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Predictors of in-hospital Mortality After Rapid Response System Activation in a Newly Established Tertiary Hospital

Yeni Kurulan Üçüncü Basamak Bir Hastanede Hızlı Müdahale Sistem Aktivasyonu Sonrası Hastane İçi Mortalite Prediktörleri

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ABSTRACT *Objective:* Rapid response systems (RRSs), which aim to prevent cardiac arrests and unexpected deaths, have been implemented across hospitals worldwide. Most studies on RRS shave evaluated the effects of its implementation on in-hospital mortality. In this study, we evaluated the predictive factors of in-hospital mortality for patients who were subjects of RRS activation in a newly established major hospital in Turkey.

Materials and Methods: Data on RRS activations were reviewed from paper charts and electronic medical records between March 2019 and February 2020. The demographic characteristics of patients, time of and reasons for RRS activation, initial cardiac rhythm, heart rate, mean arterial pressure, pulse oximetry-measured blood oxygen saturation (SpO_2), time of arrival of the rapid response team, red cell distribution width, platelet distribution width obtained from the first blood gas analysis and haemogram test results as well as glucose, sodium, potassium, pH, lactate, neutrophils and lymphocyte levelswere recorded. Univariate and multivariate logistic regression analyses were conducted to determine the independent predictors of in-hospital mortality.

Results: A total of 531 patients were included in the analysis. Of these, 189 (35.6%) died during hospital admission. Compared with survivors, non-survivors were older (median age, 64 vs. 52 years) and more likely to be male (65.6% vs. 34.4%); be admitted for cardiovascular, pulmonary and oncologic diseases and trigger RRS at nightand weekends than during the day. Activation of RRS by respiratory and haemodynamic triggers as well as during nighttime and weekend hours oncologic reasons for hospital admission, low SpO_2 levels, high neutrophil-to-lymphocyte ratio (NLR), potassium levels and lactate levels were predictive of in-hospital mortality.

Conclusion: This study found some weaknesses in the current RRS of the hospital. Hospital staffs working overnight and on weekends should be trained and empowered. SpO_2, potassium and lactate levels as well as NLR are predictors of in-hospital mortality and can guide triage decision making, which is usually a challenging and stressful task.

Keywords: Rapid response team, code blue, medical emergency team, predictor, mortality

ÖZ *Amaç:* Amacı kardiyak arrest ve beklenmeyen ölümleri engellemek olan hızlı müdahale sistemleri (RRS) dünya hastanelerinde genellikle kullanılmaktadır. İlgili çalışmaların çoğunda RRS kullanımının hastane mortalitesine etkileri araştırılmıştır. Bu çalışmada Türkiye'deki yeni kurulan majör bir hastanede, RRS aktivasyonu yapılan hastalardaki hastane içi mortalite için prediktif faktörleri değerlendirdik.

Gereç ve Yöntem: Mart 2019 ve Şubat 2020 arasındaki RRS aktivasyonları, basılı ve medikal elektronik kayıtlardan incelendi. Hastaların demografik özellikleri, RRS aktivasyon zamanı, aktivasyon nedeni, ilk kardiyak ritim, kalp hızı, ortalama arteriyel basınç, pulse oksimetre ile ölçülen kan oksijen satürasyonu, hızlı müdahale ekibinin varış süresi, ilk kan gazı ve hemogram analizindeki glukoz, sodyum, potasyum, pH, laktat, nötrofil, lenfosit, kırmızı hücre dağılım genişliği, platelet dağılım genişliği kaydedildi. Bağımsız hastane içi mortalite prediktörlerini belirlemek için univariate ve multivariate lojistik regresyon analizleri yapıldı.

Bulgular: Toplamda 531 hasta analize dahil edildi. Bunlardan 189'u (%35,6) hastane yatışı sırasında öldü. Ölenler yaşayanlarla kıyaslandığında daha yaşlı (medyan yaş 64 ve 52 yıl), daha çok erkek (%65,6 ve 34,4) ve daha fazla kardiyovasküler, solunumsal ve onkolojik nedenlerle yatışı yapılmış hastalardı. Ayrıca gündüz saatleriyle karşılaştırıldığında RRS'nin daha çok gece saatleri ve hafta sonunda aktive edildiği hastalardan oluşmaktaydı. RRS'nin solunumsal ve hemodinamik nedenlerle, gece ve hafta sonu, onkolojik nedenlerle yatışı yapılan hastalarda aktivasyonu, düşük SpO_2 düzeyleri, yüksek nötrofil-lenfosit oranı (NLR), potasyum ve laktat düzeyleri hastane içi mortalite prediktörleriydi.
Sonuç: Bulgularımız hastanemiz RRS sisteminde bazı zayıflıklar olduğunu göstermiştir. Hafta sonu ve gece personeli eğitilmeli ve güçlendirilmelidir. Ayrıca SpO_2, potasyum, laktat ve NLR düzeyleri hastane içi mortalite prediktörleri olarak genellikle zor ve stresli olan triyaj kararlarını yönlendirebilir.
Anahtar Kelimeler: Hızlı müdahale ekibi, mavi kod, tıbbi acil ekibi, prediktör, mortalite

Introduction

Rapid response systems (RRS) have been widely implemented across world hospitals since the introduction of this concept in the 1990s (1,2). These systems include an afferent arm which is based on identifying non-intensive care unit (ICU) patients with clinical deterioration, especially those who are at an earlier stage (3). Rapid response teams (RRT) constitute the efferent arm of the RRS and mainly triage patients to intensive care units. These systems aim to prevent cardiac arrests and unexpected deaths (4).

Most of the studies about RRS aim to evaluate the utility of these systems and have focused on the comparison of patient outcomes before and after the implementation (5-7). Predictors of in-hospital mortality for patients who are subjects of a RRS activation are less studied. In this study we aimed to determine the predictors of in-hospital mortality for these patients and thereby improve the organization of the RRS.

Materials and Methods

This was a retrospective study conducted in a tertiary education and research hospital. The study protocol was reviewed and approved by the Ankara City Hospital Ethics Committee (IRB number: 72300690-799, date: 29.07.2019). Personal informed consent was not required.

RRT Description

Ankara City Hospital is a new tertiary education and research hospital with 3,810 beds in the capital of Turkey. It has been designed as a conglomerate of seven blocks; a main connecting block and six blocks serving as branch hospitals connected with the central block. The hospital has been functioning since February 2019 and a new RRS which is active at wards and other hospital areas except emergency and intensive care departments has been established since its opening. Each branch hospital has its own RRT. The team consists of a resident physician and two nurses from 8 am to 5 pm on week days, whereas it consists of a physician assistant and a nurseat nighttime and on weekends. Activation of the team can occur by any hospital staff member via a pager system. The criteria for RRT activation include the following: acute and persistent declining oxygen saturation (SpO_2) <90%, acute and persistent changes in heart rate <40 or >120 bpm, mean arterial pressure (MAP) <65 mmHg and respiratory rate <8 and >28/min, acute mental status changes, unexplained agitation more than 10 minutes and staff concern for any other reason.

Patients

The records of RRT activations in two branch hospitals were reviewed from paper charts and electronic medical records between March 2019 and February 2020 (12 months). These two branch hospitals include 1,029 beds and care for adult patients with cardiovascular, pulmonary, oncologic, haematologic, gastroenterelogic, renal and urologic problems. Calls with missing or incomplete data were excluded.

Patient Variables

Demographic characteristics of patients, time of RRT activation, reasons for activation, initial cardiac rhythm, heart rate, MAP, pulse oximetry measured blood SpO_2, arrival time of the RRT, parameters obtained from first blood gas (glucose, Na, K, pH, lactate) analysis and hemogram test (neutrophil, lymphocyte, red cell distribution width, platelet distribution width) were recorded. Blood samples were collected immediately after the first intervention as a routine procedure of our hospital. The study outcome was in-hospital mortality.

Statistical Analysis

All statistical analysis was performed using SPSS Statistics 18 (IBM corp., Inc., Chicago, IL, USA). Differences between patients who survived to discharge and those who did not were evaluated using chi-square or Fisher's Exact tests for categorical variables and Student's t-test or

Mann-Whitney U test for continuous variables. Continuous variables were presented as mean ± standard deviation or median (minimum-maximum) and categorical data were summarized as percentages. Univariate logistic regression analyses were performed to examine the association between each predictor and in-hospital mortality separately. We also conducted a backward stepwise multivariate logistic regression to determine the independent predictors of mortality. A criterion of $p<0.05$ for entry was imposed in this procedure. We have introduced in the multivariate logistic regression analysis variables that are plausibly important based on theory even if the p-value was <0.05 in the univariate analysis (8). Model fit was assessed with the Hosmer-Lemeshow goodness-of-fit test. Odds ratios (ORs) for continuous variables were described using standardized ORs, which were associated with a one standard deviation change in the variable.

Results

Between March 1, 2019 and February 1, 2020, the RRT was activated 543 times resulting in an average of 45 activations per month. The most common reason for activation of the RRT was haemodynamic deterioration, followed by mental status changes. Respiratory deterioration was present in 17.3% of the activations. Twelve calls were excluded because of missing data. A final total of 531 patients who were the subjects of RRT activations were included in the analysis. Of these, 189 (35.6%) died during hospital admission. Patient and RRT event characteristics in patients who survived versus those who did not are shown in Table 1. Nonsurvivors were older (median age 64 years vs. 52 years), were more likely to be male (65.6% vs. 34.4%), were more likely to be admitted for cardiovascular, pulmonary and oncologic diseases and were more likely to trigger RRS activation during nighttime and weekend hours (NWH) than daytime hours (DH). Other reasons for hospital admission included a heterogeneous group of patients who were admitted for benign urologic and gastroenterologic reasons, the family members of patients and hospital staff. Vital signs were more likely to be abnormal in nonsurvivors with higher rates of bradycardia (heart rate <40 bpm; 62.4% vs. 19.3%), hypotension (MAP <65 mmHg; 78.8% vs. 46.5%), and hypoxia (SpO_2 <90%; 83.6% vs. 33.6%). Survivors had lower rates of comorbidities (42.1% vs. 66.7%). Arrival time of the RRS was not different between survivors and nonsurvivors. The levels of potassium, lactate and neutrophil-to-lymphocyte ratio (NLR), red cell distribution width (RDW) and platelet distribution width (PDW) were significantly lower in survivors, while lymphocyte count was significantly higher in this group.

Predictors of in-hospital Mortality

Univariate logistic regression analysis demonstrated that activation of RRS by respiratory and haemodynamic triggers and during NWH, male sex, older age, cardiovascular, pulmonary and oncologic diseases as the main reason for hospital admission, respiratoryand multiple comorbidities, heart rate, bradycardia (<40 bpm) MAP, hypotension (MAP <65 mmHg), SpO_2, hypoxia (SpO_2 ≤90%), asystole and pulseless electrical activity (PEA) as initial rhythm, higher potassium, lactate, NLR, RDW levels andlower lymphocyte countwere significantly associated with mortality (Table 2).

Activation time and triggers of RRS, sex, age, reasons for hospital admission (cardiovascular, pulmonary and oncologic diseases), comorbidities (respiratory and multiple comorbidities), heart rate, MAP, SpO_2, initial rhythms, potassium, lactate, NLR, RDW levels, lymphocyte count were included in the multivariate analysis. The final step of multivariate analysis retained activation time and triggers of RRS, reasons for hospital admission, SpO_2, comorbidities, PEA as initial rhthyhm and potassium, lactate, NLR levels. Activation of RRS by respiratory and haemodynamic triggers and during NWH, oncologic diseases for hospital admission, low SpO_2 levels, high NLR, potassium and lactate levels remained significant as predictors of mortality (Table 2).

Discussion

In this study we retrospectively evaluated the predictors of in-hospital mortality in patients who were the subjects of a RRS activation by using the paper and electronic records of patients. Our study demonstrates that independent predictors of in-hospital mortality were: 1) activation of RRS during NWH (factor associated with RRS); 2) respiratory and haemodynamic deterioration as RRS trigger, oncologic reasons for hospital admission, low SpO_2 values(factors associated with clinical variables of the patients); and 3) NLR, potassium and lactate levels (factors associated with the first blood test of the patient).

RRTs are specialised teams that aims to immediately respond non-ICU patients experiencing clinical deterioration. They are the efferent arms of RRS, whereas the afferent

Table 1. Comparison between survivors and non-survivors				
	Demographics, clinical presentation and labaratory findings of patients			
	Total (n=531)	Survivors (n=342)	Non-survivors (n=189)	p
Activation time of RRS				
Daytime hours	268 (50.5)	224 (65.5)	44 (23.2)	**<0.001**
Nighttime and weekend hours	263 (49.5)	118 (34.5)	145 (76.8)	
Trigger for RRS activation				
Mental status changes	142 (26.7%)	137 (40.1)	5 (2.6)	**<0.001**
Unexplained agitation	34 (6.4%)	34 (9.9)	0 (0.0)	**<0.001**
Staff concern	109 (20.5%)	105 (30.7)	4 (2.1)	**<0.001**
Respiratory deterioration	92 (17.3%)	34 (9.9)	58 (30.7)	**<0.001**
Haemodynamic deterioration	154 (29.0%)	32 (9.4)	122 (64.6)	**<0.001**
Sex				
Male	304 (57.3)	180 (52.6)	124 (65.6)	**0.004**
Female	227 (42.7)	162 (47.4)	65 (34.4)	
Age (years)	56.7±17.7 (60;18-91)	52.3±18.4 (53;18-91)	64.7±13.0 (66;21-91)	**<0.001**
Reason for hospital admission				
Cardiovascular	123 (23.2)	70 (20.5)	53 (28.0)	**0.048**
Pulmonary	51 (9.6)	25 (7.3)	26 (13.8)	**0.016**
Oncologic	162 (30.5)	75 (21.9)	87 (46.0)	**<0.001**
Hematologic	14 (2.6)	12 (3.5)	2 (1.1)	0.092
Renal	42 (7.9)	35 (10.2)	7 (3.7)	**0.008**
Other	139 (26.2)	125 (36.5)	14 (7.4)	**<0.001**
Pulse (bpm)	58±47 (71;0-218)	71±1 (78;0-218)	34±48 (0;0-162)	**<0.001**
>120	40 (7.5)	26 (7.6)	14 (7.4)	0.935
<40	345 (65.0)	66 (19.3)	118 (62.4)	**<0.001**
MAP (mmHg)	42±43 (47;0-147)	52±44 (69;0-147)	24±36 (0;0-133)	
<65	223 (42.0)	159 (46.5)	149 (78.8)	**<0.001**
≥65	308 (58.0)	183 (53.5)	40 (21.2)	**<0.001**
SpO_2 (%)	56±45 (88;0-100)	70±41 (95;0-100)	29±40 (0;0-100)	
≥90	258 (48.6)	227 (66.4)	31 (16.4)	**<0.001**
<90	273 (51.4)	115 (33.6)	158 (83.6)	**<0.001**
Comorbities				
None	261 (49.2)	198 (57.9)	63 (33.3)	**<0.001**
Respiratory	21 (4)	8 (2.3)	13 (6.9)	**0.010**
Cardiac	64 (12.1)	38 (11.1)	26 (13.8)	0.371
Neurologic	11 (2.1)	8 (2.3)	3 (1.6)	0.561
Malignancy	16 (3.0)	8 (2.3)	8 (4.2)	0.222
Diabetes mellitus	20 (3.8)	15 (4.4)	5 (2.6)	0.314
Renal	15 (2.8)	11 (3.2)	4 (2.1)	0.465
Multiple	123 (23.2)	56 (16.4)	67 (35.4)	**<0.001**
Time to arrival of RRT (min)	1.3±0.8 (1;0.2-8)	1.2±0.8 (1;0.2-8)	1.5±0.8 (1;0.2-6)	0.304

Initial rhythm				
NSR	253 (47.7)	207 (60.5)	46 (24.3)	**<0.001**
Asystole	146 (27.5)	49 (14.3)	97 (51.3)	**<0.001**
Bradicardia	31 (5.8)	15 (4.4)	16 (8.5)	0.055
PEA	80 (15.1)	20 (5.8)	60 (31.7)	**0.032**
VT/VF	5 (0.9)	3 (0.9)	2 (1.1)	0.837
Unknown	16 (3.0)	8 (2.3)	8 (4.2)	0.222
Blood gas parameters				
Glucose	110±78 (94;29-390)	105±69 (94;29-390)	121±93 (96;29-390)	0.410
Na	134±8 (135;102-163)	134±8 (137;102-155)	134±8 (133;102-163)	0.561
K	4.1±1.1 (4.0;2.6-9.0)	3.7±1.0 (3.9;2.6-8.7)	4.7±1.1 (5.0;2.6-9.0)	**<0.001**
pH	7.09±0.19 (7.0;6.8-7.6)	7.09±0.19 (7.0;6.8-7.55)	7.09±0.19 (7.0;6.78-7.55)	0.866
Lactate	5.7±3.12 (7.0;0.8-21)	5.1±2.3 (6.0;0.8-14)	6.7±4.0 (6.4;0.8-21)	**<0.001**
Hemogram parameters				
Neutrophil	6.3±7.4 (3.5;1.0-82.2)	5.7±6.1 (3.6;1-82.2)	7.7±9.2 (3.0;1-66.6)	0.410
Lymphocyte	1.5±1.9 (1.0;0.1-24.8)	1.7±2.1 (1.3;0.1-24.8)	1.2±1.5 (1.0;0.1-12.3)	**<0.001**
NLR	11.9±22.9 (3.7;0.8-225.0)	8.5±16.3 (3.2;0.2-130)	18.1±30.6 (6.2;0.6-225)	**<0.001**
RDW	15.8±2.6 (15.3;5.4-26.0)	15.4±2.5 (14.6;5.4-23.8)	16.5±2.6 (16.4;5.4-26.0)	**<0.001**
PDW	55.9±12.7 (57.0;18.0-84.0)	55.0±12.1 (56.4;18.0-84.0)	57.6±13.5 (57.6;18.9-84.0)	**0.004**

Values are shown as number (percentage) or mean ± standard deviation (median; minimum-maximum). Significant values marked in bold. RRS: Rapid response system, MAP: mean arterial pressure, SpO_2: pulse oximetry derived oxygen saturation, RRT: rapid response team, NSR: normal sinus rhythm, PEA: pulseless electrical activity, VT: ventricular tachycardia, VF: ventricular fibrillation, NLR: neutrophil-to-lymphocyte ratio, RDW: red cell distribution width, PDW: platelet distribution width

arm is based upon hospital staff who determines the patient with acute physiological derangement and triggers the RRS activation. The composition of RRTs is tailored to some factors like aim of the team and resources of the hospital (4). The amount and level of experience of staff who are available in both arms of the RRS at NWH may differ from those available at DH (9). These working periods include fewer and less-experienced physicians coupled with reduced patient/nursing ratios on both the wards as well as the RRT. As a result; delays in RRT activations and mismanagement of deteriorating patient may occur more frequently at NWH. In our study RRT activation during NWH was an independent predictor of mortality. Our findings are consistent with a national registry study in the United States and a smaller study in Canada that reported increased mortality with overnight RRT activations (9,10). Our study differs from these reports by comparing DH and NWH. Nighttime and weekend hours resemble each other in some key aspects including fewer andless-experienced staff members. The problem in our hospital may arise from the limited staff resource of this newly established hospital and use of paper based observation charts in wards. The afferent and efferent arms of RRS can be improved by strengthening the staff in size and competence at NWH and moving from paper based observation charts to electronic medical records (11).

Other predictors of mortality were respiratory and haemodynamic deterioration as RRS trigger, oncologic reasons for hospital admission, low pulse oximetry values, high potassium and lactate levels after RRS activation. This finding is not surprising considering that most of these factors, including respiratory and haemodynamic triggers, low pulse oximetry values and high lactate levels are associated with impairment of tissue oxygenation. Shappell et al. (12) also reported that patients who died more likely to have a respiratory or cardiovascular triggers for RRS activation in their study. Hyperkalemia decreases the resting membrane potential of the myocardium, thereby myocardial cell conduction velocity decreases and rate of repolarization increases (13). McMahon et al. (14) demonstrated that potassium level is robustly associated with mortality risk even at moderate increases above normal. This is the most possible explanation for potassium-mortality association.

Cancer and its treatment usually lead to diminished physiological reserve (15). Almost one third of our study

Table 2. Univariate and multivariate analysis of risk factors for mortality after RRS activation				
	Univariate analysis of mortality		Multivariate logistic regression analysis of mortality	
	OR (95% CI)	p	OR (95% CI)	p
Activation time of RRS				
- Daytime hours - Nighttime and weekend hours	6.25 (4.17-9.37)	**<0.001**	2.91 (1.52-5.88)	**0.002**
Trigger for RRS				
- Respiratory deterioration	4.01 (2.5-6.4)	**<0.001**	31.12 (11.88-81.51)	**<0.001**
- Haemodynamic deterioration	17.64 (11.0-28.2)	**<0.001**	43.02 (17.65-104.83)	**<0.001**
Sex				
- Male - Female	0.58 (0.40-0.84)	**0.004**	-	-
Age (years)	1.04 (1.03-1.06)	**<0.001**	-	-
Reason for hospital admission				
- Cardiovascular	1.51 (1.003-2.28)	**0.040**	2.08 (0.79-5.52)	0.140
- Respiratory	2.02 (1.13-3.61)	**0.016**	2.67 (0.84-8.54)	0.098
- Oncologic	3.03 (2.06-4.45)	**<0.001**	6.29 (2.34-16.9)	**<0.001**
Pulse (bpm)	0.98 (0.98-0.99)	**<0.001**		
<40	0.14 (0.09-0.21)	**<0.001**		
MAP (mmHg)				
<65	0.98 (0.98-0.98)	**<0.001**		
≥65	0.23 (0.15-0.35)	**<0.001**		
SpO_2 (%)				
≥90	0.98 (0.96-0.98)	**<0.001**	0.99 (0.98-0.10)	**0.002**
<90	10.00 (6.44-15.70)	**<0.001**		
Comorbities				
Respiratory	3.08 (1.25-7.58)	**0.01**	4.49 (0.92-21.85)	0.063
Multiple	2.8 (1.85-4.2)	**<0.001**	1.96 (0.97-4.02)	0.060
Initial rhythm				
- Asystole	6.3 (4.1-9.5)	**<0.001**	0.46 (0.18-1.17)	0.102
- PEA	0.6 (0.3-1.0)	**<0.001**		
Blood gas parameters				
- K	2.46 (2.01-3.02)	**<0.001**	1.95 (1.42-2.67)	**<0.001**
- Lactate	1.19 (1.11-1.27)	**<0.001**	1.33 (1.18-1.50)	**<0.001**
Hemogram parameters				
- Lymphocyte	0.83 (0.71-0.97)	**0.020**	1.02 (1.00-1.03)	0.440
- NLR	1.02 (1.01-1.03)	**<0.001**		
- RDW	1.17 (1.09-1.26)	**<0.001**		
- PDW	1.01 (1.01-1.03)	**0.02**		

Values are shown as number (percentage) or mean ± standard deviation (median; minimum-maximum). Significant values marked in bold. RRS: Rapid response system, OR: odds ratio, CI: confidence interval, MAP: mean arterial pressure, SpO_2: pulse oximetry derived oxygen saturation, RRT: rapid response team, PEA: pulseless electrical activity, NLR: neutrophil-to-lymphocyte ratio, RDW: red cell distribution width, PDW: platelet distribution width

population was cancer patients and 53.7% of these patients did not survive after RRS activation. This result is in line with previous two studies suggesting that cancer patients have worse outcomes following in-hospital cardiac arrest and hematologic oncology patients for whom the RRS was activated have high rates of subsequent ICU admission and mortality.

Interestingly, our results indicate that a MAP did not predict mortality whereas pulse oximetry did. Although MAP is commonly used as a surrogate of organ perfusion (16); it provides a reasonable estimate of the adequacy of organ perfusion as long as venous pressure and vascular resistance remains constant (17,18). Therefore a target of keeping MAP ≥65 mmHg should be individualized based on comorbidities (16). Besides this; it is known that peripheral circulation is the first to reflect a disturbance of the microcirculation and pulse oximeters generally have been shown to be accurate incritically ill patients (19,20). Ebmeier et al. (21) reported that there was no overall statistically significant bias in paired SpO_2/SaO_2 measurements in critically ill patients. Therefore we think that macrohemodynamic parameters like MAP and heart rate (as a determinant of cardiac output) may be less predictive of mortality than SpO_2 which provides a measure of microvascular oxygenation, especially if they are evaluated with cut off points.

To our knowledge, this is the first study to demonstrate the predictive value of NLR in patients receiving RRS activation. NLR is a helpful biomarker associated with the severity and prognosis of many conditions including cardiovascular diseases, certain types of cancers and sepsis (22). It is inexpensive, easily accessible and can be used for assessing the systemic inflammatory state as well as physiological stress (23).

It is obvious that ICU resources are scarce and costly. Therefore triage decisions during RRT activations should also give priority for patients with greater benefit (24). Patients who are less likely to survive or likely to have morbidity if not admitted to the ICU should be preffered (25). Furthermore some patients can benefit from "comfort care only" orders which should be discussed with patients and/or families. Our results provide more evidence for appropriate and quick triage decisions since most of the factors we found to predict mortality can be simply assessed at bedside using patients' charts and blood gas analysis. On the other hand; NLR is calculated from a complete blood count test and can be obtained in a short period of time. We think that it can be used for appropriateness of triage decisions as well as avoiding futile interventions at the end of life.

There are several limitations of this study. First, this was a retrospective observational study and has the limitations inherent in this study design. Second the sample size was relatively small compared to other published studies (12,26,27). On the other hand, we analyzed some predictive factors of mortality in the first hour after RRS activation, which may be the most important but not the only ones. Other factors that affect prognosis, but may appear in the following hours and days, were not analyzed.

Conclusion

In conclusion, we found that the most important mortality risk factors in patients for whom the RRS was activated were presence of respiratory or haemodynamic triggers, activation of RRS during NWH, oncologic reasons for hospital admission, low SpO_2 values, high NLR, potassium and lactate levels. Since our findings demonstrate some weakness in the current RRS of our hospital; overnight staff, both in RRT and hospital wards, should be trained and empowered. Besides this; SpO_2, potassium and lactate levels can guide triage decisions which is usually a challenging and stressful duty. We also found NLR as a predictive of mortality that may help to reevaluate the appropriateness of these decisions.

Ethics

Ethics Committee Approval: The study protocol was reviewed and approved by the Ankara City Hospital Ethics Committee (IRB number: 72300690-799, date: 29.07.2019).

Informed Consent: Personal informed consent was not required.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: B.T., Ç.B.D., İ.M., D.A., Concept: B.T., Design: B.T., Data Collection and Process: B.T., M.C., Ç.B.D., Analysis or Interpretation: B.T., İ.M., Literature Search: B.T., M.C., Writing: B.T.

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