Research Article / Araştırma Makalesi

Clinical Assessment of Perfusion Index in Patients Presenting to the Emergency Department with Non-ST-segment Elevation Myocardial Infarction and Unstable Angina Pectoris

Acil Servise ST Segment Elevasyonlu Olmayan Miyokard Enfarktüsü ve Kararsız Angina Pektoris ile Başvuran Hastalarda Perfüzyon İndeksinin Klinik Değerlendirmesi

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Abstract

Background: We aimed to evaluate the perfusion index (PI) level at the 10th minute of admission to the emergency department in patients with non-ST-segment elevation myocardial infarction (NSTEMI) and unstable angina pectoris (USAP). In addition, we aimed to evaluate whether PI is useful in differentiating NSTEMI and USAP patients in the emergency department in the early stage.
Materials and Methods: Eighty NSTEMI (Group 1) and 50 USAP (Group 2) patients who were consecutively admitted to our emergency department between November 2017 and May 2019 and diagnosed with acute coronary syndrome were included in the study. In both patient groups, PI measured with the Massimo-SET Root 7362A RDS7 non-invasive pulse oximetry probe and other routine laboratory measurements were measured and compared.
Results: The mean PI was significantly lower in NSTEMI patients (p <0.001). At 30-day patient follow-up, the PI of the reduce was significantly lower (P <0.001). The area under the curve was significantly lower for PI in NSTEMI patients (area under the curve 0.313, p = 0.016). At 30-day patient follow-up, the level of PI was significantly lower in the died patients than the survived patients (P <0.001). The area under the curve was significantly lower for PI in NSTEMI patients (area under the curve 0.313, p = 0.016).
Conclusions: Although our study shows that PI may be an early marker in the distinguish of NSTEMI and USAP patients and may be useful in predicting the mortality of these patients, more extensive studies will support our hypothesis.

Key Words: Perfusion Index, Non ST segment elevation myocardial infarction , Unstable angina pectoris

ÖZ.

Amaç: segmenti yükselmesi olmayan miyokard infarktüsü (NSTEMI) ve kararsız anjina pektoris **(**USAP) hastalarında, acil servise başvurularının 10. dakikasında perfüzyon indeksi (PI) düzeyini değerlendirmeyi amaçladık. Ayrıca, acil serviste NSTEMI ve USAP hastalarını erken safhada ayırt etmede PI'nın bir faydalı olup olmadığını değerlendirmeyi amaçladık.
Materyal ve Metod: Kasım 2017- Mayıs 2019 tarihleri arasında acil servisimize ardışık olarak başvuran, akut koroner sendromu tanısı alan 80 NSTEMI (Grup 1) ve 50 USAP hastası (Grup 2) çalışmaya dahil edildi. Her iki hasta grubunda, Massimo-SET Root 7362A RDS7 non invazif pulse oksimetri cihazı probu yardımı ile ölçülen PI ve diğer rutin laboratuvar ölçüldü ve karşılaştırma yapıldı.
Bulgular: NSTEMI hastalarında PI ortalaması belirgin olarak düşük idi (p<0.001). 30 günlük hasta takibinde, ölen hastalarda PI seviyesi hayatta kalan hastalara göre anlamlı olarak daha düşüktü (P <0.001). Eğri altındaki alan, NSTEMI hastalarında PI için önemli ölçüde daha düşüktü (eğri altındaki alan 0.313, p = 0.016).
Sonuç: Çalışmamız, PI'nin NSTEMI ve USAP hastalarının ayırt edilmesinde erken bir belirteç olabileceğini ve bu hastaların mortalitesini tahmin etmede faydalı olabileceğini gösterse de daha kapsamlı çalışmalar hipotezimizi destekleyecektir.

Anahtar kelimeler: Perfüzyon İndeksinin,ST segmenti yükselmesi olmayan miyokard infarktüsü, Kararsız anjina pektoris, Acil Servis

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Introduction

The clinical spectrum of non-ST-elevation acute coronary syndrome (ACS) includes patients with cardiomyocyte necrosis or biochemical evidence of non-ST-segment myocardial infarction (NSTEMI) and unstable angina patients without cardiomyocyte necrosis. The clinical representation of these syndromes can range from asymptomatic patients at presentation to individuals with ongoing ischemia, electrical or hemodynamic instability, and those who need urgent revascularization (1). In the studies, it has been reported that high-sensitivity cardiac troponin (hsTn**)** is useful in excluding acute myocardial infarction (AMI) with high confidence and without the need for additional testing. However, a reliable test result around 60 minutes can be considered as a disadvantage. The pathological mechanism in acute STEMI is coronary artery total occlusion. The pathological mechanism for acute NSTEMI and unstable angina pectoris (USAP) may be incomplete occlusion of the coronary artery. The sudden onset and rapid development of acute coronary syndrome can lead to life-threatening conditions at any time. Therefore, early detection and diagnosis is critical for patients with ACS (2).

Studies conducted in recent years suggest that the perfusion index (PI) is an auxiliary method to evaluate the perfusion status in adults and to determine the severity of the disease (3,4).

PI, which is an indirect and non-invasive measurement, is the evaluation of arterial pulsatile power in a specific area (hand, finger, foot). It is calculated by pulse oximetry by calculating the percentage of the pulsatile signal. In the literature, we did not find any record of a relationship between PI, a noninvasive method that measures microcirculation, and cardiovascular death. We thought that IP could be useful in differentiating between NSTEMI and USAP and predicting the prognosis, which are easy to use and give rapid results. Thus, we aimed to evaluate the PI level of NSTEMI and USAP patients when they admitted to emergency department (ED), and also to evaluate whether there is an early prediction in the differentiation of NSTEMI and USAP patients.

Materials and Methods

The study was designed as a observational and prospective study. The study approved by the Diyarbakır Gazi Yaşargil Training and Research Hospital Ethics Committee (approval date: 29/09/2017 number: 83),

Study Population: Between November 2017 and May 2019, 130 patients with acute coronary syndrome,80 patients with NSTEMI (Group 1) and 50 patients with USAP (Group 2), consecutively admitted to the ED were included in the study. Most of the patients had symptoms, typical chest pain, as well as the equivalent ischemic symptoms suggestive of ACS such as shortness of breath, nausea, vomiting, jaw pain, arm pain, and some participants. Cases were selected from patients who were brought to the ED consecutively and diagnosed as a result of anamnesis, electrocardiography (ECG), troponin and ECHO.

The exclusion criteria of the participants in the study were determined as follows: 1. STEMI patients, 2. cancer patients, 3. chronic obstructive pulmonary disease, 4. hematological and rheumatic diseases, 5. acute febrile disease, 6. organ transplant or those who take other narcotic drugs, 7. those who take alcohol, cigarettes or other addictive substances.9. Oxygen saturation below 95%.

Patients with a life-threatening condition and requiring immediate invasive treatment were hospitalized. In all participants, ECG was taken and PI was measured in the first 10 minutes. Blood samples of the patients were taken in the first hour. Routine hemogram, biochemistry, CRP and Troponin T tests were studied in the blood samples taken. Patients with confirmed diagnoses were then followed up in the relevant clinics for further treatment and follow-up, while patients with the appropriate criteria were excluded from the study.

Study variables

PI and hs-CRP levels were the primary independent variables. Troponin I and creatine kinase MB fraction (CK-MB) values were recorded and evaluated with ECG in the differentiation of NSTEMI and USAP.

Measurement of Perfusion Index

PI measurement was performed with Massimo-SET Root 7362A RDS7 non-invasive pulse oximetry device saturation probe. Before administering any medication and oxygen therapy, the probe of the device was attached to the distal phalanx of the non-dominant middle finger of the patients, with the hand at heart level. During the procedure, continuous measurement was made with the PI probe by keeping it waiting for 2 minutes.

Masimo Signal Extraction Technology (SET®), the PI measured by Masimo is a numerical value obtained from amplification of the pulsations displayed on the plethysmographic waveform. It is calculated as the ratio of the pulsatile signal to the non-pulsatile signal. Perfusion index values between 0.02 and 20 can be detected by Masimo (5). The Masimo pulse oximetry model focuses on the true arterial signal. The normalized infrared pulsatile signal (IR) and normalized red pulsatile signal (RD) detected in motion states include both the arterial saturation signal and the venous (or non-arterial) motion noise signal. In conventional pulse oximetry systems, low perfusion condition increases the unwanted signal-to-noise ratio and results in pulse oximetry error. The software and hardware features of Masimo SET® are designed to give the best performance in patients with poor perfusion (5).

Other laboratory measurements

In blood samples from both NSTEMI and USAP patients on admission to ED, complete blood count and routine biochemical tests (Aeroset, Abbott, Abbott Park, Illinois, USA),

cardiac markers (CK MB; reference weight 0.18-5 ng/mL and troponin I; reference weight 0.02 0.06 ng/mL) with electrochemilumine scan, Siemens Immulite 2000 instrument] and highly sensitive C-reactive protein (hs-CRP) by (Roche / Hitachi Cobas system, Roche Diagnostics, Germany) was carried out. The blood of all subjects was centrifuged within 10 minutes with 3500 cycles within 10 minutes to study a tube hemogram and another tube to study hs-CRP and other routine biochemistry, within 10-15 minutes after taking the blood from the vein. The precipitate was measured immunoturbidimetrically and results were obtained in approximately 40 minutes. White blood cell count (WBC) was counted by laser scattering using the Cell Dyn Ruby analyzer (range 4-10x109/L) (Abbott Laboratories Diagnostic Division, Abbott Park, IL 60064 USA).

Statistical Analysis

Statistical analysis of the data was performed using SPSS (version 20.0; SPSS Inc., Chicago, IL, USA). The number of cases included in the study was determined by power analysis. A comparison was made between the PI levels of NSTEMI and USAP cases. Under the conditions of α = 0.005 of the standard deviation of the PI with 80% power, and the difference between the two groups, the number of people needed was calculated as 43 for each group. Shapiro–Wilk test was used for normal distribution evaluation. Arithmetic mean±standard deviation was used for continuous variables, frequency and percentage were used for categorical variables. Comparisons of normally distributed numerical variables were made using Student's t test. Categorical variables were analyzed using chi-square or Fisher's exact tests. Receiver operating characteristic (ROC) curve analyzes were performed to evaluate the diagnostic accuracy of PI. The area under the ROC curve was estimated. Specificity and sensitivity values were determined. Tests for hypotheses P values less than 0.05 were considered statistically significant.

Results

As shown in Table 1, of the 130 participants included in the study, 80 (61.5%) had NSTEMI (37 males, 43 females; group 1) and 50 had USAP (21 males and 29 females; group 2). It was similar in terms of gender (p=0.534); the mean age of NSTEMI patients was 67.04.05 years, and USAP patients was 64.36±16.76 (p=0.329).

As seen in Table 2, the mean PI was 4.04±2.46 in NSTEMI patients and 6.24±7.69 in USAP patients (Figure 1). PI level was significantly higher in USAP patients (p<0.001).

In contrast, the hs-CRP level was significantly higher in NSTEMI patients than in USAP patients (20.15±23.50 vs. 10.37±13.67; p= 0.012; Figure 2).

Although WBC and NEU levels were higher in NSTEMI patients, the difference between the groups was not significant (p=0.269 and p=0.170, respectively; Table 2).

Table 1. Average of demographic and laboratory values of NSTEMI and USAP Patients

Parameters	Group 1 (61.5%, n=80) [Mean±SD]	Group 2 (38.5%, n=50) [Mean±SD]	P*
Age (yıl)	67.04±14.05	64.36± 16.76	0.329
SBP (mmHg)	136.99±23.95	131.94± 16.19	0.191
DBP (mmHg)	78.04±12.69	79.88±10.60	0.393
Time (hour)	11.89±15.08	9.78±14.95	0.438
Pulse (beats/min)	84.58± 24.50	83.86±21.65	0.866
BMI (kg/m²)	27.19±1.80	26.68±3.41	0.365
Troponin I(ng/mL)	5.73±7.66	0.24±0,13	<0,001
T.Chol (mg/dL)	188.68±49.44	184.90±42.34	0.821
LDL (mg/dL)	114.64±36.84	108.78±33.08	0.655
HDL (mg/dL)	41.61±13.68	44.03±7.70	0.590
TG (mg/dL)	193.20±125.16	137.33±71.05	0.199
LDH (U/L)	294.91±112.63	289.14±207.98	0.655
HbA1c (%)	10.92±29.88	7.47±1.61	0.717
CL (mmol/ L)	101.26±4.51	101.26±3.68	0.998
Ca (mg/dL)	9.16± 0.63	9.21±0.51	0.653
NA (mEq/L)	139.73±4.04	139.72±3.83	0.998
K (mEq/L)	4.41±0.56	4.46±0.52	0.611
HGB(g/dL)	13.40±2.07	13.77±2.49	0.374
HCT (%)	41.46±5.83	43.98±4.72	0.013
Platelet count	252.78±86.77	254.13±5.84	0.923
MCV (fL)	89.82±6.66	6.66±6.65	0.175
MCH fL(fL)	29.06± 2.66	28.26±28.26	0.443

**Student t test and Chi-square test. ALT- Alanine Aminotransferase, APTT- Active partial thromboplastin time, AST- Aspartate aminotransferase, BMI- Body mass index,Ca- Calcium, CL- Chlorine, DBP-diastolic blood pressure, HCT- Hematocrit,HGB- Hemoglobin, HDL- High-density lipoprotein, Na- Sodium, MCH- Mean corpuscular hemoglobin, MCV- Mean corpuscular volume, SBP- Systolic blood pressure, T.Chol-Total cholesterol, LDL- Low-density lipoprotein, TG- Triglyceride*

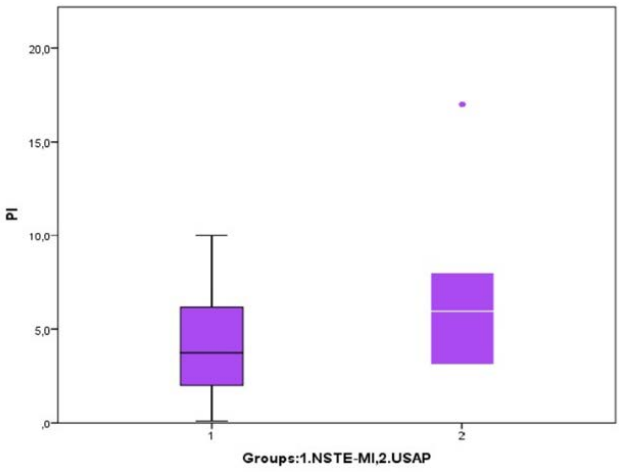

Figure 1. Mean PI in NSTEMI and USAP patients

Table 2. The Mean Hs-CRP, WBC and NEU of NSTEMI and USAP Patients

Parameters	Group 1 (61.5%, n=80) [Mean±SD]	Group 2 (38.5%, n=50) [Mean±SD]	P*
PI	4.04±2.46	6.10±3.31	<0.001
Hs-CRP, mg / L	20.15±23.50	10.37±13.67	0.012
WBC	11.79±3.92	10.95±4.46	0.269
NEU	8.04±3.06	7.16±4.08	0.170

P-Student t test. PI- Perfusion index, Hs-CRP- high sensitivity C-reactive protein, WBC- White blood cells, NEU- Neutrophil*

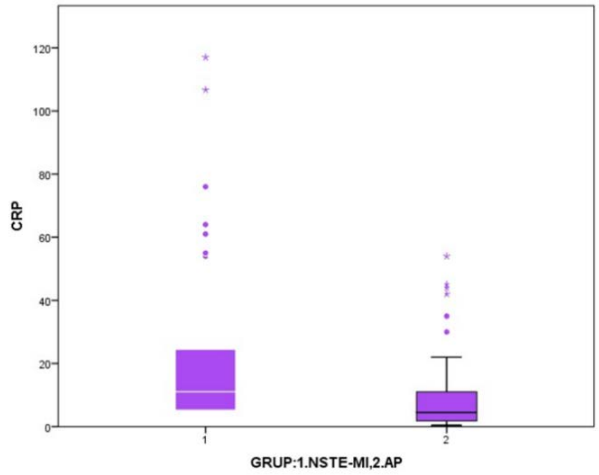

Figure 2. Average hs-CRP level in NSTEMI and USAP patients

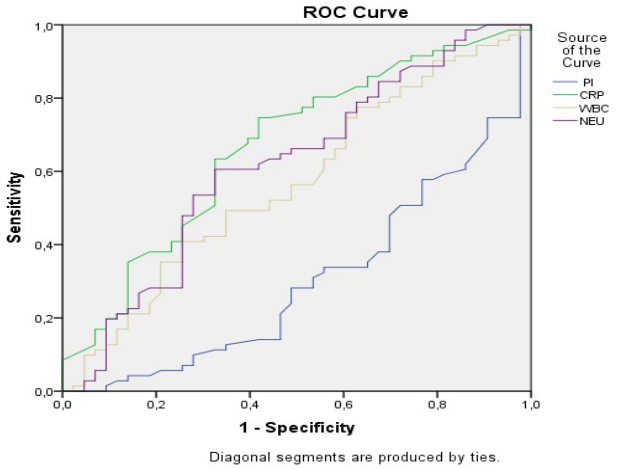

Figure 3. ROC analysis of PI, hs-CRP, WBC and Neutrophil levels

Table 3. The means of Hs-CRP, WBC and NEU in Died and Survive patients

Parameter	Survive patients (92.3%, n=120) [Mean±SD]	Died patients (7.7%, n=10) [Mean±SD]	P*
PI	5,08±2,93	1,83±3.31	<0.001
Hs-CRP (mg / L)	15,82±20,86	22,08±18,96	0.386
WBC (10^3/mm3)	11,40±4,13	12,35±4,33	0.490
NEU (103/mm3)	7,72±3,50	7,75±3,39	0.970

P-Student t test. PI- Perfusion index, Hs-CRP- high sensitivity C-reactive protein, WBC- White blood cells, NEU- Neutrophil*

The 30-day follow-ups were analyzed, and then the data of the patients who died were compared with the data of the patients who did not die (Table 3).

The PI value of the survivors was 5.08±2.93, while the PI value of the dead was 1.83±3.31 and the difference was statistically significant (Figure 3, P <0.001). ROC analyzes of PI, hs-CRP, WBC and Neutrophil levels are shown in Figure 4; The area under the curve was significantly lower for PI in NSTEMI patients (area under the curve 0.313, p=0.016).

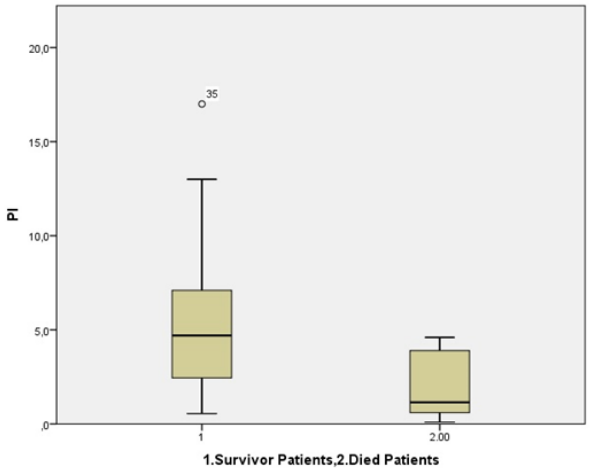

Figure 4. Comparison of the mean PI values of deceased and surviving cases

Discussion

This study revealed that the mean PI values were significantly higher in USAP patients than the mean of NSTEMI patients, whereas the hs-CRP level was significantly higher in NSTEMI patients. In addition, it showed that patients with low PI values significantly increased the risk of death in our study.

Ischemic heart disease (IHD) is the leading cause of death worldwide, and more importantly, the demographics of the condition is changing with the increasing frequency of elderly patients presenting with ACS (6). Among the available clinical biomarkers commonly used in ACS, specifically Cardiac troponin I (cTnI), cardiac troponin T (cTnT), creatine kinase-MB (CK-MB), and myoglobin. Especially hypersensitive troponin I / T are markers of myocardial necrosis with high sensitivity and specificity. However, it has recently been found that troponin I / T levels increase in diseases other than myocardial ischemic necrosis (7-9). Also, effective clinical biomarkers for unstable angina pectoris are still not available. Therefore, new biomarkers, particularly expressive fluorescent, sensitive and stable, are important for patients with ACS (especially USAP).

It is beneficial for clinicians to have an clue about the circulatory status and changes in peripheral perfusion so that they can make more accurate decisions in patient management. The PI value may vary depending on the region where the measurement is made. The best monitoring areas should be selected from those with relatively stable PI (10,11).

It requires the insertion of a light, small probe in only one of the fingers of the patients, and the results are read on the small screen of the device within 1 to 2 minutes. Studies have reported that low perfusion reduces the pulse oximetry performance and leads to a decrease in oxygen saturation values (12). There are limited studies on the PI cut-off value (13). Hummler et al. defined a perfusion index with a cut-off value of less than 2 as low perfusion (12,14). In our study, we measured the PI cut-off value as 2.3 in NSTEMI patients. We are aware that this cut off value is affected by

different situations. For this purpose, measurements were made from all patients under similar conditions as much as possible. Measurements were made from the distal pulp of the middle finger of the non-dominant hand of the patients in the resuscitation room with the same temperature environment. With this understanding, PI measurement was performed at the 10th minute of the patients' arrival.

Cardiovascular diseases are the primary cause of mortality and morbidity not only in the early stage of critical illness but also in a clinical setting. Clinical studies have reported the importance of microcirculation in the early stages of critical diseases (13,14). It has been reported that mortality rates increase in cardiovascular patients with low PI (15). In a study, an increase in PI was observed in patients with AF with rapid rapid ventricular response when rate-limiting therapy was applied (16). In our study, we measured PI for an early clinical prediction in patients with NSTEMI and USAP at admission to ED. The PI value was significantly lower in NSTMI patients than in USAP patients. A low PI rate was associated with an increased risk of death. Cardiac biomarkers cTnI and cTnT are the mainstay in the evaluation of patients with suspected acute coronary syndrome (ACS). However, the disadvantage is that it is relatively expensive and the result is obtained in approximately one hour. The main advantage of PI measurement is that it gives results in a very short time and is cheap.

Our study has many limitations. Our study is single-centered and covers relatively few cases. Another important limiting factor is that we do not have precise data on the use of vasodilator or vasoconstrictor drugs that may affect PI.

Conclusion

Although our study shows that PI may be an early marker in differentiating NSTEMI and USAP patients and may be useful in predicting the mortality of these patients, more comprehensive studies will strengthen our hypothesis. As a result, simple, non-invasive PI measurement in the emergency department can be a useful indicator in differentiating NSTEMI and USAP in a very short time and predicting the risk of death of these patients.

Ethical Approval: *The study approved by the Diyarbakır Gazi Yaşargil Training and Research Hospital Ethics Committee (approval date: 29/09/2017 number: 83)*

Author Contributions:
Concept: MTG,GSG
Literature Review: ÖK
Design : MTG,GSG
Data acquisition: MÖ
Analysis and interpretation: GSG
Writing manuscript: GSG
Critical revision of manuscript: . MTG

Conflict of Interest: *The authors have no conflicts of interest to declare.*

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References

1. Karabulut D, Karabulut U, Erdal GS, Kasapoğlu P,Turhan N, Satılmışoğlu MH,et al. Biyobelirteçler, koroner arter hastalığının şiddetini gösterebilir mi? Cukurova Med J 2021;46(3):883-8.
2. Nanas S, Gerovasili V, Renieris P, Angelopoulos E, Poriazi M, Kritikos K , et al. Non-invasive assessment of the microcirculation in critically ill patients. Anaesth Intensive Care, 2009;37(5):733-9.
3. Benjamin E J, Virani SS, Callaway CW, Chamberlain AM, Chang AR,Cheng S. et al., Heart disease and stroke statistics-2018 update: a report from the American Heart Association, Circulation, 2018: 20;137(12):e67-e492.
4. De Felice C, Latini G, Vacca P, Kopotic RJ. The pulse oximeter perfusion index as a predictor for high illness severity in neonates. Eur J Pediatr. 2002;161(10):561-2.
5. Goldman JM, Petterson MT, Kopotic RJ, Barker SJ. Masimo signal extraction pulse oximetry. Journal of clinical monitoring and computing 2000;16(7):475-83.
6. 6.Chan D, Martin-Ruiz C, Saretzki G, Neely D, Qiu W, Kunadian V. The association of telomere length and telomerase activity with adverse outcomes in older patients with non-ST-elevation acute coronary syndrome. PLoS One 2020:10;15(1):e0227616.
7. Wang L, Ji Y. Noncoding RNAs as Biomarkers for Acute Coronary Syndrome. BioMed Research International. Hindawi BioMed Research International 2020;3;1-11.
8. Finsterer J, Stollberger C, Krugluger W. Cardiac and noncardiac, particularly neuromuscular, disease with troponin-T positivity. The Netherlands Journal of Medicine 2007:65(8);289-95.
9. Røsjø H, Varpula M. Hagve TA, Karlsson S,Ruokonen E,Pettilä V et al. Circulating high sensitivity troponin T in severe sepsis and septic shock: distribution, associated factors, and relation to outcome.Intensive Care Med 2011:37(1):77-85.
10. Enes Celik E, Kavak GO. Evaluation of Brachial Plexus Block With Plethysmographic Variability Index and Perfusion Index. Journal of Harran University Medical Faculty 2021;18(2):170-5.
11. Galvin EM, Niehof S, Verbrugge SJ, et al. Peripheral flow index is a reliable and early indicator of regional block success. Anesth Analg 2006; 103:239–43.
12. Hummler HD, Engelmann A, Pohlandt F, Högel J, Franz AR. Decreased accuracy of pulse oximetry measurements during low perfusion caused by sepsis: Is the perfusion index of any value? Intensive Care Med 2006; 32:1428–31.
13. Louie A, Feiner JR, Bickler PE, Rhodes L, Bernstein M, Lucero J. Four Types of Pulse Oximeters Accurately Detect Hypoxia during Low Perfusion and Motion. Anesthesiology 2018; 128:520-30.
14. De Backer D, Donadello K, Sakr Y, Ospina-Tascon G,Salgado D,Scolletta Set al. Microcirculatory alterations in patients with severe sepsis: impact of time of assessment and relationship with outcome. Crit Care Med 2013; 41:791–9.
15. Okada H, Tanaka M, Yasuda T, Okada Y, Norikae H, Fujita T et al. Decreased microcirculatory function measured by perfusion index is predictive of cardiovascular death. Heart Vessels. Heart and Vessels 2020; 35 (7):930–5.
16. Sürmeli M: Acil servise başvuran hastalarda hızlı ventrikül cevaplı atrial fibrilasyonun perfüzyon indeksi üzerine etkisi. Uzmanlık tezi: Sağlık Bilimleri Üniversitesi, İstanbul Eğitim ve Araştırma Hastanesi, Acil Tıp Kliniği, İstanbul, 2015.