmir, Turkey

Abstract: Triage and scoring systems have been developed to differentiate critical patients from others and to ensure early intervention in crowded emergency departments. We aimed to determine the utility of the perfusion index in the triage of patients, and its association with mortality in comparison and combination with the Modified Early Warning score. This was a single-center and prospective study. The study included patients who received yellow or red triage code in emergency department. The modified Early Warning scores were calculated from patients data. The perfusion index value was measured using a Masimo® device with probe. The outcomes of the patients and one-month mortality were recorded. 397 patients were included in the study. Mean perfusion index and Modified Early Warning score was 4.05 (± 2.67) and 1.99, respectively in patients discharged from the emergency department, 1.12 (± 0.97) and 7.5, respectively in patients deceased at the emergency department. Finally, the Modified Early Warning score was added to the perfusion index and the effect of the created model on mortality was evaluated. In this case, the new model had an accurate classification rate of 91.7%, with a sensitivity of 98.6% and a specificity of 45.1%. Nagelkerke's R2 of 0.434 suggested that the model was effective in explaining the dependent variable (mortality) at a rate of 43.4%. It would be possible to make early decisions on intervention and prevent mortality since the combined use of perfusion index and Modified Early Warning score provide higher reliability in identifying critical patients.
Keywords: Critically ill, emergency, Modified Early Warning score, perfusion index, triage

Özet: Kalabalık acil servislerde kritik hastaları diğerlerinden ayırmak ve erken müdahaleyi sağlamak için triyaj ve skorlama sistemleri geliştirilmiştir. Hastaların triyajında Perfüzyon indeksinin faydasını ve Modifiye Erken Uyarı skoru(MEWS) ile karşılaştırma ve kombinasyon halinde mortalite ile ilişkisini belirlemeyi amaçladık. Bu tek merkezli ve prospektif bir çalışmadır. Çalışmaya acil serviste sarı veya kırmızı triyaj kodu alan hastalar dahil edildi. MEWS puanları hasta verilerinden hesaplanmıştır. Perfüzyon indeksi değeri, problu bir Masimo® cihazı kullanılarak ölçüldü. Hastaların sonuçları ve bir aylık mortalite durumları kaydedildi. Çalışmaya 397 hasta dahil edildi. Acil servisten taburcu edilen hastalarda ortalama perfüzyon indeksi ve modifiye erken uyarı skoru sırasıyla 4,05 (± 2,67) ve 1,99, acil serviste ölen hastalarda sırasıyla 1,12 (± 0,97) ve 7,5 idi. Son olarak MEWS değeri perfüzyon indeksine eklenmiş ve oluşturulan modelin mortaliteye etkisi değerlendirilmiştir. Bu durumda yeni model, %98,6 hassasiyet ve %45,1 özgüllük ile %91,7 doğru sınıflandırma oranına sahipti. Nagelkerke'nin 0,434 olan R2'si, modelin bağımlı değişkeni (mortalite) açıklamada %43,4 oranında etkili olduğunu öne sürdü. Perfüzyon indeksi ve modifiye erken uyarı skorunun birlikte kullanılması kritik hastaların belirlenmesinde daha yüksek güvenilirlik sağladığından müdahale konusunda erken karar vermek ve mortaliteyi önlemek mümkün olacaktır.
Anahtar Kelimeler: Kritik hasta, acil, modifiye erken uyarı skoru, perfüzyon indeksi, triyaj

ORCID ID of the authors: AA. 0000-0002-7706-0963, RK. 0000-0003-1831-2566, ZK. 0000-0003-0562-8297

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Correspondence: **Agit AKGÜL-** Emergency Department, Prof.Dr. Cemil Taşcıoğlu City Hospital, Istanbul, Turkey
e-mail: agitakgul@hotmail.com

1. Introduction

Today, urbanization and population growth lead to significant problems in the delivery of healthcare services. The emergency department has become the primary referral unit for accessing healthcare services, especially in big cities. This results in overcrowding in emergency departments, reduced quality of the service, and an increased likelihood of malpractice by physicians. Therefore, triage and scoring systems have been developed to differentiate critical patients from others and to prevent delays in early intervention in high-volume emergency departments [1-3].

The Early Warning Score (EWS), one of the scoring systems, includes the assessment of physiological parameters. The EWS was first defined by Morgan et al. in 1997 and subsequently revised by Stenhouse et al. as the Modified Early Warning Score (MEWS)[4, 5]. The MEWS is an easy-to-use system because it is a non-invasive measure of vital parameters, it can be calculated quickly, and does not require laboratory workup [6, 7]. However, vital signs can be measured within normal limits when compensation mechanisms are active and may cause miscalculation. This has created the need for systems that could detect perfusion disorders at the tissue level. Among these systems, infrared spectroscopy gives a perfusion index (PI) by calculating the ratio of the pulsatile blood flow to the non-pulsatile (static) blood flow in peripheral tissues. The PI value, which is noninvasively obtained by attaching a device to the fingertip of the patient, provides information on perfusion at the tissue level [8, 9].

The present study aimed to determine the utility of the PI in the triage of patients presenting to the emergency department, its ability to predict critical patients, and its association with mortality in comparison and combination with the MEW score.

2. Materials and Methods

Study design

This was a single-center and prospective study. The study was conducted in the tertiary emergency department of the university hospital. Green, yellow, red and trauma areas receive approximately 800-1000 patient admissions per day. The study was initiated following the approval of the Izmir Katip Celebi University Ethics Committee (Date: January 9, 2020, and Decision No: 536).

Patients presenting to the emergency department of our hospital are assessed using a four-category triage system [10]. Initial assessment of the patients is performed in the triage area at the entrance of the emergency department. Triage is performed by certified emergency nurses who have received triage training. Level of consciousness (AVPU or Glasgow Coma Scale), vital signs (pulse rate, systolic blood pressure, body temperature, SPO2) are recorded in the patient cards. Patients with life-threatening conditions or at risk of extremity loss are placed in category 1 (red zone), patients with urgent conditions but not compatible with category 1 are placed in category 2 (yellow zone), and patients with no need for emergency intervention in category 3 (green zone)[10].

Study population

The study included patients presenting to the emergency department of our hospital between January 1, 2020, and February 1, 2020**.**

Inclusion criteria:

Patients who received yellow or red triage code,

Aged above 18 years,

Patients who volunteered to participate in the study. Consent was obtained from the legal guardians of unconscious patients brought to the emergency department.

Exclusion criteria:

Pregnants

Trauma patients,

Patients with extremity loss and peripheral vascular diseases that would hinder PI measurement,

Patients admitted to the emergency department as cardiopulmonary arrest,

Patients who declined to volunteer for the study were excluded.

Data collection

Age, sex, systolic blood pressure (BP), pulse rate, and level of consciousness of the patients eligible for the study were recorded and the MEW scores were calculated from the data obtained. Patients were divided into two risk groups (patents with a MEWS of < 5 as low risk, and MEWS of ≥5 as high risk) according to the MEW score [6, 7].

The PI value was measured from three different fingers of the patients using a Masimo® (Masimo Corporation, Irvine, CA) device a noninvasive probe for five seconds and the values were recorded after a value fixed on the monitor [11]. It measures with infrared and infrared photoplethysmographic signals with Masimo Signal Extraction Technology. It has optical sensors protected from radiofrequency and light. Unlike conventional devices, it detects both arterial and venous blood movement in the measurement area. With this technology, Masimo Signal Extraction Technology gives true tissue oxygen saturation [12].

The emergency department outcomes of the patients were divided into four groups as discharge from the emergency department, admission to the ward, admission to the intensive care unit, and deceased in the emergency department.

The status of hospital admission (intensive care/ward), discharge, and one-month mortality were monitored through the hospital automation system. The mortality status of the discharged patients was followed up from the Türkiye Cumhuriyeti Health Ministry e-nabız system.

Statistical analysis

The study data were assessed using IBM SPSS Statics Version 20 software. The normality of quantitative data was analyzed by the one-sample Kolmogorov-Smirnov test and the use of parametric or nonparametric tests was decided accordingly. Frequency and percentage distribution for descriptive statistics, and mean, standard deviation, minimum and maximum values for continuous variables were calculated. The variables were compared between the groups using the Pearson’s Chi-Square, Mann-Whitney U, and Kruskal-Wallis statistical tests, and the associated interpretations were used.

A Binary Logistic model was used to explore the effect of the PI and MEWS on mortality.

3. Results

397 patients who met the inclusion criteria and had adequate data were included in the study. Mean age of patients were 70,32 ± 13,78 years. Male patients accounted for 53.4% of the study population.

The PI, age, systolic BP, pulse rate, respiratory rate, SpO2, and fever data were found to be not normally distributed. The results of analysis patients groups that discharged from ED, hospitalized in ward, hospitalized in ICU and deceased in ED and the variables revealed that the AVPU score ($p<0.001$), MEW score ($p<0.001$), PI ($p<0.001$), SpO2 ($p<0.001$), and mortality ($p<0.001$) were statistically significant (Table 1).

The analysis of the association between the outcomes of the patients and the PI and MEWS variables, in turn, revealed that the mean PI and MEWS was 4.05 (± 2.67) and 1.99, respectively in patients discharged from the emergency department compared to 1.12 (± 0.97) and 7.5, respectively in patients deceased at the emergency department. The differences in the values were statistically significant (Figure 1).

Concerning the effects of the study parameters on mortality, PI, systolic BP, respiratory rate, SpO2, AVPU, MEWs were statistically significantly associated with mortality ($p<0.05$) (Table 2).

The Binary Logistic Regression Model

The data obtained in this study, which aimed to determine the variables affecting mortality in patients presenting to the emergency department, were analyzed using a binary logistic regression model. Mortality was determined as the dependent variable and the effects of AVPU score, MEW score, PI, systolic BP, SpO2, and respiratory rate on mortality were examined.

When the potential risk factors to be included in the model and the main factors associated with patient mortality were evaluated, the PI ($p<0.001$) and MEWS ($p<0.001$) with a $p<0.20$ were identified as the factors with the greatest effect on patient outcomes in the created model. The PI ($p<0.001$; Exp (B) = 0.652) and MEWS ($p<0.001$; Exp (B) = 2.023) were remarkably effective. The PI was inversely related to the probability of mortality (B = - 0.428), while the MEWS (B = 0.705) increased the probability of mortality with a positive effect.

The mortality risk decreased by 0.652 times as the PI of the patient increased, while the mortality risk was 2.023 times higher in patients with a high MEWS than in those with a low MEWS.

After the variables to be included in the model were determined, first, the effect of the PI variable on patient mortality was evaluated (Step 1a). The accurate classification rate of the created model was 87.2%, which was significant. Nagelkerke's R2 of 0.175 suggested that the model was effective in explaining the dependent variable (mortality) at a rate of 17.5%. Then, the effect of the MEWS variable on mortality was evaluated (Step 1b). The accurate classification rate of the created model was 90.9%, which was significant. Nagelkerke's R2 of 0.346 suggested that the model was effective in explaining the dependent variable (mortality) at a rate of 34.6%.

Finally, the MEWS was added to the PI and the effect of the created model on mortality was evaluated (Step 2a). In this case, the new model had an accurate classification rate of 91.7%, with a sensitivity of 98.6% and a specificity of 45.1%. Nagelkerke's R2 of 0.434 suggested that the model was effective in explaining the dependent variable (mortality) at a rate of 43.4% (Table 3).

Table 1. Evaluation of variables according to patient outcomes

	Outcomes of patients (N = 397)				
	Discharged from ED	Hospitalized in ward	Hospitalized in ICU	Deceased in ED	p
	(n=289)	(n=64)	(n=32)	(n=12)	
PI (Mean ± SD) (min-max)	4.05±2.67 (0.10–10.00)	3.60±2.32 (0.20–9.10)	2,13±1.56 (0.20–6.00)	1.12±0.97 (0.20–3.60)	0.001
Age (Mean ± SD) (min-max)	69.96±4.32 (20.00-98.00)	69.67±12.28 (30.0-96.00)	73.56±12.89 (46.00-96.00)	73.92±9.05 (55.00-91.00)	0.237
systolicBP/mmHG (Mean ± SD) (min-max)	124.00±20.00 (80.00-180.00)	125.00±23.00 (80.00-170.00)	114.00±22.00 (80.00-160.00)	128.00±21.00 (100.00-160.00)	0.089
Pulse/min (Mean ± SD) (min-max)	87.57±16.50 (52.00-160.00)	95.78±30.42 (58.00-280.00)	90.59±19.24 (63.00-130.00)	95.75±24.83 (68.00-140.00)	0.284

RR/min (Mean ± SD) (min-max)		21.85±4.86 (10.00-36.00)	23.77±5.73 (14.00-44.00)	24.19±6.91 (16.00-40.00)	20.58±3.60 (15.00-26.00)	0.054
SpO2 (Mean ± SD) (min-max)		95.46±2.86 (76.00-100.00)	94.88±3.72 (80.00-100.00)	94.00±4.27 (80.00-98.00)	91.08±4.78 (78.00-96.00)	0.001
Fever/C° (Mean ± SD) (min-max))		36.40±0.57 (36.00-39.00)	36.28±0.46 (36.00-37.00)	36.45±0.52 (36.00-37.00)	36.33±0.49 (36.00-37.00)	0.618
Gender n (%)	Male	154 (72.64)	35 (16.51)	15(7.08)	8 (3.77)	
	Female	135 (72.97)	29 (15.68)	17 (9.19)	4 (2.16)	0.696
AVPU n (%)	1	241 (79.28)	44 (14.47)	19 (6.25)	0 (0)	
	2	48 (64.86)	12 (16.22)	12 (16.22)	2 (2.7)	
	3	0 (0)	4 (40)	1 (10)	5 (50)	
	4	0 (0)	4 (44.44)	0 (0)	5 (55.56)	0.001
Mortality n (%)	Live	289 (83,53)	55 (15,9)	2 (0,58)	0 (0)	
	Deceased	0 (0)	9 (17.65)	30 (58.82)	12 (23.53)	0.001
MEWS n (%)	(5<)	280	47	25	0	
	(5≥)	9 (20)	17 (37.78)	7 (15.56)	12 (26.67)	0.001

PI: perfusion index, BP: systolic blood pressure, RR:respiration rate, MEWS:modified early warning score, ED:emergency department, ICU:intensive care unit, AVPU: alert, verbal, pain, unresponsible.

Table 2. Relationship between patients' mortality and variables**.**

		Patients			
		Total (n=397)	**Alive (n= 346)**	**Deceased (n=51)**	**P**
PI (Mean±SD) (min-max)		3.74±2.60 (0.10-10.00)	4.02±2.60 (0.10-10.00)	1.83±1.59 (0.20-6.60)	0.001
Age (Mean±SD) (min-max)		70.32±13.78 (20.0-98.00)	70.06±14.00 (20.00-98.00)	72.14±12.14 (41.00-96.00)	0.393
systolicBP/mmHg (Mean±SD) (min-max)		123.00±21.00 (80-190)	124.00±20.00 (80.00-180.00)	117.00±24.00 (80.00-190.00)	0.03
Pulse/min (Mean±SD) (min-max)		89.39±20.04 (52.00-280.00)	89.01±20.14 (52.00-280.00)	91.96±19.39 (63.00-140.00)	0.953
RR/min (Mean±SD) (min-max)		22.31±5.23 (10.00-44.00)	22.23±5.09 (10.00-44.00)	22.80±6.11 (15.00-40.00)	0.03
SpO2 (Mean±SD) (min-max)		9.12±3.30 (76.00-100.00)	95.47±2.88 (76.00–100.00)	92.75±4.77 (78.00–98.00)	0.001
Fever/ C° (Mean±SD) (min-max)		36.38±3.30 (36.00-39.00)	36.38±0.55 (36.00-39.00)	36.31±0.47 (36.00-37.00)	0.718
Gender n (%)	Male	212	184 (86.79)	28 (13.21)	0.818
	Female	185	162 (87.57)	23 (12.43)	
AVPU n (%)	1	304	286 (94.08)	18 (5.92)	0.001
	2	74	60 (81.08)	14 (18.92)	
	3	10	0 (0)	10 (100)	
	4	9	0 (0)	9 (100)	

MEWS	<5	352	328 (93.18)	24 (6.82)	0.001
n (%)	≥5	45	18 (40)	27 (60)	

PI: perfusion index, BP: systolic blood pressure, RR:respiration rate, MEWS:modified early warning score, ED:emergency department, ICU:intensive care unit, AVPU: alert, verbal, pain, unresponsible.

Table 3: Evaluation of Risk Factors Associated with Mortality in the Binary Logistic Regression Model

Variables in theEquation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	P.I	-0.479	0.093	26.238	1	0.000	0.619	0.516	0.744
	Constant	-0.598	0.245	5.948	1	0.015	0.55		
Step 1[b]	MEWS	0.731	0.099	54.445	1	0.000	2.077	1.711	2.523
	Constant	-4.277	0.394	117.832	1	0.000	0.014		
Step 2[a]	P.I	-0.428	0.101	17.795	1	0.000	0.652	0.535	0.795
	MEWS	0.705	0.107	42.981	1	0.000	2.023	1.639	2.498
	Constant	-2.946	0.449	42.988	1	0.000	0.053		

a. Variable(s) entered on step 1: P.I, MEWS.
P.I: perfusion index, MEWS:modified early warning score.

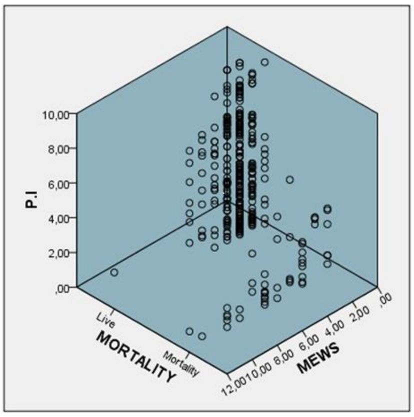

Figure 1. Evaluation of PI and MEW scores of patients discharged from the emergency department and patients who died in the emergency department
P.I: perfusion index, MEWS: modified early warning score

4. Discussion

With technological developments, novel systems have been introduced to clinical practice. The PI is one of these systems. It is non-invasive and easy to use, resulting in increased use in emergency departments [9, 13]. Studies have been conducted to establish the PI range, assess its values in critical patients, and determine its discriminatory power. For instance, Lima et al. compared the PI between critical patients and healthy individuals and found a PI of 1.4 as the critical threshold value. The authors reported that values lower than this threshold indicated the presence of abnormal perfusion [14]. He et al. examined PI values at T0 (the time of hospital admission of the patient) and hour 8 (T8) (the eighth hour after the treatment). The authors evaluated the patients in three groups according to the PI values as 0.6 < P I = 0.6–1.4 > 1.4. The T8 PI value, measured after the treatment was found to be associated with mortality. The authors reported that the PI value could be used to monitor the treatment process [15]. The PI value obtained in the present study, on the other hand, was measured on admission of the patients to the emergency department. These values differed between the patients who were discharged from the emergency department, who were admitted to the hospital, and who died. The PI value of the patients admitted to the ward and intensive care unit was found to be low, and the PI value of the patients who died in the emergency department was found to be 1.12 (± 0.97). These findings are important for the prediction of patients requiring a rapid response in the emergency department. The death of patients, while they are still undergoing examinations and interventions in the emergency department, is an indicator of a severely critical condition. Identifying these patients during the initial admission is of vital importance. Therefore, we believe that the values obtained in the present study are significant. In addition, the fact that PI was found to be high in patients who were discharged from the emergency department without the need for hospitalization suggests that patients with a high PI value may be kept waiting in crowded emergency rooms thereby contributing to prioritizing the patients with a high risk of mortality. Savastano et al., recorded the post-ROSC PI for 30 minutes in patients receiving CPR and evaluated the patients for survival. The mean PI was found to be 1.2 (0.6–2.38). The authors divided the patients into three groups according to the measurement results. Accordingly, among the patients with a PI of 1.83–7.8, survivors accounted for 57%. In other words, the authors reported that survival increased with increased PI values [16]. He et al found that PI less than 0.6 is an independent factor for 30-day mortality. The present study found the PI value in non-surviving patients to be 1.83 (± 1.59). The findings of the present study are consistent with the PI values described as the critical threshold by Savastano et al., and He et al.[15, 16]. We established that the patient mortality decreased by 0.652 times as the critical PI value of 1.83 (± 1.59) increased. Decreased patient mortality with improved peripheral perfusion suggests that survival would improve in critical patients with rapid response. according to our findings, 1.86(± 1.59) values of PI had an accurate classification possibility of 87,2% in differentiating surviving and non-surviving patients. The Nagelkerke's R2 of 0.175 for PI suggests that the power of PI to predict mortality was low. The use of PI alone in the emergency department triage remains weak in mortality prediction. Similar to the present study, Oskay et al. evaluated patients who were classified as yellow and red in triage. The authors did not find any association between PI and mortality. Oskay et al. emphasized that the assessment of vital parameters was more valuable [11].

Another parameter evaluated in the present study was the MEW score, which is calculated using the vital signs of the patients and is used frequently in triage in emergency departments. No laboratory workup is needed for the calculation. It is calculated using the vital signs and the level of consciousness on patient admission [4, 5]. Therefore, the MEW score has been evaluated for the prediction of the prognosis of patients in emergency departments. Subbe et al. established that patients with a MEW of ≥ 5 had a high risk of mortality and ICU admission [7]. Similarly, the study by Armagan et al. with 309 patients presenting to the emergency department reported that patients with a MEW score of ≥5 were high-risk patients. The authors stated that the high-risk patients had a high rate of admission to the intensive care unit and a higher in-hospital or intensive care unit mortality [17]. Batnagar et al. reported that patients with a MEW score of ≥ 5 had a mortality rate of 31.6% and 54.3% of the survivors had a complicated hospital stay [18]. The present study accepted the critical patient threshold value for MEW as ≥5, as commonly indicated in the previous studies. When the status of hospital admission and discharge from the emergency department were evaluated, a statistically significant difference was established between patients with a MEW of <5 and a MEW of ≥ 5. The MEW score calculated on admission of the patients to the emergency department is a useful system to differentiate critical patients. The severity of the patient's condition and the risk of mortality increase with increasing MEW scores. The MEW score of patients who died in the emergency department was ≥

7.5 in the present study. Patients with such a value of MEW require a very rapid response.

On the contrary, patients with a low MEW score were stable and the patients discharged from the hospital even had a mean MEW of ≤ 2.1. Similar to the findings of the present study, Maftoohian et al., reported a MEW score of ≥ 3 for mortality prediction. The authors stated that patients with a MEW score lower than this value were stable. The authors also reported that a MEW score of ≥ 3 predicted mortality with a sensitivity of 78.26% (56– 92) and a specificity of 68.44% (63– 73) [19]. Bathnagar et al. stated that mortality could be predicted with a sensitivity of 78% and a specificity of 94% in patients with a MEW score of ≥ 5 [18]. Shaikh et al., on the other hand, found that a MEW score of 3.5 predicted mortality with a sensitivity of 89.2% and a specificity of 65% [6]. In the present study, the MEW score alone could predict mortality with a probability of 34.6% and an accuracy of 90.9%. Our findings are consistent with these studies. we can say that the MEW score has high specificity for mortality is a good predictor of surviving patients in the emergency department. However, the MEW score appears to have different values and low sensitivity in predicting mortality. Therefore, we evaluated the effect of a model created by adding the MEWS variable to the PI value, which is obtained noninvasively similar to the MEW parameters, on mortality. In this case, the new model was found to differentiate non-surviving patients with a sensitivity of 98.6% and an accuracy of 91.7%. The size of the effect of the MEW score alone on mortality was 34.6% and the PI alone on mortality was 17.5%, while it increased to 43.4% when the two parameters were evaluated together. Also, the PI's rate of accurate classification of surviving and non-surviving patients increased to 91.7% from 87.2%. In this case, the rate of patient mortality prediction is likely to be higher when the MEW score and PI are evaluated together.

Other parameters (systolicBP, AVPU and SpO2) that we obtained statistically significant results in the comparison of deceased and surviving patients are the parameters used in calculating the MEW score. Therefore, it is an expected result that they are associated with mortality. However, as a result of our regression analysis, we found that these parameters to determine mortality separately is weak. Therefore, these parameters should not be used as a stand-alone mortality indicator.

Limitation

Since our study was conducted prospectively, only the patients evaluated by the authors were included in the study. Therefore, our number of patients is low. Another limitation; the clinical burden of the patients could not be evaluated with objective tools such as SOFA or APACHE II.

5. Conclusion

In conclusion, the present study is the first to evaluate MEWS and PI together and these parameters can be easily used in emergency departments. It would be possible to make early decisions on intervention and prevent mortality since the combined use of PI and MEWS provide higher reliability in identifying critical patients. Our study findings will be guiding in the re-creation and development of triage systems.

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Ethics

Ethics Committee Approval: This study was approved by the Noninterventional Clinical Research Ethics Committee of the Izmir Katip Celebi University (Decision no:536, Date: 09.01.2020).

Informed Consent: Informed consent was obtained from the patients who agreed to participate in the study. Consent was obtained from the legal guardians of unconscious patients brought to the emergency department.

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