JARSS 2019;27(1):56-62
doi: 10.5222/jarss.2019.32042

In-Hospital Mortality and Complications Following Coronary Artery Bypass Surgery; is it Possible to Predict with Preoperative Values?

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Koroner Arter Baypas Cerrahisi Sonrası Gelişen Hastane İçi Mortalite ve Komplikasyonlar, Preoperatif Değerlerle Prediksiyon Mümkün mü?

ABSTRACT

Objective: *The aim of this study is to evaluate short-term complications and mortality in patients undergoing isolated coronary artery bypass surgery with preoperative predictors commonly used in the literature.*
Methods: *A total of 518 patients who underwent coronary artery bypass surgery using cardiopulmonary bypass pump were retrospectively investigated. Preoperative fasting blood glucose, hemoglobin, neutrophil, platelet count, erythrocyte distribution width, mean platelet volume, platelet lymphocyte ratio, neutrophil lymphocyte ratio, metabolic syndrome criteria were recorded. These preoperative data have been investigated in relation to postoperative short term complications and mortality.*
Results: *Twenty-six (5%) out of 518 patients exited within postoperative 30 days. Mortality was associated with advanced age, presence of hypertension, fasting blood glucose and platelet lymphocyte ratio. However, in multivariate analyzes, only advanced age was seen as an independent predictor of mortality. At least one postoperative complication was seen in 66 (12.7%) patients. Age, fasting blood glucose, hemoglobin value, mean platelet volume, neutrophil lymphocyte ratio were found to be associated with the development of complications. However, in multivariate analyzes only age was seen as independent predictor of development of complications.*
Conclusion: *It is not possible to predict mortality and complications in patients undergoing coronary artery bypass surgery using only preoperative data.*

Keywords: *Coronary artery bypass surgery, complications, mortality, preoperative predictors*

ÖZ

Amaç: *Bu çalışmanın amacı, izole koroner arter baypas cerrahisi geçiren hastalardaki, kısa dönemde gelişen komplikasyon ve mortalitenin, literatürde sık kullanılan preoperatif prediktörler ile değerlendirilmesidir.*
Yöntem: *Kardiyopulmoner baypas pompası kullanılarak koroner arter baypas cerrahisi yapılan 518 hasta retrospektif olarak araştırılmıştır. Preoperatif açlık kan glukozu, hemoglobin, nötrofil, platelet sayısı, eritrosit dağılım genişliği, ortalama platelet hacmi, platelet lenfosit oranı, nötrofil lenfosit oranı, metabolik sendrom kriterleri kaydedilmiştir. Bu preoperatif verilerin postoperatif kısa dönem komplikasyonlar ve mortalite ile ilişkisi araştırılmıştır.*
Bulgular: *518 hastanın 26'sında (%5) 30-günlük mortalite gözlenmiştir. Mortalite ile ileri yaş, hipertansiyon varlığı, açlık kan glukozu ve platelet lenfosit oranı ilişkili bulunmuştur. Ancak, çok değişkenli analizlerde yalnızca ileri yaşın mortalite için bağımsız prediktör olduğu görülmüştür. Hastaların 66'sında (%12,7) postoperatif en az bir komplikasyon görülmüştür. Yaş, açlık kan glukozu, hemoglobin değeri, ortalama platelet hacmi, nötrofil lenfosit oranı komplikasyon gelişimi ile lişkili bulunmuştur. Ancak çok değişkenli analizlerde yalnızca ileri yaş komplikasyon gelişimi için bağımsız prediktör olarak görülmüştür.*
Sonuç: *Yalnızca preoperatif veriler ile koroner arter baypas cerrahisi geçiren hastalarda mortalite ve komplikasyon öngörmek olası değildir.*

Anahtar kelimeler: *Koroner arter baypas cerrahisi, komplikasyon, mortalite, preoperatif prediktörler*

Alındığı tarih: 24.10.2018
Kabul tarihi: 12.12.2018
Yayın tarihi: 31.01.2019

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INTRODUCTION

The 30-days mortality rate after cardiac surgery is reported to be 1-4% in large studies of cardiac surgery [1]. According to the Society of Thoracic Surgeons (STS) the mortality rate for isolated coronary artery bypass surgery (CABG) is 2.3%, and 3.4% for valve surgery [2,3]. The term "early mortality" defines mortality 30 days after cardiac surgery. Mortality and morbidity risks of the patients are evaluated by many scoring systems on preoperative period. The aim of preoperative evaluation in cardiac surgery is to reveal the severity of the disease, to determine the surgical risk, to optimize the patient before surgery and to take measures to reduce the risk of perioperative complications. With a better understanding of these risks, it is aimed to prevent possible complications, to increase life expectancy and quality after surgery, to shorten the length of intensive care and hospital stay and to reduce the hospital cost.

In the literature, many preoperative parameters have been investigated in order to estimate mortality and development of complication after cardiac surgery by simple and easy methods instead of detailed scoring systems. In this study, we aimed to evaluate the patients who died, and developed complications in the short term after isolated coronary artery bypass surgery in terms of simple preoperative predictors used frequently in the literature.

MATERIAL and METHODS

Following the approval of the hospital board for our retrospective cross-sectional study (date: 09.08.2018, number: 8802), 518 patients who underwent isolated coronary artery bypass grafting surgery using cardiopulmonary bypass (CPB) in 2018 were retrospectively investigated. Pediatric patients, patients who had undergone valve surgeries, aortic and other vascular surgeries, combined surgeries, off-pump surgeries, heart transplantation and surgeries for the implantation of ventricular support devices were not included in the study. Preoperative and postoperative data of these patients were obtained by scanning the files from hospital electronic database and archives. In addition to demographic information, preoperative fasting blood glucose, and hemoglobin values , neutrophil and platelet counts, red cell distribution width (RDW), mean platelet volume (MPV), platelet lymphocyte ratio (PLR) and neutrophil lymphocyte ratio (NLR) were recorded. Patients with at least 3 or more criteria were separated according to the criteria of metabolic syndrome (MS).

Diagnostic criteria of metabolic syndrome;

- Abdominal obesity (BMI ≥30 kg m^{-2} or waist circumference in women ≥80 cm, in men ≥94 cm)
- Triglyceride ≥150 mg dL^{-1}
- Fasting blood glucose ≥100 mg dL^{-1}, or being under the treatment of diabetes mellitus
- Blood pressure ≥130/85 mmHg, or being under the treatment of Hypertension
- HDL level in men <40 mg dL^{-1}, in women <50 mg dL^{-1}

  *BMI (body mass index), HDL (high density lipoprotein)

Only isolated CABG surgery were included in the study in order to reach the right conclusion in terms of metabolic syndrome. Major complications in the postoperative period were classified as; cardiac, pulmonary, renal, cerebral, mediastinitis, revision surgery related with bleeding or tamponade. Cardiac complications, called as "major adverse cardiac events" (MACE); coronary artery stenting, nonfatal myocardial infarction, re-CABG, any cause of cardiac death were evaluated. Respiratory failure was defined as the need for postoperative mechanical ventilator support, which lasts more than 72 hours. Indication for dialysis or ≥ 1 mg dL^{-1} in postoperative serum creatinine relative to baseline value was defined as acute renal failure (ARF). Stroke was defined as a new, temporary or permanent central neurological deficits after cardiac surgery. Mediastinitis was defined as a deep sternal wound infection [4]. All major and minor complications developed in the postoperative period were classified under "overall adverse events". Patients were grouped according to mortality and complications. The effects of preoperative predictors of mortality and complication on the methods described below in these groups were investigated.

Statistical Analysis

Normally distributed continuous variables were expressed as "mean values ± standard deviation (SD)" or

median values with the interquartile range if not normally distributed. Categorical variables were expressed as numbers and percentages. Demographic characteristics, perioperative variables and calculated values were compared using "independent samples t-test" or "Mann-Whitney-U test" for continuous variables and "chi-square test" or "Fisher's exact test" for categorical variables. Correlations were assessed using Pearson's correlation test. For the multivariate analysis, the possible factor identified with univariate analyses (p<0.10 for the first model and p<0.05 for the second model) was further entered into the logistic regression analysis to determine independent predictors of adverse events and mortality. Hosmer-Lemeshow goodness of fit statistics were used to assess model fit. A p value<0.05 was considered statistically significant. All statistical analyses were performed using the SPSS statistical software (SPSS for Windows 15.0, Inc., Chicago, IL, USA).

RESULTS

A total of 518 patients who underwent isolated CABG surgery with CPB within 1 year were included in the study. Patients with and without mortality were compared according to their preoperative characteristics and laboratory data (Table I). Age, presence of hypertension, preoperative blood glucose level and preoperative PLR were found to be associated with mortality (p<0.001, p=0.064, p=0.066, p=0.039, respectively). However, multivariate analy-

Table II. Multivariate analysis to determine independent predictor of mortality (Model 1 and Model 2)

	Model 1			Model 2		
	OR	95% CI	P value	OR	95% CI	P value
Age (years)	1.10	1.05-1.16	<0.001	1.11	1.05-1.16	<0.001
HT	1.79	0.74-4.37	0.331	-	-	-
Glucose	0.97	0.89-1.05	0.441	-	-	-

Table I. Preoperative characteristics and laboratory values of patients with and without mortality

	Total n=518		Mortality (-) n=492		Mortality (+) n=26		
Features	Mean ± SD or n(%)	Median (IQR)	Mean ± SD or n(%)	Median (IQR)	Mean ± SD or n(%)	Median (IQR)	P value
Age (years)	60.4±9.2	60 (53-68)	60.0±9.1	60 (53-67)	67.9±8.2	69.5 (62-74)	<0.001
Male gender	416 (80.3%)		397 (80.7%)		19 (73.1%)		0.341
Hypertension	267 (51.5%)		249 (50.6%)		18 (69.2%)		0.064
BMI	28.3±4.3	27.9 (25.6-31.1)	28.4±4.3	28.1 (25.6-31.1)	27.1±4.5	26.4 (23.5-30.1)	0.150
Metabolic syndrome	266 (51.4%)		250 (50.8%)		16 (61.5%)		0.286
Glucose	134.8±67.8	109 (94-154)	134.5±68.7	107.5 (94-152)	141.5±47.8	105 (105-179)	0.066
Hemoglobin	14.1±1.7	14.3 (13.2-15.2)	14.1±1.7	14.3 (13.2-15.2)	13.4±2.1	13.9 (12.4-15.0)	0.178
Neutrophil	5.5±2.1	5.1 (4.2-6.3)	5.5±2.1	5.1 (4.2-6.3)	5.5±2.3	5.5 (4.0-6.1)	0.892
Platelet	234.8±64.6	227 (191-265)	234.4±64.9	228 (192-264)	241.6±78.7	215 (181-281)	0.894
RDW	14.0±1.3	13.8 (13.2-14.4)	14.0±1.3	13.8 (13.2-14.4)	14.2±1.4	13.8 (13.4-14.3)	0.463
MPV	9.0±1.1	8.9 (8.2-9.7)	9.0±1.1	8.9 (8.2-9.7)	9.1±1.2	9.0 (8.4-9.7)	0.573
PLR	116.2±49.5	108 (84-134)	115.6±49.8	107 (84-134)	128.2±41.1	121.5 (106-141)	0.039
NLR	2.8±2.4	2.4 (1.8-3.2)	2.8±2.5	2.4 (1.8-3.2)	2.9±1.1	2.8 (1.9-3.6)	0.200

N: Number of patients, BMI: Body mass index, RDW: Redcell distribution width, MPV: Mean platelet volume, PLR: Platelet lymphocytes ratio, NLR: Neutrophil lymphocyte ratio

Table III. Postoperative complications of patients with and without mortality

	Total N=518		Mortality (-) N=492		Mortality (+) N=26		
Features	Mean ± SD or n(%)	Median (IQR)	Mean ± SD or n(%)	Median (IQR)	Mean ± SD or n(%)	Median (IQR)	P value
MACE	33 (6.4%)		9 (1.8%)		24 (92.3%)		<0.001
Respiratory insuff	12 (2.3%)		11 (2.2%)		1 (3.8%)		0.595
ARF	9 (1.7%)		4 (0.8%)		5 (19.2%)		<0.001
Stroke	8 (1.5%)		8 (1.6%)		0		0.512
Mediastinitis	11 (2.1%)		11 (2.2%)		0		0.441
Revision for bleeding/tamponade	7 (1.4%)		5 (1.0%)		2 (7.7%)		0.004
Overall adverse events	66 (12.7%)		40 (8.1%)		26 (100 %)		<0.001

N: Number of patients, MACE: Major adverse cardiac events, ARF: Acute renal failure

Tablo IV. Patients with mortality

	Age/Sex	Complications	Mortality days
1.	53/M	Bleeding/Tamponade	2
2.	70/F	MACE	1
3.	61/M	MACE	3
4.	75/F	MACE	1
5.	76/F	MACE	1
6.	72/F	MACE	3
7.	74/M	MACE	3
8.	76/M	MACE,ARF	20
9.	59/M	MACE	1
10.	62/M	MACE	2
11.	73/M	MACE,ARF	6
12.	69/M	MACE	1
13.	75/M	MACE,ARF	5
14.	70/F	MACE	6
15.	74/M	MACE	5
16.	69/F	MACE	1
17.	51/F	MACE	1
18.	58/M	MACE,ARF,bleeding/tamponade	4
19.	75/M	MACE	4
20.	51/M	Respiratory failure	28
21.	67/M	MACE,ARF	30
22.	74/M	MACE	2
23.	67/M	MACE	4
24.	68/M	MACE	3
25.	81/M	MACE	3
26.	66/M	MACE	4

MACE: Major adverse cardiac events, ARF: Acute renal failure

Table VI. Multivariate analysis to determine independent predictor of adverse events (Model 1 and Model 2)

	Model 1			Model 2		
	OR	95% CI	P value	OR	95% CI	P value
Age (years)	1.06	1.02-1.09	0.001	1.05	1.02-1.09	0.001
Glucose	1.00	1.00-1.01	0.271	1.00	1.00-1.01	0.271
Hb	0.87	0.75-1.01	0.074	0.87	0.75-1.01	0.074
MPV	1.19	0.95-1.50	0.135	-	-	-
NLR	0.98	0.90-1.08	0.732	0.99	0.90-1.08	0.732

PLR: Platelet lymphocytes ratio, NLR: Neutrophil lymphocyte ratio

sis of these data with indicated models, showed that only age was an independent predictor of mortality (p<0.001) (Table II). In Table III, patients who exited, and survived were compared according to postoperative complications. MACE (p<0.001), ARF (p<0.001), revision surgery related with bleeding/tamponade (p=0.004) and overall adverse events (p<0.001) were found to be statistically significant in relation to mortality. Twenty-six exited patients were listed according to age, sex, complications and date of death in Table IV. Major adverse cardiac events caused death

Table V. Characteristics of patients with and without adverse events

	Total N=518		Adverse events (-) N=452		Adverse events (+) N=66		
Features	**Mean ± SD or n(%)**	**Median (IQR)**	**Mean ± SD or n(%)**	**Median (IQR)**	**Mean ± SD or n(%)**	**Median (IQR)**	**P value**
Age (years)	60.4±9.2	60 (53-68)	59.9±9.1	60 (53-67)	65.2±9.4	66 (59-71)	<0.001
Male gender	416 (80.3%)		363 (80.3%)		53 (80.3%)		0.999
Hypertension	267 (51.5%)		228 (50.4%)		39 (59.1%)		0.189
BMI	28.3±4.3	27.9 (25.6-31.1)	28.4±4.4	28.1 (25.6-31.1)	27.9±3.9	27.6 (25.6-30.1)	0.488
Metabolic syndrome	266 (51.4%)		228 (50.4%)		38 (57.6%)		0.279
Glucose	134.8±67.8	109 (94-154)	133.4±68.5	107 (94-152)	144.9±62.9	122 (96-179)	0.046
Hemoglobin	14.1±1.7	14.3 (13.2-15.2)	14.2±1.6	14.4 (13.3-15.2)	13.5±2.0	13.7 (12.4-14.7)	0.005
LDL	111.3±42.0	107 (80-137)	111.5±41.3	107 (82-137)	109.8±46.6	103 (77-136)	0.465
Neutrophil	5.5±2.1	5.1 (4.2-6.3)	5.4±2.0	5.0 (4.1-6.3)	6.0±2.5	5.5 (4.6-6.4)	0.073
Platelet	234.8±64.6	227 (191-265)	235.6±64.4	230 (191.5-265)	229.2±66.5	212 (191-255)	0.199
RDW	14.0±1.3	13.8 (13.2-14.4)	14.0±1.3	13.7 (13.2-14.4)	14.2±1.4	13.9 (13.3-14.6)	0.152
MPV	9.0±1.1	8.9 (8.2-9.7)	8.4±1.1	8.9 (8.1-9.7)	9.2±1.0	9.1 (8.4-9.8)	0.097
PLR	116.2±49.5	108 (84-134)	116.1±51.0	107 (84-133)	117.6±38.0	115 (95-137)	0.228
NLR	2.8±2.4	2.4 (1.8-3.2)	2.8±2.6	2.3 (1.8-3.2)	3.1±1.3	3.0 (2.0-3.7)	0.003
Mortality	26 (5.0%)		2 (0.4%)		24 (36.4%)		<0.001

N: Number pf patients, BMI: Body mass index, LDL: Low density lipoprotein RDW: Redcell distribution width, MPV: Mean platelet volume, PLR: Platelet lymphocytes ratio, NLR: Neutrophil lymphocyte ratio

of 24 patients. Patients with and without complications are compared in Table V according to their preoperative characteristics and laboratory data. Age, preoperative blood glucose level, hemoglobin value, MPV and NLR were associated with the development of complications (p<0.001, p=0.046, p=0.005, p=0.097, and p=0.003, respectively). However, multivariate analysis of these data using the indicated models showed that only age was an independent predictor of complications (p<0.001) (Table VI).

DISCUSSION

In this study, we aimed to evaluate the patients who died or developed complications in the hospital within 30 days after coronary artery bypass surgery in terms of some simple and easy preoperative predictors. Comorbidities and the detailed scoring systems were not evaluated in detail. In the literature, there are publications regarding simple predictors for evaluating postoperative complications and mortality, regardless of the detailed preoperative characteristics of the patients [5-8]. However our results showed that none of the preoperative simple parameters were found to be independent predictors, only age was an independent predictor of mortality and complications. It is a well-known fact in the literature that mortality rates increase with aging [9-11].

It is a great challenge to predict outcomes in cardiac surgery procedures. Besides the personal characteristics of each patient, evaluating the severity of the disease is quite complex and far from our current capacity in cardiac surgery. EuroSCORE system is one of the frequently used and most specific assessment for heart surgery. Age, gender and comorbidities such as renal, pulmonary pathologies, arteriopathy, endocarditis and diabetes are scored as factors related to the patient within the EuroSCORE system.

Body mass index is often considered as a factor that increases early postoperative complications but does not affect mortality [12,13]. In our study, BMI was not associated with mortality or postoperative complications. The effect of metabolic syndrome on postoperative outcomes of patients undergoing surgery is another subject of interest. The incidence of MS, which is 23-28% in the general population [14,15], is close to 46% in cardiac surgery patients [16,17]. In our study, in which we received the data of isolated coronary artery bypass surgery, the incidence of MS was 51.4%.

Also, our results have shown that the metabolic syndrome has no significant effect on mortality and adverse events (p=0.286, p=0.279). Obesity and diabetes are diagnostic complexes that are intertwined with MS. Almost one third/half of those who have been diagnosed with MS and have undergone CABG surgery are diabetic [16,17]. In our patient population, 85% of the patients with MS were diabetic. MS appears to be an independent predictor of mortality after CABG surgery [18,19]. However, it has been suggested that MS does not affect mortality in diabetic patients, but its incidence increases in non-diabetic patients [17]. In our study, the diagnosis of MS in was not found to be predictive of postoperative complications and mortality in our patient population. Similar to our conclusion, there are studies that have not found any association between mortality and MS [20,21]. Mean preoperative fasting blood glucose was found to be 134±141 mg dL^{-1} in patients with and without mortality and 133±144 mg dL^{-1} in patients with and without complication. In patients who were prepared for operation under elective conditions, blood glucose values were closely observed and no significant difference was found.

It is common practice in the literature to suggest preoperative hematologic parameters predict mortality and complications in the search for practical and easy methods. It is emphasized that the preoperative diagnosis of anemia is strongly associated with mortality [8,22]. Hemoglobin values below 13 g dL^{-1}, which is accepted as a diagnostic criterion for anemia, were not found in our patients. In multivariate analysis, the hemoglobin value was not predictive. In terms of another marker, high inflammatory mediators in circulation predispose the patients to the development of cardiovascular disease [23]. MPV, RDW, NLR, PLR from hematological parameters are easily measurable in this respect. MPV is directly related to the aggregation function of platelets, MPV levels increase in acute coronary syndromes and diseases that increase cardiovascular risk [6,7,24]. Similarly, RDW has been shown to vary in different clinical conditions such as stroke, myocardial infarction, atrial fibrillation and heart failure, and it predicts mortality and morbidity in cardiac surgery [5,6]. However, no significant changes in MPV and RDW were observed in patients with mortality and complications. Similarly, PLR and NLR values did not show any predictive impact. In this study, the number of our patients is lower than in the literature. This may be the reason why we achieved these results. This may be because in-hospital mortality and complications are more closely related to intraoperative variables, as well. Gomes et al. [25] studied 1458 patients to present a new prognostic score. They found that

postoperative first day factors such as inotropic use, duration of mechanical ventilation longer than 12 hours, and PO_2/FiO_2 ratio were associated with mortality as well as CPB duration of 180 minutes and more. According to another study, intraoperative factors such as inexperienced surgeons, longer CPB time, re-do CPB, intra-aortic balloon usage, are known to improve preoperative risk estimation [26]. Lesser surgeon experience and low-volume cardiac surgery centers are said to be associated with mortality [27]. The emergence of a new Q wave, highly effective myocardial protection during CPB, the types of grafts used (internal mammary artery & saphenous vein), the diameter of the coronary arteries, the quality of anastomosis, bleeding and transfusion, as well as many other intraoperative factors are found to be related with postoperative outcomes. In our study, MACE, ARF and bleeding/tamponade complications were significantly higher in exited patients (Table III). MACE is one of the most common causes of morbidity and mortality after CABG surgery [28]. This demonstrates the importance of intraoperative variables such as the quality of coronary artery anastomoses or myocardial protection. In our study, the euroSCOREs, preoperative organ function indicators, comorbidities of the patients, various intraoperative variables such as CPB duration, number of anastomoses, transfusion of blood products, which may affect the results, were not observed. We could have more comprehensive results if we had more detailed pre-, intra-, and postoperative patient information, but this was not possible.

As a result of this study, it may not possible to predict mortality and complications after CABG surgery, only with preoperative laboratory values. In order to achieve ideal results, comprehensive intraoperative and surgical data and early postoperative data should be taken into consideration.

Acknowledgments

There is not any financial support or sponsorship in current study.

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