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Original Article / Özgün Makale

Age, creatinine, ejection fraction score: simpler is easier

Yaş, kreatinin, ejeksiyon fraksiyonu skoru: Daha basit olan daha kolaydır

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Background: In this study, we compared the age, creatinine, ejection fraction (ACEF) score and logistic European system for cardiac operative risk evaluation (EuroSCORE) predicted mortality rates with observed mortality in patients undergoing elective cardiac surgery.

Methods: This retrospective single-center study included 993 (279 females, 714 males; mean age: 61.2±10.5 years; range 32 to 91 years) of a total of 1044 patients who underwent elective cardiac surgery and met ACEF scores between January 2011 and February 2013. The observed operative mortality and predicted operative mortality using the ACEF score and the logistic EuroSCORE were calculated.

Results: The observed mortality rate was 1.70%. The calculated ACEF score predicted mortality was similar to the observed mortality (2.38%; p=0.269), whereas the logistic EuroSCORE predicted mortality overestimated the observed mortality (3.26%; p=0.021). The comparison analysis was repeated for isolated coronary artery bypass graft patients in whom both systems overestimated the mortality rate (ACEF: 2.45%, p=0.009; logistic EuroSCORE: 2.78%; p=0.022 vs. observed mortality: 1.0%).

Conclusion: To the best of our knowledge, this is the first study documenting the ACEF score predicted mortality results from Turkey. The ACEF score predicted mortality was comparable to the observed mortality in patients undergoing elective cardiac surgery, whereas the logistic EuroSCORE predicted mortality overestimated the observed mortality. In addition, both systems overestimated the mortality in isolated coronary artery bypass graft surgery.

Keywords: Age, creatinine, ejection fraction score; cardiac surgical procedure; European system for cardiac operative risk evaluation; mortality.

Amaç: Bu çalışmada, elektif kalp cerrahisi uygulanan hastalarda, yaş, kreatinin, ejeksiyon fraksiyon (ACEF) skoru ve lojistik Avrupa kalp cerrahisi risk değerlendirme sistemi (EuroSCORE) ile tahmin edilen mortalite oranlarının gözlenen mortalite ile karşılaştırılması amaçlandı.

Çalışma planı: Bu retrospektif tek merkezli çalışmaya Ocak 2011 ve Şubat 2013 tarihleri arasında, elektif kalp ameliyatı yapılan ve ACEF skorlarını karşılayan toplam 1044 hastadan 993 hasta (279 kadın; 714 erkek; ort. yaş 61.2±10.5 yıl; dağılım 32-91 yıl) dahil edildi. Gözlenen cerrahi mortalite ve tahmin edilen cerrahi mortalite oranları, ACEF skoru ve lojistik EuroSCORE kullanılarak hesaplandı.

Bulgular: Gözlenen mortalite oranı %1.70 idi. Hesaplanan ACEF skoru ile tahmin edilen mortalite, gözlenen mortaliteye benzerdi (%2.38; p=0.269); ancak lojistik EuroSCORE ile tahmin edilen mortalite gözlenen mortaliteyi daha fazla hesapladı (%3.26; p=0.021). Bu karşılaştırma analizi, izole koroner arter baypas greft hastaları için tekrarlandığında, her iki sistem de gözlenen mortaliteyi daha yüksek hesapladı (ACEF: %2.45, p=0.009; lojistik EuroSCORE: %2.78; p=0.022; gözlenen mortalite: %1.0).

Sonuç: Bilgimiz dahilinde, bu Türkiye'den ACEF skoru ile tahmin edilen mortalite sonuçlarını gösteren ilk çalışmadır. Elektif kalp cerrahisi uygulanan hastalarda ACEF skoru ile tahmin edilen mortalite, gözlenen mortaliteye benzerdi; ancak lojistik EuroSCORE ile belirlenen mortalite gözlenen mortaliteyi daha yüksek hesapladı. İzole koroner arter baypas greft cerrahisinde de her iki sistem mortaliteyi yüksek hesapladı.

Anahtar sözcükler: Yaş, kreatinin, ejeksiyon fraksiyon skoru; kardiyak cerrahi girişim; Avrupa kalp cerrahisi risk değerlendirme sistemi; mortalite.

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The invention of cardiopulmonary bypass (CPB) and technological advances allowed the application of cardiac surgery. Following the wide applicability of cardiac surgery, possible solutions for mortality have become an area of great interest. Once the preoperative estimation of operative risks became popular guiding surgical strategies and therapeutic algorithms, various mortality risk scores were developed in previous years.[1]

Today, the most common risk model is the European system for cardiac operative risk evaluation (EuroSCORE) which was first established in 1999.[2] However, the major drawback of the EuroSCORE system is the use of several parameters in the scoring system. The complexity of the scoring system led researchers to develop a simpler method. In 2009, Ranucci et al.[3] established a novel operative mortality risk stratification method in elective cardiac surgery. The new system was named after the parameters included in the assessment: age, creatinine, ejection fraction (ACEF). The novel system had similar or better accuracy compared to more complex risk scoring systems.[3-5]

In this study, we compared the logistic EuroSCORE and ACEF score in predicting mortality in patients undergoing elective cardiac surgery.

PATIENTS AND METHODS

This retrospective single-center study included 993 (279 females, 714 males; mean age 61.2±10.5 years; range 32 to 91 years) of a total of 1044 patients who underwent elective cardiac surgery and met ACEF scores between January 2011 and February 2013.

The study protocol was approved by the institutional ethics committee. Informed consents were obtained from all patients for storage their medical information in the hospital database for scientific analysis in an anonymous form in accordance with the Turkish law on data protection and privacy.

Operative mortality was defined according to the Society of Thoracic Surgeons and EuroSCORE definition as the mortality during hospitalization in which the surgical procedure is performed irrespective of time limitations and mortality within 30 days of surgery following discharge, unless there is a clear documentation which the death is not related to surgery.[2,3,6] As the ACEF scoring system excludes patients below 18 years of age and with congenital heart disease and an emergent surgery, we excluded such patients from this study.[3,4]

The ACEF score was calculated using the following equation:[3]

ACEF score= [Age (years)/ejection fraction (%)] + 1 (if the preoperative serum creatinine level >2.0 mg/dl)

Operative mortality risk was calculated using the following equation:[4]

Operative mortality (%)= eACEFX1.24-5.41/(1 + eACEFX1.24-5.41)

The logistic EuroSCORE was calculated as defined by Roques et al.[7]

In the validation series, the followings were documented for ACEF scores: the sensitivity was 71%, specificity was 78% with a positive predictive value of 8%, and the negative predictive value of 99%. For the logistic EuroSCORE, the documented sensitivity was 72%, specificity was 73% with a positive predictive value of 6.6%, and the negative predictive value was 99%.[3] Fındık et al.[8] documented 92.3% sensitivity and 82.2% specificity for the EuroSCORE system in a Turkish population.

We filled out a standard form for each patient on admission including the demographic characteristics and some of the most important operative and postoperative variables. All variables of the study were withdrawn from these files. The creatinine values were the values measured on the day of hospital admission for operation (within one or two days prior to the operation).

Statistical analysis

Statistical analyses were performed using the SPSS software for Windows version 17.0 (SPSS Inc., Chicago, IL, USA) and Epi Info version 6.0 (Centers for Disease Control and Prevention, Atlanta, GA, USA). Continuous variables were expressed in mean values ± standard deviation (SD). Categorical variables were expressed in numbers and percentages. The mortality and non-mortality groups were compared using the independent samples t-test for continuous variables; Logistic EuroSCORE predicted mortality, ACEF score predicted mortality. The observed mortality rates were compared using the chi-square test. A p value of <0.05 was considered statistically significant.

RESULTS

An isolated coronary artery bypass grafting (CABG) was performed in 786 patients (79.2%). The demographic characteristics of the patients are presented in Table 1. Since the definition of ACEF score mandates the exclusion of non-elective cases, the cases with critical preoperative state, emergent surgery, and surgery of acute ventricular septal defect were excluded from the study. The excluded cases

Table 1. The preoperative demographic characteristics of the patients (n=993)

	n	%
Age (≥60 years)	584	58.8
Gender		
Female	279	28.1
CABG	786	79.2
Chronic pulmonary disease	94	9.5
Extra-cardiac arteriopathy	61	6.1
Neurological dysfunction disease	3	0.3
Serum creatinine (>200 μmol/l)	23	2.3
Myocardial infarction within 90 days	287	28.9
Pulmonary hypertension		
(systolic >60 mmHg)	17	1.7
Moderate LV dysfunction (EF: 30-50%)	346	34.8
Severe LV dysfunction (EF <30%)	39	3.9
Surgery other than isolated CABG	207	20.8
Surgery on thoracic aorta	28	2.8
Unstable angina	155	19.7*
Active endocarditis	–	–
Previous cardiac surgery	–	–
Critical postoperative state	–	–
Post-infarct septal rupture	–	–

LV: Left Ventricle; EF: Ejection fraction; CABG: Coronary artery bypass grafting; * Out of 786 patients undergoing CABG.

were originally defined as parameters of the logistic EuroSCORE system.[3]

The calculated mean ACEF score was 1.23±0.43 for the entire group (n=993). The calculated ACEF score predicted mortality was 2.38% (95% confidence interval, 2.25-2.52), the logistic EuroSCORE predicted mortality was 3.26% (95% confidence interval, 3.04-3.48), whereas the observed mortality rate was 1.70% (n=17) (Table 2). The mortality rate predicted using the ACEF score was not significantly different from the observed mortality (Chi-square=1.22; p=0.269), whereas the observed mortality rate was significantly overestimated by the logistic EuroSCORE (Chi-square= 5.25; p=0.021).

The analysis was then repeated in the isolated CABG subgroup (n=786). The observed mortality rate was 1.0% (n=8). In the CABG patients, the mean ACEF score was 1.24±0.43. The ACEF score predicted mortality was 2.45% (95% confidence interval, 2.28-2.61) and the logistic EuroSCORE predicted mortality was 2.78% (95% confidence interval, 2.59-2.96) (Table 3). In the isolated CABG group, both score systems significantly overestimated the observed mortality (Chi-square=6.66, p=0.009 and Chi-square= 5.24, p=0.022 for logistic EuroSCORE and ACEF score predicted mortality rates, respectively).

DISCUSSION

Various risk score systems were developed in the last two decades in cardiac surgery.[1] The primary goal of these systems was to predict the operative mortality as well as to evaluate perioperative cardiac care. The most commonly used risk score for the evaluation of cardiac operative mortality is the EuroSCORE.[2,9] Either logistic or additive EuroSCORE systems had good levels of accuracy, although these overestimated operative mortalities.[5,10-12] In 2011, to eliminate these insufficiencies and drawbacks, the EuroSCORE II was established,[13] despite the limited data on test validation.[14,15] The ACEF score system which was established in 2009 was applied only three basic parameters, namely age, creatinine, and EF.[3,5] Di Dedda et al.[16] conducted a validation study of the EuroSCORE II and compared the findings with the original standard and logistic EuroSCORE and the ACEF score. The authors concluded that the EuroSCORE II was more useful than the previous version, as it showed better clinical performance and identically high level of accuracy.

In our clinical practice, we mostly employ the standard EuroSCORE model stipulated by the Social Security Institution with a few differences. In addition, we have been using the ACEF system in our practice for over six months. We have some experiences on the

Table 2. Characteristics of 993 patients included in the study

	n	%	Mean±SD	95% CI	Range
Age			61.2±10.5	60.58-61.88	20-91
Ejection fraction (%)			53.9±11.5	53.15-54.59	18-75
Serum creatinine (mg/dl)			1.0±0.8	0.94-1.04	0.45-9.26
ACEF score			1.2±0.4	1.20-1.25	0.36-3.75
ACEF score predicted mortality (%)			2.4±2.2	2.25-2.52	0.69-31.86
Logistic EuroSCORE predicted mortality			3.3±3.5	3.04-3.48	0.82-51.59
Observed mortality	17	1.7			

SD: Standard deviation; CI: Confidence interval; ACEF: Age, creatinine, ejection fraction; EuroSCORE: European System for Cardiac Operative Risk Evaluation.

Table 3. Characteristics of 786 patients with isolated coronary artery bypass grafting

	n	%	Mean±SD	95% CI	Range
Age			61.8±9.7	61.11-62.47	32-91
Ejection fraction (%)			53.9±11.8	53.05-54.70	18-75
Serum creatinine (mg/dl)			1.0±0.8	0.94-1.06	0.45-9.26
ACEF score			1.2±0.4	1.21-1.27	0.53-3.75
ACEF score predicted mortality (%)			2.5±2.3	2.28-2.61	0.85-31.86
Logistic EuroSCORE predicted mortality (%)			2.8±2.6	2.59-2.96	0.82-34.15
Observed mortality	8	1.0			

SD: Standard deviation; CI: Confidence interval; ACEF: Age, creatinine, ejection fraction; EuroSCORE: European System for Cardiac Operative Risk Evaluation.

overestimation with the EuroSCORE compared to the ACEF score, although we have not documented these incidents until now.

During the developmental process of the EuroSCORE II, reports have suggested that the number of variables be reduced.[17] In 2009, Ranucci et al.[3,5] proposed the simple ACEF score system and the ACEF score predicted mortality stating "the easier, the better". The ACEF score includes only three basic parameters: age, creatinine, and ejection fraction. Age is an objective parameter which is not subject to personal estimation. The serum creatinine value considered during calculation should be the most recent value. The EF values may vary among patients according to the examination technique in which either angiography or echocardiography was performed. Ejection fraction values may also vary according to the examiner conducting the assessment. The ACEF system suggests using the most recent value or the lowest value. By using this approach, the ACEF calculation is not subject to personal interpretation.[4] We began to preferably use the ACEF score system in the last six months based on its ease for use and our belief that it generates more accurate estimations.

Following the establishment of the ACEF score, Ranucci et al.[5] reported their expanded series consisting of 29.659 patients from 14 different centers in Italy. The predicted mortality rate was 2.84% with the ACEF score, 6.26% with the additive EuroSCORE, and 9.67% with the logistic EuroSCORE. The observed mortality rate was 2.77%. No statistically significant differences between the observed and ACEF score predicted mortality rates were observed. However, the additive and logistic EuroSCORE systems overestimated the operative mortality risk. The aim of this study was to validate the ACEF score predicted mortality. We also performed a similar study using 993 patients in a single-center cohort. We compared the results of the ACEF score predicted mortality and logistic EuroSCORE predicted mortality with observed mortality and documented similar results with that of the previous study. The logistic EuroSCORE overestimated mortality, whereas the ACEF score did not. However, in isolated CABG cases, both systems overestimated the observed mortality. Despite our observations of ease and applicability of the ACEF score system on mortality prediction compared to the EuroSCORE system, there are still some drawbacks. It is widely accepted that the mortality rate of isolated CABG cases is lower than that of the overall cardiac surgery cases,[16] which was also valid in our practice (1.0% vs. 1.7%). Conversely, we observed that the ACEF score predicted mortality for overall patient population was 2.38% compared to 2.45% for the isolated CABG cases. This may be explained by the fact that the ACEF score system utilizes a limited number of parameters. Since those parameters were similar among patients and the isolated CABG cases subgroup the 0.01 point increase in the ACEF score resulted in a 0.07% increase in mortality. However, the other parameters such as existence of pulmonary hypertension and thoracic aorta surgery affected the EuroSCORE system and therefore decreased the predicted operative mortality in isolated CABG cases (from 3.26% to 2.78%).

The ACEF score was employed in different purposes after assessing operative mortality risk. In the LEADERS trial, the ACEF score was calculated for 1,208 patients undergoing percutaneous coronary interventions (PCI) and clinical outcomes at one-year follow-up were studied according to ACEF score tertiles. The rate of cardiac death, myocardial infarction, and composite definite, possible and probable stent thrombosis were higher in the high ACEF score group.[18] In an attempt to improve the accuracy of operative mortality predictive models, Ranucci et al.[19] incorporated pH, bicarbonate levels, mean arterial pressure, central venous pressure, heart rate, and serum lactate levels at admission to the intensive

care unit. They studied 1255 adult patients who were operated in a single center. They documented that the heart rate over 120/min and serum lactate levels over 4 mmol/L were independent predictors of operative mortality and incorporation of those parameters in the logistic EuroSCORE and ACEF systems increased their accuracy. Of note, the main purpose of this study was not to increase the parameters used in operative mortality assessment systems. They suggested that a double-staged operative mortality assessment would help evaluate the quality of surgical care. In cases of higher operative risk calculation at ICU admission compared to the preoperative calculated values, it would be suggestive for an improvement in intraoperative management strategy. Unlikely, in our study, we did not include those parameters.

It is well-established that the responses to score systems may vary in different populations, as the systems are usually developed in European countries. For those reasons, in 2011, Akar et al.[11] designed an invaluable study on validating the EuroSCORE risk models in Turkish adult cardiac surgical population. They calculated additive and logistic EuroSCORE models in 8,018 patients. The actual observed operative mortality was 1.96% and the additive predictive mortality rate was 2.98%, whereas the logistic predictive mortality rate was 3.17% ($p<0.001$ vs. observed in both EuroSCORE models). For isolated CABG, the observed mortality rate was 1.23%, whereas the additive and logistic mortality rates were 2.87% and 2.98%, respectively. They concluded that the EuroSCORE risk models overestimated mortality in a Turkish population and remodeling or creation of a new model was suggested. We also documented overestimated mortality rates with the logistic EuroSCORE, however, we did not calculate the TurcoSCORE in our patient population.

Recently, the same research group evaluated the performance of EuroSCORE II in a Turkish population. Kunt et al.[14] compared the traditional additive and logistic EuroSCORE and EuroSCORE II. The observed mortality rate was 7.9%. The predictive mortality rates were 6.4% for the additive EuroSCORE, 7.9% for the logistic EuroSCORE, and 1.7% for EuroSCORE II. The EuroSCORE II system underestimated mortality. In this study, it was surprising that the logistic EuroSCORE was accurate in predicting mortality rate, as the patients were extracted from TurcoSCORE database, which revealed overestimation with logistic EuroSCORE in the previously published original report.[11]

To the best of our knowledge, no study regarding the ACEF scores from Turkey is available in the literature. Although our study cannot be defined as a population study, we may conclude that the ACEF score is more accurate than the logistic EuroSCORE in predicting operative mortality in patients undergoing elective cardiac surgery based on the large sample size in our study.

Limitations

In Turkey, the national health authority, Social Security Institution, stipulates the use of the standard EuroSCORE model with a few differences.[11] The EuroSCORE II values of the patients in the hospital data may not be accurate for scientific interpretation. This study is a retrospective study, and due to missing data, it was not possible to calculate the accurate EuroSCORE II values of the patients. However, we aimed to document the results of the ACEF score predicted mortality in a single center in Turkey.

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REFERENCES

1. Nilsson J, Algotsson L, Höglund P, Lührs C, Brandt J. Comparison of 19 pre-operative risk stratification models in open-heart surgery. Eur Heart J 2006;27:867-74.
2. Siregar S, Groenwold RH, de Heer F, Bots ML, van der Graaf Y, van Herwerden LA. Performance of the original EuroSCORE. Eur J Cardiothorac Surg 2012;41:746-54.
3. Ranucci M, Castelvecchio S, Menicanti L, Frigiola A, Pelissero G. Risk of assessing mortality risk in elective cardiac operations: age, creatinine, ejection fraction, and the law of parsimony. Circulation 2009;119:3053-61.
4. Ranucci M, Castelvecchio S; Surgical and Clinical Outcome Research (SCORE) group. The ACEF score one year after: a skeleton waiting for muscles, skin, and internal organs. EuroIntervention 2010;6:549-53.
5. Ranucci M, Castelvecchio S, Conte M, Megliola G, Speziale G, Fiore F, et al. The easier, the better: age, creatinine, ejection

fraction score for operative mortality risk stratification in a series of 29,659 patients undergoing elective cardiac surgery. J Thorac Cardiovasc Surg 2011;142:581-6.
6. Swinkels BM, Plokker HW. Evaluating operative mortality of cardiac surgery: first define operative mortality. Neth Heart J 2010;18:344-5.
7. Roques F, Michel P, Goldstone AR, Nashef SA. The logistic EuroSCORE. Eur Heart J 2003;24:881-2.
8. Fındık O, Haberal İ, Akyıldız M, Aksoy T, Ertürk E, Zorman Y ve ark. EuroSCORE, Cleveland ve CABDEAL klinik risk sınıflama sistemlerinin Türk toplumu için duyarlılık ve özgüllüklerinin karşılaştırılması. Turk Gogus Kalp Dama 2012;20:458-66.
9. Nashef SA, Roques F, Michel P, Gauducheau E, Lemeshow S, Salamon R. European system for cardiac operative risk evaluation (EuroSCORE). Eur J Cardiothorac Surg 1999;16:9-13.
10. Gogbashian A, Sedrakyan A, Treasure T. EuroSCORE: a systematic review of international performance. Eur J Cardiothorac Surg 2004;25:695-700.
11. Akar AR, Kurtcephe M, Sener E, Alhan C, Durdu S, Kunt AG, et al. Validation of the EuroSCORE risk models in Turkish adult cardiac surgical population. Eur J Cardiothorac Surg 2011;40:730-5.
12. Bhatti F, Grayson AD, Grotte G, Fabri BM, Au J, Jones M, et al. The logistic EuroSCORE in cardiac surgery: how well does it predict operative risk? Heart 2006;92:1817-20.
13. Nashef SA, Roques F, Sharples LD, Nilsson J, Smith C, Goldstone AR, et al. EuroSCORE II. Eur J Cardiothorac Surg 2012;41:734-44.
14. Kunt AG, Kurtcephe M, Hidiroglu M, Cetin L, Kucuker A, Bakuy V, et al. Comparison of original EuroSCORE, EuroSCORE II and STS risk models in a Turkish cardiac surgical cohort. Interact Cardiovasc Thorac Surg 2013;16:625-9.
15. Carnero-Alcázar M, Silva Guisasola JA, Reguillo Lacruz FJ, Maroto Castellanos LC, Cobiella Carnicer J, Villagrán Medinilla E, et al. Validation of EuroSCORE II on a single-centre 3800 patient cohort. Interact Cardiovasc Thorac Surg 2013;16:293-300.
16. Di Dedda U, Pelissero G, Agnelli B, De Vincentiis C, Castelvecchio S, Ranucci M. Accuracy, calibration and clinical performance of the new EuroSCORE II risk stratification system. Eur J Cardiothorac Surg 2013;43:27-32.
17. Ranucci M, Castelvecchio S, Menicanti L, Frigiola A, Pelissero G. Accuracy, calibration and clinical performance of the EuroSCORE: can we reduce the number of variables? Eur J Cardiothorac Surg 2010;37:724-9.
18. Wykrzykowska JJ, Garg S, Onuma Y, de Vries T, Goedhart D, Morel MA, et al. Value of age, creatinine, and ejection fraction (ACEF score) in assessing risk in patients undergoing percutaneous coronary interventions in the 'All-Comers' LEADERS trial. Circ Cardiovasc Interv 2011;4:47-56.
19. Ranucci M, Ballotta A, Castelvecchio S, Baryshnikova E, Brozzi S, Boncilli A, et al. Intensive care unit admission parameters improve the accuracy of operative mortality predictive models in cardiac surgery. PLoS One 2010;5:e13551.