Relationship between TIMI frame count and admission glucose values in acute ST elevation myocardial infarction patients who underwent successful primary percutaneous intervention

Başarılı perkütan koroner girişim uygulanan akut ST yükselmeli miyokart enfarktüslü hastalarda başvuru glikoz düzeyleri ve TIMI kare sayısı arasındaki ilişki

Meltem Ege, Ümit Güray[1], Yeşim Güray[1], Mehmet Birhan Yılmaz[2], Burcu Demirkan[1], Ali Şaşmaz[1], Şule Korkmaz[1]

Cardiology Clinic, Yalova State Hospital, Yalova
[1]Cardiology Clinic, Yüksek Ihtisas Hospital, Ankara
[2]Department of Cardiology, Faculty of Medicine, Cumhuriyet University, Sivas, Turkey

ABSTRACT

Objective: Admission hyperglycemia is associated with poor prognosis in patients with acute myocardial infarction. Final Thrombolysis in Myocardial Infarction (TIMI) frame counts of culprit coronary arteries may show significant variability despite successful coronary reperfusion after primary percutaneous coronary intervention (PCI). In this prospective observational study, relationship between final TIMI frame counts of the culprit coronary artery and admission glucose values was investigated in patients who underwent successful primary PCI due to acute ST-elevation myocardial infarction (STEMI).

Methods: During a 6- month period of time, 73 non-diabetic patients presented with acute STEMI who have undergone primary PCI with final TIMI 3 flow were consecutively included in the study. Patients were divided into two groups according to final TIMI frame counts. Group 1 (n=53) consisted of patients with final TIMI frame counts of the culprit coronary artery within the two standard deviation of predefined values and Group 2 (n=20) consisted of those with higher TIMI frame counts. Statistical analysis was performed using Chi-square, Mann-Whitney U tests and multiple linear regression analysis.

Results: Despite similar fasting glucose values, admission glucose levels were significantly higher in Group 2 as compared to Group 1 (138 [114-165] vs. 123 [97-143] mg/dl, p=0.03). In whole group, admission glucose values were significantly correlated with corrected TIMI frame counts of culprit coronary arteries (r=0.30, p=0.01). In addition, there were significant association between admission glucose values and peak creatine kinase-MB (r=0.36, p=0.007) values as well as left ventricular ejection fraction (r=-0.43, p=0.009). In multiple linear regression analysis, only admission glucose value was found to be significantly related to the final TIMI frame count of the culprit artery (β=0.04, 95% CI: 0.02-0.085, p=0.04).

Conclusion: High admission glucose values were significantly associated with impaired coronary flow even after successful primary PCI in non-diabetic patients with STEMI. *(Anadolu Kardiyol Derg 2011; 11: 213-7)*

Key words: Admission hyperglycemia, acute myocardial infarction, coronary flow, TIMI frame count, multiple linear regression analysis

ÖZET

Amaç: Akut miyokart enfarktüsü ile başvuran hastalarda hiperglisemi olumsuz prognozla ilişkilidir. Primer perkütan koroner girişim (PKG) yapılan hastalarda, enfarkttan sorumlu arterin işlem sonu Miyokart Enfarktüste Trombolizis (TIMI) kare sayıları başarılı reperfüzyona rağmen önemli oranda farklılık gösterebilmektedir. Bu prospektif gözlemsel çalışmada ST yükselmeli miyokart enfarktüsü (STYMİ) sebebi ile başarılı primer PKG uygulanan hastalarda başvuru glikoz değerleri ile işlem sonucunda sorumlu koroner arter TIMI kare sayılarının ilişkisi araştırılmıştır.

Yöntemler: Altı aylık zaman süresi içerisinde, STYMİ ile başvuran ve PKG ile TIMI 3 akım sağlanan ardışık 73 diyabetes mellitusu olmayan hasta çalışmaya dahil edilmiştir. Hastalar TIMI kare sayılarına göre iki gruba bölünmüştür. Grup 1 (n=53), enfarkttan sorumlu koroner arter TIMI kare

Address for Correspondence/Yazışma Adresi: Dr. Ümit Güray, 451. Sokak 42. Cadde İpekyolu konutları 7/23, Çukurambar, 06520 Ankara, Turkey
Phone: +90 312 306 18 38 Fax: +90 312 324 39 83 E-mail: umit.guray@gmail.com

Accepted Date/Kabul Tarihi: 14.09.2010 **Available Online Date/Çevrimiçi Yayın Tarihi:** 21.03.2011

©Telif Hakkı 2011 AVES Yayıncılık Ltd. Şti. - Makale metnine www.anakarder.com web sayfasından ulaşılabilir.
©Copyright 2011 by AVES Yayıncılık Ltd. - Available on-line at www.anakarder.com
doi:10.5152/akd.2011.055

sayıları daha önceden belirlenmiş değerlerin iki standart sapması içine giren hastalardan, Grup 2 (n=20) ise yüksek TIMI kare sayısına sahip hastalardan oluşmuştur. İstatistiksel analiz Ki-kare, Mann-Whitney U testleri ve çoklu doğrusal regresyon analizi ile gerçekleştirildi.
Bulgular: Benzer açlık glikoz değerlerine rağmen, başvuru kan şekeri değerleri Grup 2 hastalarında Grup 1'e göre anlamlı şekilde daha yüksekti (138 [114-165]'e karşılık 123 [97-143] mg/dl, p=0.03). Tüm grupta başvuru glikoz değerleri ile sorumlu koroner arter düzeltilmiş TIMI kare sayısı arasında anlamlı pozitif korelasyon izlendi (r=0.30, p=0.01). Aynı zamanda, başvuru glikoz değeri ile hem zirve kreatin kinaz-MB (r=0.36, p=0.007) hem de sol ventriküler ejeksiyon fraksiyonu arasında anlamlı korelasyon saptandı (r=-0.43, p=0.009). Çoklu lineer regresyon analizinde incelenen parametrelerden (başvuru glikozu, beyaz küre sayısı, zirve kreatin kinaz-MB ve sol ventrikül ejeksiyon fraksiyonu), sadece başvuru glikozu infarkt arterinin nihai TIMI kare sayısı ile ilişkili olduğu saptandı (β=0.04, %95 GA:0.02-0.085, p=0.04).
Sonuç: Yüksek başvuru kan şekeri değerleri, başarılı primer PKG uygulanan diyabetes mellitusu olmayan hastalarda bile işlem sonrası bozulmuş koroner akım ile ilişkilidir. *(Anadolu Kardiyol Derg 2011; 11: 213-7)*
Anahtar kelimeler: Başvuru hiperglisemisi, akut miyokart enfarktüsü, koroner akım, TIMI kare sayısı, çoklu lineer regresyon analizi

Introduction

Acute hyperglycemia is found in up to 50% of patients presented with acute myocardial infarction (AMI) and is associated with a poor prognosis, irrespective of diabetic status (1-4). Although increased risk for congestive heart failure, cardiogenic shock, and death after acute event has been shown in patients with AMI presented with acute hyperglycemia, the mechanism of this association was not clearly understood (5). It is demonstrated that in the setting of coronary artery occlusion, higher blood glucose values may further impair coronary microvascular circulation. Ikawura et al. (6) has found that in patients with ST elevation MI (STEMI) who had undergone primary percutaneous coronary intervention, no-reflow phenomenon was more frequently observed in those who presented with acute hyperglycemia.

In patients with acute STEMI, thrombolysis in myocardial infarction (TIMI) frame counts may show significant variability despite presence of grade 3 TIMI flow after successful reperfusion and lower TIMI frame counts after reperfusion are associated with more favorable prognosis (7). No data are present regarding TIMI frame counts and admission glucose values in non-diabetic patients with acute ST elevation MI who undergo successful primary percutaneous coronary intervention.

Therefore, in the present study, we aimed to investigate relationship between TIMI frame counts of culprit coronary arteries and blood glucose values on admission in non-diabetic patients with ST-elevation AMI who underwent successful reperfusion therapy with a final TIMI grade 3 flow on cineangiography by coronary stenting.

Methods

Patient population

During a 6- month period, of the 105 consecutive patients presented with STEMI within 12 hours of symptom onset, 73 patients without known or new diagnosis of diabetes mellitus (DM) and with final TIMI 3 flow were included in the study. The diagnosis of AMI was based on prolonged chest pain lasting at least 30 minutes, ST-segment elevation ≥2 mm in at least two contiguous electrocardiographic (ECG) leads, and a more than twofold increase in serum creatine kinase –MB (CKMB) levels. The clinical characteristics and the angiographic properties of the patients were evaluated prospectively.

On admission all patients included in the study were treated with aspirin, clopidogrel and unfractionated heparin. Only small fraction of patients included were not treated with glycoprotein IIb/IIIa receptor antagonists (tirofiban) during coronary intervention. In addition to age, clinical history of risk factors such as presence of DM, hypertension, hyperlipidemia and smoking was determined from a patient interview and medical records. Patients with previous diagnosis of DM or patients who were found to have DM during hospital stay were excluded from the study. Also, patients with coronary slow flow (< TIMI 3) or no-reflow phenomenon were not included in the analysis. Patients with final TIMI 3 flow after stenting were divided into two groups according to the corrected TIMI frame count values. Group 1 was composed of patients with TIMI frame count values within the range of two standard deviations of the normal values. Patients in the group 2 had TIMI frame counts that are higher than two standard deviations of the normal values.

Coronary angiography and calculation of TIMI frame count

All patients underwent coronary angiography with standard Judkins technique. Subsequently, balloon angioplasty and stenting or direct stenting were performed for the culprit lesion. Before coronary intervention, all patients had TIMI flow grade 0 or 1 in the culprit artery. For objective evaluation of coronary blood flow, we used TIMI frame count method developed by Gibson et al. (8). In brief, corrected TIMI frame count was calculated as counting the number of angiographic frames elapsed until the contrast material arrived in the pre-specified distal marker of the individual coronary artery. Because of its higher length, corrected TIMI frame count for left anterior descending coronary artery was calculated by dividing the counted value by 1.7. Normal TIMI frame count values are 36.2±2.6, 22.2±4.1, 20.4±3 for left anterior descending artery, left circumflex artery and right coronary artery, respectively (8).

Laboratory analysis

Admission glucose values were determined by obtaining blood samples before coronary angiography. In addition, 12-hour fasting blood samples on several occasions were taken to measure fasting glucose levels. DM was defined as fasting glucose

level of >125 mg/dl or current use of antidiabetic medication. Fasting total cholesterol, serum triglyceride and high-density lipoprotein (HDL)-cholesterol values were measured. Hypertension was defined as either a systolic or diastolic elevation of blood pressure (≥140/90 mmHg) or current use of antihypertensive pharmacologic therapy. To determine the enzymatic infarct area, multiple blood samples to measure CK-MB levels (for every 3-hours during the first 24 h, and for every 6-hours for the next 2 days, and then daily until discharge) were obtained. Serum levels of glucose, triglyceride, total-cholesterol, HDL-cholesterol and CK-MB were measured using an autoanalyzer (COBAS MIRA, Roche. Switzerland).

All patients underwent two-dimensional transthoracic echocardiography (Vingmed System 7, General Electric, Horten, Norway) to evaluate the left ventricular function using modified Simpson method within one week after primary coronary intervention. Written informed consent was obtained from all patients before coronary angiography.

Statistical analysis

SPSS 15.0 (SPSS Inc., Chicago, IL, USA) was used to perform statistical procedures. Data are expressed as median (25th-75th interquartile range) values for continuous variables and as percentages for categorical variables. Chi-square analysis and Mann-Whitney U test was used to compare categorical and continuous variables, respectively. For determining the relationship between different variables, we used nonparametric Spearman correlation analysis. To determine the independent associates of final TIMI frame count of the culprit coronary artery, a multiple linear regression analysis was performed. Parameters included into the multiple regression analysis were admission glucose, white blood cell count (WBC), peak CK-MB and LVEF. A p value of <0.05 was considered statistically significant.

Results

Of the 105 consecutive patients presented with STEMI, 20 were excluded because of previous or new diagnosis of diabetes mellitus and 10 of them were excluded due to presence of coronary slow or no-reflow after coronary stenting and 2 were excluded because of spontaneous TIMI 3 flow at coronary angiography. Therefore, 73 patients with final TIMI 3 flow of the culprit coronary arteries after percutaneous intervention constituted the study population.

Clinical, laboratory and angiographic characteristics of the study patients are presented in Table 1. As shown in the Table 1, baseline clinical characteristics were similar between the 2 groups. Almost all patients received intravenous glycoprotein IIb/IIIa receptor antagonist during and after coronary intervention except for three patients in group 1 and 1 patient in group 2. Although there were no significant differences among the location of MI and the culprit artery between groups, the admission glucose levels were significantly lower in group 1 as compared with the group 2 (p=0.03). Also, the WBC and peak CK-MB levels were significantly lower in the group 1 as compared with the other group (p<0.001, p=0.02, respectively). There was no significant difference between the fasting glucose values between two groups. Left ventricle ejection fraction (LVEF) determined within one week of the was significantly higher in the group 1 than in group 2 (p=0.001).

In all patients, although there was a significant positive correlation between the admission glucose levels and the corrected TIMI frame counts of the culprit arteries (r=0.30, p=0.01), no significant relationship between fasting glucose values and TIMI frame counts was detected. In addition, there was a significant positive correlation between the peak CK-MB levels and TIMI frame counts of culprit coronary arteries (r=0.31, p=0.001). In addition, there was a significant negative correlation between LVEF and TIMI frame counts (r=-0.31, p=0.002). Moreover, moderate but significant positive correlation was found between admission glucose values and peak CK-MB values (r=0.36, p=0.007). Moderate but significant negative correlation was detected between LVEF and admission glucose values (r=0.43, p=0.009).

Table 1. Clinical, laboratory and angiographic characteristics of the study groups

Variables	Group 1 (n=53)	Group 2 (n=20)	*p
Age, years	56 (50-65)	55 (50-70)	0.4
Gender, Male/Female, n	48/5	16/4	0.2
Hypertension, n (%)	16(30)	7(35)	0.7
Current Smoking, n (%)	30(56)	11(55)	0.9
Total cholesterol, mg/dl	175 (147-193)	177 (142-197)	0.9
HDL-cholesterol, mg/dl	41 (35-47)	42 (36-45)	0.8
Triglyceride, mg/dl	111 (78-157)	128 (81-159)	0.7
Admission glucose, mg/dl	123 (97-143)	138 (114-165)	0.03
Fasting glucose, mg/dl	94 (79-113)	103 (86-120)	0.1
GP IIb/IIIa antagonist, n (%)	50 (95)	19 (97)	0.8
Time from symptom onset, h	7 (6-9)	8 (7-9)	0.3
TIMI frame count	22 (17-24)	31 (28-34)	<0.001
Peak CKMB	190 (133-275)	377 (265-521)	<0.001
White blood cell countx(10^3)/mm^3	10.2 (7.4-12)	12.5 (9.2-15.8)	0.02
Left ventricular EF, %	54 (48-58)	43 (35-50)	0.001
Culprit coronary artery			
Left anterior descending, n (%)	29 (54)	12 (60)	0.6
Circumflex, n (%)	3 (6)	2 (10)	
Right coronary artery, n (%)	21 (39)	6 (30)	

Variables are expressed as median (25^{th}-75^{th} interquartile range) and number (percentage)
*Chi-square and Mann-Whitney U tests
CKMB - creatine kinase-MB, EF - ejection fraction, GP - glycoprotein, HDL - high density lipoprotein, TIMI - thrombolysis in myocardial infarction

A multiple linear regression analysis (Table 2) was performed to determine the independent associates of final TIMI frame count. Among the parameters included (admission glucose, WBC, peak CK-MB and LVEF), only admission glucose value was found to be significantly related to the TIMI frame count of the culprit artery (β=0.04, 95% CI: 0.02-0.085, p=0.04).

Discussion

In this study, acute hyperglycemia on admission was found to be significantly correlated with TIMI frame count values of culprit coronary arteries in patients who underwent successful primary PCI for acute STEMI (defined as TIMI 3 flow after stenting). However, no significant relationship was found between the fasting plasma glucose values and TIMI frame count of stented coronary arteries. Moderate but significant association was found between admission glucose levels and peak CK-MB values as well. Besides, left ventricular function was negatively correlated with the admission glucose levels. Finally, among the variables that are associated with the final TIMI frame count of the culprit artery, only admission glucose value was found to be independently associated with this parameter.

Patients with acute hyperglycemia in the acute phase of the MI have higher mortality rate. In addition, higher incidences of cardiogenic shock, congestive heart failure and larger infarct area have been reported in patients with admission hyperglycemia during acute coronary syndromes (1-4). Although the exact mechanisms are not clear, it is commonly regarded as a response to stress accompanied by high levels of catecholamines and glucocorticoids. These hormones increase glycogenolysis and lipolysis and reduce insulin sensitivity, resulting in elevated glucose levels (9-11). In this situation, glucose utilization is reduced and free fatty acids become the mainly used nutrients in the myocardium. Utilization of free fatty acids as the main nutrient is associated with increased oxygen demand in ischemic myocardium and accumulation of unoxidized products of free fatty acids (12). By adversely affecting nitric oxide availability, hyperglycemia may reduce collateral blood flow as well (13). All these changes may exacerbate myocardial damage during coronary occlusion. Timmer et al. (14) showed that patients with elevated glucose levels had more often Killip class >1 at admission and had larger enzymatic infarct size and more reduced LVEF. Accordingly, in our study, there was significant positive correllation between the serum glucose levels on admission and peak CK-MB levels and significant negative correlation was present between admission glucose values and LVEF.

Table 2. Predictors of final TIMI frame count of the culprit coronary artery

Variables	β	95% CI for β	p
Admission glucose, mg/dl	0.043	(0.02)-(0.085)	0.04
Peak CKMB, u/l	0.006	(-0.005)- (0.02)	0.2
Left ventricular EF, %	-0.19	(-0.04)-(0.03)	0.09
White blood cellx(10^3)/mm^3	0.05	(0.004)-(0.044)	0.9

Multiple linear regression analysis data as the final TIMI frame count of the culprit coronary artery dependent variable
CI - confidence interval, CKMB - creatine kinase-MB, EF - ejection fraction, TIMI - Thrombolysis in Myocardial Infarction

The degree of microvascular dysfunction after successful coronary reperfusion is closely related to the morbidity and mortality of patients with acute MI (15, 16). No-reflow phenomenon is found in 25% to 30% patients with AMI, despite successful coronary reperfusion and is associated with a worse outcome (17, 18). Studies have demonstrated that acute hyperglycemia is associated with reduced spontaneous coronary perfusion and impaired tissue perfusion as compared to euglycemia (19, 20). In a study of Iwakaru et al. (6), patients with AMI and no-reflow phenomenon were found to have higher blood glucose levels on admission than did those without no-reflow phenomenon despite the similar frequency of DM and similar levels of hemoglobin A1C values of the two groups. Furthermore, in addition to lesion length, Suenari et al. (21) has shown that acute hyperglycemia at admission was an independent predictor of coronary slow/no-re-flow in patients with acute myocardial infarction undergoing primary PCI. However, we found that even in patients with TIMI 3 flow after PCI, final TIMI frame counts were higher in patients with admission hyperglycemia. Therefore, in addition to no-reflow phenomenon, high blood glucose values might also cause subtle changes in coronary flow despite the presence of final TIMI 3 flow of the culprit coronary artery. Plugging of leucocytes in the microcirculation might contribute to the impaired coronary flow (22). Also, blood glucose is an independent predictor of platelet dependent thrombosis. Presence of a microthrombus in the coronary capillaries plays a crucial role in the slow- or no-reflow phenomenon after AMI (23). Besides, hyperglycemia can also reduce collateral flow to the ischemic area (13), resulting in greater myocardial damage before reperfusion and subsequently the impaired coronary flow.

Study limitations

In addition to small sample size, some limitations must be taken into consideration before evaluating our study. Although patients with DM were excluded from our study, some patients have still have occult DM, which can be exposed by oral glucose tolerance test. In addition, hemoglobin A1C values were not present for most patients. Incorporating of this parameter into the analysis could be more invaluable. Finally, different imaging techniques such as TIMI blush grade or contrast echocardiography other than TIMI frame count are more reliable method of choice in assessing microvascular integrity of coronary circulation.

Conclusion

Our study suggests that in patients who present with an AMI and who underwent successful reperfusion with PCI, elevated blood sugar upon admission is associated with high TIMI frame

counts despite presence of a final TIMI 3 flow. Admission hyperglycemia is also related to higher myocardial damage resulting in poorer left ventricular function as well. Therefore, even in patients without known DM, admission hyperglycemia during an acute coronary syndrome should alert physicians as a possible negative prognostic marker, which might indicate a more complicated course.

Conflict of interest: None declared.

References

1. Wahab NN, Cowden EA, Pearce NJ, Gardner MJ, Merry H, Cox JL; ICONS Investigators. Is blood glucose an independent predictor of mortality in acute myocardial infarction in the thrombolytic era? J Am Coll Cardiol 2002; 40: 1748-54.
2. Capes SE, Hunt D, Malmberg K, Gerstein HC. Stress hyperglycaemia and increased risk of death after myocardial infarction in patients with and without diabetes: a systematic overview. Lancet 2000; 355: 773-8.
3. Malmberg K, Norhammar A, Wedel H, Rydén L. Glycometabolic state at admission: important risk marker of mortality in conventionally treated patients with diabetes mellitus and acute myocardial infarction: long-term results from the Diabetes and Insulin-Glucose Infusion in Acute Myocardial Infarction (DIGAMI) study. Circulation 1999; 99: 2626-32.
4. Stranders I, Diamant M, van Gelder RE, Spruijt HJ, Twisk JW, Heine RJ, et al. Admission blood glucose level as risk indicator of death after myocardial infarction in patients with and without diabetes mellitus. Arch Intern Med 2004; 164: 982-8.
5. Deedwania P, Kosiborod M, Barrett E, Ceriello A, Isley W, Mazzone T, et al. American Heart Association Diabetes Committee of the Council on Nutrition, Physical Activity, and Metabolism. Hyperglycemia and acute coronary syndrome: a scientific statement from the American Heart Association Diabetes Committee of the Council on Nutrition, Physical Activity, and Metabolism. Circulation 2008; 117: 1610-9.
6. Iwakura K, Ito H, Ikushima M, Kawano S, Okamura A, Asano K, et al. Association between hyperglycemia and the no-reflow phenomenon in patients with acute myocardial infarction. J Am Coll Cardiol 2003; 41: 1-7.
7. Gibson CM, Murphy SA, Rizzo MJ, Ryan KA, Marble SJ, McCabe CH, et al. Relationship between TIMI frame count and clinical outcomes after thrombolytic administration. Thrombolysis In Myocardial Infarction (TIMI) Study Group. Circulation 1999; 99: 1945-50.
8. Gibson CM, Cannon CP, Daley WL, Dodge JT Jr, Alexander B Jr, Marble SJ, et al. TIMI frame count: a quantitative method of assessing coronary artery flow. Circulation 1996; 93: 879-88.
9. Oswald GA, Smith CC, Delamothe AP, Betteridge DJ, Yudkin JS. Raised concentrations of glucose and adrenaline and increased in vivo platelet activation after myocardial infarction. Br Heart J 1988; 59: 663-71.
10. Oswald GA, Smith CC, Betteridge DJ, Yudkin JS. Determinants and importance of stress hyperglycaemia in non-diabetic patients with myocardial infarction. Br Med J (Clin Res Ed) 1986; 293: 917-22.
11. Mizock BA. Alterations in fuel metabolism in critical illness: hyperglycaemia. Best Pract Res Clin Endocrinol Metab 2001; 15: 533-51.
12. Tansey MJ, Opie LH. Relation between plasma free fatty acids and arrhythmias within the first twelve hours of acute myocardial infarction. Lancet 1983; 2: 419-22.
13. Kersten JR, Toller WG, Tessmer JP, Pagel PS, Warltier DC. Hyperglycemia reduces coronary collateral blood flow through a nitric oxide-mediated mechanism. Am J Physiol Heart Circ Physiol 2001; 281: H2097-104.
14. Timmer JR, van der Horst IC, Ottervanger JP, Henriques JP, Hoorntje JC, de Boer MJ, et al (Zwolle Myocardial Infarction Study Group). Prognostic value of admission glucose in non-diabetic patients with myocardial infarction. Am Heart J 2004; 148: 399-404.
15. Reffelmann T, Kloner RA. The "no-reflow" phenomenon: basic science and clinical correlates. Heart 2002; 87: 162-8.
16. Reffelmann T, Kloner RA. The no-reflow phenomenon: A basic mechanism of myocardial ischemia and reperfusion. Basic Res Cardiol 2006; 101: 359-72.
17. Ito H, Tomooka T, Sakai N, Yu H, Higashino Y, Fujii K, et al. Lack of myocardial perfusion immediately after successful thrombolysis. A predictor of poor recovery of left ventricular function in anterior myocardial infarction. Circulation 1992; 85: 1699-705.
18. Porter TR, Li S, Oster R, Deligönül U. The clinical implications of no reflow demonstrated with intravenous perfluorocarbon containing microbubbles following restoration of Thrombolysis In Myocardial Infarction (TIMI) 3 flow in patients with acute myocardial infarction. Am J Cardiol 1998; 82: 1173-7.
19. Timmer JR, Ottervanger JP, de Boer MJ, Dambrink JH, Hoorntje JC, Gosselink AT, et al (Zwolle Myocardial Infarction Study Group). Hyperglycemia is an important predictor of impaired coronary flow before reperfusion therapy in ST-segment elevation myocardial infarction. J Am Coll Cardiol 2005; 45: 999-1002.
20. Prasad A, Stone GW, Stuckey TD, Costantini CO, Zimetbaum PJ, McLaughlin M, et al. Impact of diabetes mellitus on myocardial perfusion after primary angioplasty in patients with acute myocardial infarction. J Am Coll Cardiol 2005; 45: 508-14.
21. Suenari K, Shiode N, Shirota K, Ishii H, Goto K, Sairaku A, et al. Predictors and long-term prognostic implications of angiographic slow/no-flow during percutaneous coronary intervention for acute myocardial infarction. Intern Med 2008; 47: 899-906.
22. Rezkalla SH, Kloner RA. Coronary no-reflow phenomenon: from the experimental laboratory to the cardiac catheterization laboratory. Catheter Cardiovasc Interv 2008; 72: 950-7.
23. Montalescot G, Barragan P, Wittenberg O, Ecollan P, Elhadad S, Villain P, et al (ADMIRAL Investigators). Abciximab before Direct Angioplasty and Stenting in Myocardial Infarction Regarding Acute and Long-Term Follow-up. Platelet glycoprotein IIb/IIIa inhibition with coronary stenting for acute myocardial infarction. N Engl J Med 2001; 344: 1895-903.