J Surg Med. 2020;4(6):501-504.
DOI: 10.28982/josam.753862

Research article
Araştırma makalesi

Journal of Surgery and Medicine
e-ISSN=2602-2079

Can C-reactive protein to albumin ratio be used as a predictor of amputation development in acute lower extremity ischemia?

C-reaktif protein - albümin oranı akut alt ekstremite iskemisinde amputasyon gelişiminin öngörücüsü olarak kullanılabilir mi?

Burak Erdolu [1], Mesut Engin [2]

[1] University of Health Sciences, Bursa Yuksek Ihtisas Training and Research Hospital, Department of Cardiovasculer Surgery, Mimar Sinan Town. Emniyet Street. Yıldırım, Bursa, Turkey
[2] University of Health Sciences, Mehmet Akif İnan Training and Research Hospital, Department of Cardiovascular Surgery, Karaköprü, Şanlıurfa, Turkey

ORCID ID of the author(s)
BE: 0000-0002-4679-8682
ME: 0000-0003-2418-5823

Corresponding author/Sorumlu yazar:
Mesut Engin
Address/Adres: Mentik Akif İnan Eğitim ve Araştırma Hastanesi, Sağlık Bilimleri Üniversitesi, Esentepe Kasabası, Kalp ve Damar Cerrahisi Kliniği, Ertuğrul Caddesi, Posta kodu: 63200, Karaköprü, Şanlıurfa, Türkiye
e-Mail: mesut_kvc_cor@hotmail.com

Ethics Committee Approval: Bursa Yüksek İhtisas Training and Research Hospital Clinical Research Ethics Committee issued approval with number 2011-KAEK-25 2019/10-09. All procedures in this study involving human participants were performed in accordance with the 1964 Helsinki Declaration and its later amendments.
Etik Kurul Onayı: Bursa Yüksek İhtisas Eğitim ve Araştırma Hastanesi Klinik Araştırmalar Etik Kurulu onayı 2011-KAEK-25 2019/10-09 yayınladı. İnsan katılımcıların katıldığı çalışmalardaki tüm prosedürler, 1964 Helsinki Deklarasyonu ve daha sonra yapılan değişiklikler uyarınca gerçekleştirilmiştir.

Conflict of Interest: No conflict of interest was declared by the authors.
Çıkar Çatışması: Yazarlar çıkar çatışması bildirmemişlerdir.

Financial Disclosure: The authors declared that this study has received no financial support.
Finansal Destek: Yazarlar bu çalışma için finansal destek almadıklarını beyan etmişlerdir.

Published: 6/30/2020
Yayın Tarihi: 30.06.2020

Abstract

Aim: Acute lower limb ischemia is a cardiovascular emergency that occurs due to embolic and thrombotic causes. Inflammatory biomarkers obtained from routine blood parameters have been used in the diagnosis and progression of many cardiovascular diseases. In this study, we aimed to reveal the predictive value of C reactive protein to albumin ratio (CAR) in predicting limb loss, which is a significantly morbid result of thromboembolectomy.

Methods: Patients who were admitted to our clinic with acute lower extremity ischemia between March 15, 2015-March 15, 2018 and who underwent thromboembolectomy were included in this retrospective cohort study. The patients in which no extremity amputation was performed after the surgery were included in Group 1 and those in which amputation was performed in the early post-operative period (in-hospital) were included in Group 2. Multivariate logistic regression analysis was utilized to predict parameters supporting amputation in patients with lower extremity thromboembolism.

Results: There were 207 patients in Group 1 and 32 in Group 2. Amputation was performed above the knee in 5 patients (15.6%), below the knee in 23 patients (71.8%) and below the ankle in 4 patients (12.5%) in Group 2. The mean age of patients in Groups 1 and 2 were 58.7 (9.8) years and 68.3 (10.3) years, respectively (P<0.001). In the regression analysis, advanced age (OR: 1.045, CI 95%: 1.004-2.144, P=0.011), CAR (OR: 1.679, CI 95%: 1.224-3.794, P=0.005) and hospital admission time (OR: 1.054, CI 95%: 1.010-1.458, P=0.022) were determined as independent predictors for amputation.

Conclusion: The CAR value obtained from routine blood parameters obtained before the procedure may be a good predictor of amputation risk.

Keywords: Inflammation, Amputation, Embolectomy, Lower extremity

Öz

Amaç: Akut alt ekstremite iskemisi embolik ve trombotik nedenlerden dolayı ortaya çıkan kardiyovasküler acil bir durumdur. Rutin kan parametrelerinden elde edilen inflamatuar biyobelirteçler birçok kardiyovasküler hastalığın tanısında ve progresyonunda kullanılmıştır. Bu çalışmada, tromboembolektominin önemli bir morbid sonucu olan ekstremite kaybının öngörülmesinde C reaktif proteinin albümin oranının (CAR) prediktif değerini ortaya koymayı amaçladık.

Yöntemler: Kliniğimize akut alt ekstremite iskemi durumu olan 15 Mart 2015-15 Mart 2018 tarihleri arasında başvuran ve tromboembolektomi uygulanan hastalar bu retrospektif kohort çalışmasına dahil edildi. Ameliyat sonrası ekstremite amputasyonu yapılmayan hastalar Grup 1, ameliyat sonrası erken dönemde (hasteneiçi) amputasyon yapılan hastalar Grup 2 olarak kaydedildi.

Bulgular: Hastaların 207'si Grup 1'e, 32'si Grup 2'ye dahil edildi. 5 hastada (%15,6) diz üstünde, 23 hastada (%71,8) diz altında ve 4 hastada (%12,5) ayak bileği altında amputasyon yapıldı. Grup 1'deki hastaların ortalama yaşı 58,7 (9,8) iken, Grup 2'deki hastalar 68,3 (10,3) idi (P<0,001). Alt ekstremite tromboembolizmi olan hastalarda amputasyonu destekleyen parametreleri tahmin etmek için çok değişkenli lojistik regresyon analizi kullanıldı. Bu değerlendirmede, ileri yaş (OR: 1,045, CI% 95: 1,004-2,144, P=0,011), CAR (OR: 1,679, CI %95: 1,224-3,794, P=0,005) ve hastaneye başvuru zamanı (OR: 1,054, CI %95: 1,010-1,458, P=0,022) amputasyonu göstermek için bağımsız prediktörler olarak belirlendi.

Sonuç: Sonuç olarak, işlemden önce alınan rutin kan parametrelerinden elde edilen CAR değeri amputasyon riskinin iyi bir prediktörü olabilir.

Anahtar kelimeler: Enflamasyon, Amputasyon, Embolektomi, Alt ekstremite

How to cite/Atıf için: Erdolu B, Engin M. Can C-reactive protein to albumin ratio be used as a predictor of amputation development in acute lower extremity ischemia? J Surg Med. 2020;4(6):501-504.

Introduction

Acute lower limb ischemia is a cardiovascular emergency that occurs due to embolic and thrombotic causes [1]. Surgery or endovascular intervention should be planned as soon as these patients are diagnosed. Despite advances in endovascular methods, surgical thromboembolectomy remains the gold standard. If not intervened on time as necessary, undesirable results such as limb loss, renal failure and mortality may occur [2]. Loss of extremity is a significant problem because it extends hospital stay, causes loss of workforce and psychosocial problems, thus increases treatment costs.

Inflammatory biomarkers obtained from routine blood parameters have been used in the diagnosis and progression of many cardiovascular diseases [3,4]. One of the most important among these, C reactive protein (CRP), is a nonspecific acute phase reactant synthesized in the liver. Studies have shown that CRP value may be effective in the progression of vascular diseases [5,6]. Albumin is an important compound for humans, and low albumin has poor prognostic importance for cardiovascular diseases [7]. Therefore, the value of CRP to albumin ratio (CAR) is considered an important parameter. Its predictive value has been shown in cardiovascular diseases [8,9].

In this study, we aimed to reveal the predictive value of CAR in predicting limb loss, a significant morbid result of thromboembolectomy.

Materials and methods

Patients who were admitted to our clinic with acute lower extremity ischemia between March 15, 2015 and March 15, 2018 and who underwent thromboembolectomy were included in this retrospective study, which began after approval was granted by Bursa Yüksek İhtisas Training and Research Hospital Clinical Research Ethics Committee (Approval No: 2011-KAEK-25 2019/10-09). The data of the patients were accessed from the hospital registry system and patient files. Demographic data, pre- and perioperative features of the patients were recorded. Patients who previously had peripheral vascular surgery or intervention, patients with malignancy, those with hematological or inflammatory diseases, patients with vasculitis, liver disease, irreversible tissue loss at the time of admission, and those with active infection were excluded. After the implementation of exclusion criteria, 239 consecutive patients were included in the study. Hospital admission time was defined as the time from the occurrence of the first symptoms to admission to the hospital. Amputation decision was taken together with the Department of Orthopedics in patients with standing ischemia, in whom demarcation line occurred following surgical interventions. Patients in which no extremity amputation was performed after the surgery were included in Group 1 and those who underwent amputation in the early post-operative period (in-hospital) were included in Group 2.

Diagnosis of acute lower extremity ischemia and surgical thromboembolectomy technique

Detailed anamnesis was obtained from all patients and physical examinations were performed. Clinical diagnoses were supported by Doppler ultrasonography. Angiography was performed in patients with extensive atherosclerotic disease. All operations were performed urgently under local anesthesia and mild sedation. After the incision was made in the femoral region, superficial femoral, main femoral and deep femoral artery were rotated and suspended by rotating with vascular loops. 100U / kg iv heparin was administered before vascular clamps were placed. Then, embolectomy was performed with a Fogarty (3F-7F) catheter. After sufficient backflow was provided, arteriotomy was repaired. After the operation, patients were followed up in intensive care unit for at least one day and given heparin infusion on the first day after the operation. Later, low molecular weight heparin was introduced. Thromboembolism etiology was investigated peroperatively with echocardiography and abdominal ultrasonography. Discharge medical treatments were arranged according to the etiology of thromboembolism.

Evaluation of blood parameters

Blood samples of all patients were obtained from peripheral veins after hospitalization. Hematological and biochemical evaluations were performed with an automatic analyzer. CAR was calculated as follows:

CAR= (C reactive protein level(g/dL)/Albumin level(mg/dL))

Statistical analysis

Statistical analysis was performed with SPSS 21.0 (IBM Statistical Package for the Social Sciences Statistic Inc. version 21.0, Chicago, IL, USA) program. Student's t-test was used for numerical values with normal distribution, and Mann-Whitney U test was utilized for numerical data without normal distribution. Numerical values were expressed as mean (standard deviation) or mean and interquartile range. Chi-square test was used to compare categorical variables. $P<0.05$ was considered statistically significant. Multivariate logistic regression analysis was utilized to evaluate significant parameters in the univariate analysis for predicting amputation. Receiver Operating Characteristic (ROC) analysis was performed to evaluate the predictive value of CAR for amputation and the area under the curve (AUC) was calculated.

Results

There were 207 and 32 patients in Groups 1 and 2, respectively. Amputation was performed above the knee in 5 patients (15.6%), below the knee in 23 patients (71.8%) and below the ankle in 4 patients (12.5%) in Group 2. The mean ages of patients in Groups 1 and 2 were 58.7 (9.8) years and 68.3 (10.3) years, respectively. The mean age of Group 2 was statistically significantly higher compared to Group 1 ($P<0.001$). There was no statistically significant difference between the groups in terms of gender, smoking, diabetes mellitus, chronic obstructive pulmonary disease, coronary artery disease, hypertension and hyperlipidemia rates ($P>0.05$ for all). Peripheral arterial disease rates and hospital admission times were significantly higher in Group 2 ($P=0.012$, $P<0.001$, respectively) (Table 1).

Laboratory values of the patients are presented in Table 2. There was no difference between the groups in terms of hematocrit, platelet, white blood cell, neutrophil, lymphocyte, total protein, albumin, urea and creatinine values ($P>0.05$ for all). C-reactive protein (CRP), NLR and CAR values were

significantly higher in Group 2 (P=0.002, P=0.018, P<0.001, respectively).

Multivariate logistic regression analysis was utilized to predict parameters supporting amputation in patients with lower extremity thromboembolism (Table 3). Advanced age (OR: 1.045, CI 95%: 1.004-2.144, P=0.011), CAR (OR: 1.679, CI 95%: 1.224-3.794, P=0.005) and hospital admission time (OR: 1.054, CI 95%: 1.010-1.458, P=0.022) were determined as independent predictors for amputation.

ROC analysis revealed that the cut-off value for CAR was 3.81 (AUC=0.747, 95%CI:0.638-0.857, P<0.001, 76.9% sensitivity, 56.7% specificity) (Figure 1).

Table 1: Demographic properties of the patients

Variables		Group 1 (n=207)	Group 2 (n=32)	*P*-value
Age(years) (mean(sd))		58.7 (9.8)	68.3 (10.3)	<0.001†
Male gender, n(%)		109 (52.6%)	21 (65.6%)	0.182*
Hyperlipidemia, n(%)		63 (30.4%)	11 (34.3%)	*0.654**
Hypertension, n (%)		95 (45.8%)	17 (53.1%)	0.527*
Diabetes mellitus, n (%)		33 (15.9%)	8 (25%)	0.206*
Smoking, n (%)		48 (23.1%)	9 (28.1%)	0.696*
COPD, n(%)		26 (12.5%)	16(18.7%)	0.596*
CAD, n(%)		74 (35.7%)	14 (43.7%)	0.446*
PAD, n(%)		33 (15.9%)	12 (37.5%)	*0.012**
Atrial Fibrillation, n(%)		89 (42.9%)	17 (53.1%)	*0.378**
Hospital admission time, hours		2 (1-12)	4 (1-72)	*<0.001*
Location of occlusion	İliofemoral, n(%)	88 (42.5%)	11 (34.3%)	0.279*
	Femoropopliteal, n(%)	119 (57.4%)	21 (65.6%)	0.218*

†Student's t test, *Chi-square test, COPD: Chronic obstructive pulmonary disease, CAD: Coronary artery disease, PAD: Peripheral arterial disease

Table 2: Preoperative laboratory values of the patients

Variables	Group 1 (n=207)	Group 2 (n=32)	*P*-value[m]
White blood Cell (10^3/μL)	9.1 (6.2- 15.9)	9.7 (5.4- 16.2)	0.118
Hematocrit (%)	41.8 (33.4- 53.7)	39.7 (34.3- 54)	0.289
Platelet (10^3/μL)	243.3 (156- 494)	244 (139- 455)	0.412
Neutrophil (10^3/μL)	5.1 (2.2- 11)	5.4 (2.6- 12.3)	0.094
Lymphocyte(10^3/μL)	2.1 (0.8- 4.3)	1.5 (0.7- 3.2)	0.102
Total protein (g/dL)	6.8 (5.5-8.5)	6.4 (5.5-8.2)	0.154
Albumin (g/dL)	3.6 (3.4-5.5)	3.4(3 - 5.4)	0.094
Urea (mg/dL)	18 (12- 46)	16 (18- 42)	0.377
Creatinine (mg/dL)	1.2 (0.7- 2.4)	1.2 (0.8- 2.2)	0.228
C Reactive protein (mg/dL)	8.5 (5.5- 13.6)	13.9(6.8- 21.8)	0.002
NLR	3.7 (2.1-8.8)	4.2 (2.8-9.1)	0.018
CAR	2.47 (1.3-4.6)	4.34 (2.3-6.2)	<0.001

[m] Mann Whitney U test (Data is expressed as median (interquartile range)) CAR: C reactive protein to albumin ratio

Table 3: Multivariate logistic regression analysis to identify factors affecting amputation rate in patients with femoral thromboembolism

Variables	*P* value	Exp(B) Odds Ratio	95% C.I. Lower-Upper
Age	0.011	1.045	1.004-2.144
PAD	0.109	0.789	0.556- 1.194
NLR	0.085	1.078	0.867- 1.496
CAR	0.005	1.679	1.224- 3.794
Hospital admission time	0.022	1.054	1.010-1.458

CAR: C reactive protein to albumin ratio, NLR: Neutrophil to lymphocyte ratio, PAD: Peripheral arterial disease

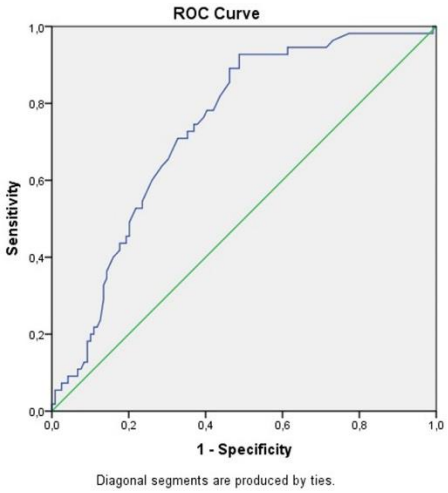

Figure 1: Receiver operation characteristic (ROC) curve and area under the curve (AUC) for C reactive protein to albumin ratio (cut-off=3.81, AUC: 0.747, 95% CI: 0.638- 0.857, P<0.001, 76.9% sensitivity, 56.7% specificity)

Discussion

Acute lower limb thromboembolism is an important clinical condition that requires immediate intervention. Acute arterial occlusion is the most common cause among all acute lower limb ischemia with a rate of about 35%. This clinical situation is due to embolization from an embolic focus or thrombosis due to atherosclerotic plaque rupture [10]. One of the most feared consequences of this disease is limb loss. With this current study, we have revealed that the CAR value obtained from the blood samples taken at the time of admission is an independent predictor in predicting amputation.

The relationship between inflammation and pathogenesis and progression of diseases has been the subject of research in many medical fields. Atherosclerosis, the cause of most cardiovascular diseases, is closely related to chronic inflammation. Endothelial dysfunction occurs with muscle proliferation in the vascular structure and the formation of fibrous plaque structures. These plaque structures contain leukocytes and are activated by interleukin 1 and tumor necrosis factor. These inflammatory pathways play an active role in the development of rupture, especially in plaque structures [11,12].

C reactive protein is an acute phase reactant, a good indicator of systemic inflammatory response. Studies have shown that CRP is effective in the development of atherosclerosis [13]. In addition, it has been demonstrated that high CRP values play an effective role in the deterioration of the stable structure in the atherosclerotic plaque [14,15]. CRP shows these effects by disrupting fibrinolysis, increasing collagen degradation in monocytes and activating the complement system [15]

Albumin has important effects on anti-inflammatory, antioxidant, anticoagulation systems and osmotic pressure in the human body [7]. Decreased serum albumin levels have been shown to increase mortality and morbidity in cardiovascular diseases [16,17]. In a study on patients with acute coronary syndrome, low albumin was found to be associated with extensiveness of coronary artery disease and in-hospital mortality [18]. In addition, low levels of albumin are associated with increased blood viscosity, impaired endothelial functions, increased platelet activation and aggregation [19,20]. All these factors also increase cardiovascular mortality and morbidity.

When all these effects of low albumin and CRP are revealed, CAR emerges as a valuable predictor for cardiovascular system diseases. In the study of Karabag et al. [21] which included 1217 ST-elevation myocardial infarction patients, the predictive value of inflammatory parameters was investigated in predicting the development of no-reflow after percutaneous intervention. The authors found that CAR value was more predictive of no-reflow than NLR, albumin and CRP values. The relationship between the severity of coronary artery disease and CAR in patients with acute coronary syndrome was investigated by Cagdas et al. [22] on 344 consecutive patients, and a significant relationship between CAR values and angiographic severity of coronary artery disease was observed by the authors. In another study, it was found that the CAR value has a poor prognostic value in patients admitted to hospitals with acute medical problems [23]. In our study, we revealed that there is a significant relationship between the development of

amputation, which is a catastrophic result of surgical thromboembolectomy, and CAR.

In the study conducted by Saskın et al. [24], the place of inflammatory parameters was investigated in predicting amputation after thromboembolism operations (Lower and upper extremities). 123 patients were included in the study and preoperative mean platelet volume and CRP values were determined as independent predictors of amputation. In addition, a positive correlation was found between NLR value and amputation risk. Similarly, in our study, although we found a significant correlation between NLR value and amputation, NLR was not an independent predictor in multivariate analysis. Unlike this study, our study included more patients and consisted only of patients with lower extremity thromboembolism.

In our study, we determined that advanced age and the length of time from the first complaint until admission to the hospital were independent predictors for amputation in addition to the CAR value. Prolonged ischemia time increases tissue damage after reperfusion, thereby increasing the risk of amputation. Advanced age is a bad prognostic factor in many cardiovascular diseases. Patients who developed acute lower extremity ischemia were divided into two groups as those under 80 years of age (41 patients) and over (24 patients) by Kubat et al. [25] and compared in terms of results. Although amputation rates were higher in patients over 80 years of age after the surgeries, there was no statistically significant difference. However, the small number of patients may have been effective in this statistical result.

Limitations

The most important limitations of our study are its retrospective and single-center design. In addition, because our study was retrospective, we may have missed possible hereditary hypercoagulation diseases. Our study needs to be supported by multicenter prospective studies.

Conclusion

Acute lower extremity ischemia is an emergency cardiovascular condition that can have mortal and morbid consequences. Surgical thromboembolectomy remains the gold standard treatment method. In these patients, the CAR value obtained from routine blood parameters obtained before the procedure may be a good predictor of the risk of amputation.

References

1. Vemulapalli S, Patel MR, Jones WS. Limb ischemia: cardiovascular diagnosis and management from head to toe. Curr Cardiol Rep. 2015;17:611.
2. Aldağ M, Öztekin A, Bademci MŞ, Kocaaslan C, Denli Yalvaç EŞ, Aydın E. Surgical results of acute thromboembolic limb ischemia in octogenarians. Damar Cer Derg. 2018;27(3):111-6.
3. Akgül E, Engin M, Özyazıcıoğlu AF. Effects of mean platelet volume and platelet counts on peripheral biodegradable stent restenosis. J Surg Med. 2019;3(9):663-5.
4. Kaya BB, Özbilgin N. Effect of cardiac rehabilitation on mortality related inflammatory markers. J Surg Med. 2019;3(8):588-92.
5. Moon AR, Choi DH, Jahng SY, Kim BB, Seo HJ, Kim SH, et al. High-sensitivity C-reactive protein and mean platelet volume as predictive values after percutaneous coronary intervention for longterm clinical outcomes: a comparable and additive study. Blood Coagul Fibrinolysis. 2016; 271:70–6.
6. Melander O, Newton-Cheh C, Almgren P, Hedblad B, Berglund G, Engström G, et al. Novel and conventional biomarkers for prediction of incident cardiovascular events in the community. JAMA. 2009;302:49–57.
7. Arques S. Human serum albumin in cardiovascular diseases. Eur J Intern Med. 2018 Jun;52:8-12.
8. Duman H, Cinier G, Bakırcı EM, Duman H, Simsek Z, Hamur H, et al. Relationship between C-reactive protein to albumin ratio and thrombus burden in patients with acute coronary syndrome. Clin Appl Thromb Hemost. 2019;25:1076029618824418.
9. Cınar T, Çagdas M, Rencuzogulları I, Karakoyun S, Karabag Y, Yesin M, et al. Prognostic efficacy of C-reactive protein/albumin ratio in ST elevation myocardial infarction. Scand Cardiovasc J. 2019;53:83–90.
10. Ueberrueck T, Marusch F, Schmidt H, Gastinger I. Risk factors and management of arterial emboli of the upper and lower extremities. J Cardiovasc Surg. 2007;48:181–6.
11. Davi G and Patrono C. Platelet activation and atherothrombosis. N Engl J Med. 2007;357:2482–94.
12. Mallika V, Goswami B, Rajappa M. Atherosclerosis pathophysiology and the role of novel risk factors: a clinicobiochemical perspective. Angiology. 2007;58:513–22.
13. Khera A, De Lemos JA, Peshock RM, Lo HS, Staneg HG, Murphy SA, et al. Relationship between C-reactive protein and subclinical atherosclerosis: the Dallas Heart Study. Circulation. 2006;113(1):38-43.
14. Pant S, Deshmukh A, Gurumurthy GS, Pothineni NV, Watts TE, Romeo F, et al. Inflammation and atherosclerosis—revisited. J Cardiovasc Pharmacol Ther. 2013;19(2):170-8.
15. Bisoendial RJ, Boekholdt SM, Vergeer M, Stroes ESG, Kastelein JJP. C-reactive protein is a mediator of cardiovascular disease. Eur Heart J. 2010;31(17):2087-91.
16. Murat SN, Kurtul A, Yarlioglues M. Impact of serum albumin levels on contrast-induced acute kidney injury in patients with acute coronary syndromes treated with percutaneous coronary intervention. Angiology. 2015;66(8):732-37.
17. Schalk BW, Visser M, Bremmer MA, Penninx BW, Bouter LM, Deeg DJ. Change of serum albumin and risk of cardiovascular disease and all-cause mortality: Longitudinal Aging Study Amsterdam. Am J Epidemiol. 2006;164(10):969-77.
18. Kurtul A, Murat SN, Yarlioglues M, Duran M, Ocek AH, Koseoglu C, et al. Usefulness of serum albumin concentration to predict high coronary SYNTAX score and in-hospital mortality in patients with acute coronary syndrome. Angiology. 2016;67:34-40.
19. Joles JA, Willekes-Koolschijn N, Koomans HA. Hypoalbuminemia causes high blood viscosity by increasing red cell lysophosphatidylcholine. Kidney Int. 1997;52:761-70.
20. Mikhailidis D, Ganotakis E. Plasma albumin and platelet function: relevance to atherogenesis and thrombosis. Platelets. 1996;7:125-37.
21. Karabag Y, Cagdas M, Rencuzogulları I, Karakoyun S, Artac I, Ilis D, et al. Usefulness of The C-Reactive Protein/Albumin Ratio for Predicting No-Reflow in ST-elevation myocardial infarction treated with primary percutaneous coronary intervention. Eur J Clin Invest. 2018;48(6):e12928.
22. Cagdas M, Rencuzogulları I, Karakoyun S, Karabag Y, Yesin M, Artac I, et al. Assessment of Relationship Between C-Reactive Protein to Albumin Ratio and Coronary Artery Disease Severity in Patients With Acute Coronary Syndrome. Angiology. 2019;70(4):361-8.
23. Fairclough E, Cairns E, Hamilton J, Kelly C. Evaluation of a modified early warning system for acute medical admissions and comparison with C-reactive protein/albumin ratio as a predictor of patient outcome. Clin Med (Lond). 2009;9(1):30-3.
24. Saskin H, Ozcan KS, Duzyol C, Baris O, Kocogulları UC. Are inflammatory parameters predictors of amputation in acute arterial occlusions? Vascular. 2017;25(2):170-7.
25. Kubat E, Erol G, Akyol FB, Karabacak K, Kadan M, Doğancı S, et al. Comparison of embolectomy outcomes for acute lower limb ischemia between patients aged ≥80 years and <80 years. Turk J Vasc Surg. 2020;29(2):84-9.

This paper has been checked for language accuracy by JOSAM editors.
The National Library of Medicine (NLM) citation style guide has been used in this paper.