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## Original Article

# Outcome Prediction After Open Heart Surgery

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**Abstract**

**Background:** Mortality is the most commonly used outcome measure after cardiac surgery. Various risk scores were developed to predict mortality after cardiac surgery with wide variability in risk stratification. We evaluated the accuracy of Acute Physiology and Chronic Health Evaluation II (APACHE II) score, Sequential Organ Failure Assessment (SOFA) score and Cardiac Surgery Score (CASUS) in predicting mortality in our patients.

**Methods:** Between October 2015 and December 2017, 103 adult patients who underwent open heart surgery were evaluated. The clinical characteristics, outcomes and risk scores data of the patients were collected. Accuracy of the scores was assessed using receiver operating curve (ROC) and the multivariate logistic regression analysis.

**Results:** 103 patients were enrolled with mortality rate of 10.3%. The non-survivors group showed statistically significant lower ejection fraction (EF), higher platelet count, higher bilirubin level and lower PO2 level (P value: 0.015, 0.020, 0.038, 0.006 respectively). Both APACHE II and SOFA scores performed better than CASUS score in predicting mortality in this study. However, APACHE II score (Area Under Curve "AUC": 0.878, sensitivity: 80%, specificity: 78.5%) and the preoperative platelet count independently predicted mortality after cardiac surgery.

**Conclusion:** Both APACHE II and SOFA scores showed the ability to predict mortality after cardiac surgery but APACHE II score rises as the best tool for risk stratification in our patient population.

**KEYWORDS**
Mortality;
Cardiac surgery;
Risk scores

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## Introduction

Cardiac surgery is a complex area for outcome prediction with a considerable risk of mortality and morbidity.[1] Various risk stratification scores can be used to predict outcome after cardiac surgery. However, to use an outcome it should be well defined, easily measured and

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objective. Mortality is the most commonly used outcome because it is relatively easy to determine.[2]

Mortality following cardiac surgery ranges from 2.94 to 32.5% depending on the different types of surgery and populations.[3-5] Numerous risk scores were developed to predict mortality after cardiac surgery but still there is wide variability among these scores with regard to score design and the initial population on which the score was developed.[6]

The focus of risk scores was on the preoperative risk models, but most of them did not consider the intraoperative circumstances and the adverse effects of the cardiopulmonary bypass. For this reason, postoperative risk scores such as APACHE II score, SOFA score and CASUS score could be considered better in predicting outcomes.[7]

Postoperative scores are widely used in mortality prediction after cardiac surgery but their validity in our patient population has not been tested. So, it was our aim to compare the ability of different scores in predicting clinical outcome after open heart surgery in our center.

## Patients and Methods:

We included 103 patients who underwent open heart surgery in the period between October 2015 and December 2017. We excluded patients less than 18 years old, patients readmitted to the intensive care unit (ICU), emergency operations and patients with incomplete data.

All available data of the study population including preoperative (full history, clinical examination and laboratory investigations), intraoperative (total bypass time, ischemic time and type of surgery) and postoperative data that included all available ICU data and investigations were recorded. Scoring systems were calculated from this database. Preoperative European System for Cardiac Operative Risk Evaluation (EuroSCORE) (additive and Logistic) was calculated in the routine preoperative workup. Ejection fraction (EF) was measured by M-mode echocardiography while estimated systolic pulmonary artery pressure was assessed by continuous wave doppler of the tricuspid flow. Patients with elevated pulmonary artery pressure were treated using sildenafil preoperatively and milrinone intraoperatively.

SOFA score was calculated daily for maximum of 4 days,[8] CASUS score was calculated on the 2nd and 4th day of ICU admission[9] and APACHE II score was calculated in the first 24 hours of ICU admission.[10] The worst data was taken for each variable of the scores.

The main outcome measure was 30-day mortality. Other measures of outcome were expressed as: duration of ventilation and length of stay in the cardiac surgery intensive care unit (CSICU) and in the ward.

## Statistical analysis:

The collected data were organized, tabulated and statistically analyzed using SPSS version 19 (Statistical Package for Social Studies) created by IBM, Illinois, Chicago, USA. For numerical values the mean and standard deviations were calculated. The differences between two mean values were used using Mann-Whitney test. Normality was tested by Shapiro-Wilk test and assessed by histogram. For categorical variable the number and percentage were calculated and differences between subcategories were tested by Monte Carlo exact test. The correlation between two variables was calculated using Pearson's correlation coefficient for normally distributed variables and spearman correlation for not normally distributed variables. Multivariate logistic regression was used for multivariate analysis of numerical variables affecting survival and Hosmer

Lemeshow test was used to express fitness of the model. The ROC curve was used to test predictability of survival by SOFA, CACUS and APACHE II. The level of significant was adopted at $p<0.05$.

## Results:

The 103 patients were adults with a mean age of 45.02+13.15 years and 54.36% were females. The overall 30-day mortality was 10.3%. The most common surgical procedure was mitral valve replacement (39 patients) followed by combined surgeries (20 patients), CABG (16 patients), aortic valve replacement (13 patients), double valve replacement (4 patients), ASD closure (2 patients), VSD closure (2 patients) and other surgeries (7 patients).

The preoperative characteristics of our patients were listed in Table 1. Compared to the survival group, the mortality group showed lower ejection fraction (54.10+9.72 percent, P-value: 0.015), higher platelet count (285.40+67.42 X $10^3/mm^3$, P value: 0.020), higher bilirubin level (0.91+0.10 mg/dL, P-value: 0.038) and lower PO2 level (78.00 +8.39 mmHg, P-value: 0.006). Table 2 shows a comparison between the survival and mortality groups regarding the intraoperative and postoperative data. The mortality group showed a marked increase in the postoperative hours of ventilation (78.44+122.22 hours, P-value: 0.025).

The estimated mortality was 17.52%, 16.06%, 16% and 3.55% according to SOFA, APACHE II, CASUS scores and EuroSCORE respectively. Both APACHE II and SOFA scores showed satisfactory significance between survivors and non-survivors as shown in Table 2. The AUC listed in Table 3 showed that both APACHE II and SOFA scores had a satisfactory ability in predicting mortality after cardiac surgery (AUC: 0.878, P-value: 0.001) and that both APACHE II and SOFA scores are better than CASUS score (AUC: 0.673, P-value: 0.108) in predicting mortality (Figure 1). The preoperative scores (EuroSCORE additive and logistic) showed no significant difference between survivors and non-survivors as shown in Table 1.

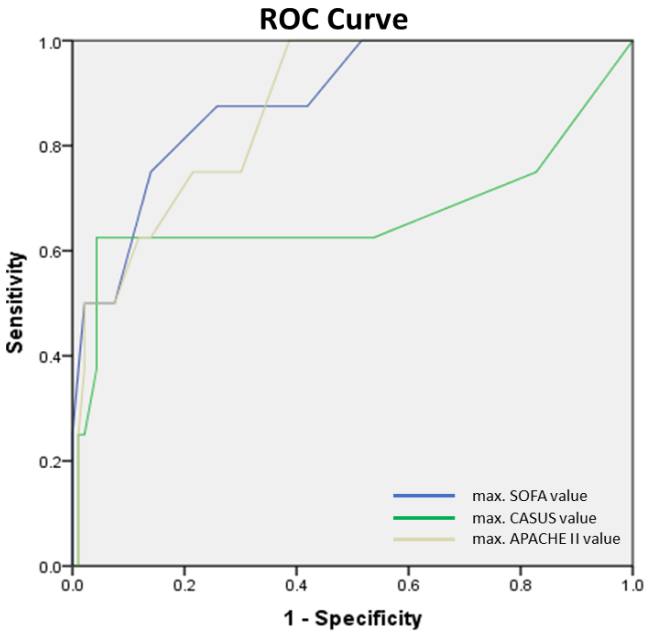


*Figure 1: ROC curve for the three scores.*

According to the multivariate logistic regression analysis only the APACHE II score and the preoperative platelet count were independent predictors of mortality after cardiac surgery (Table 4).

Regarding other outcome measures, all scores showed a significant correlation with the length of ICU stay and postoperative hours of ventilation. On the contrary none of the scores showed correlation with the length of hospital stay as shown in Table 5.

## Discussion:

Our study population included 103 patients who had cardiac interventions and admitted to ICU after open heart surgery. The overall 30-day mortality was 10.3% which is considered to be higher than the average mortality reported in previous studies 9.3%, 9.6% and 6%.[11-13] This may be due to the higher rate of postoperative cardiac and respiratory

*Table 1: Preoperative characteristics. Categorical variables are presented as numbers and percentage (%). Continuous variables are presented as mean+ SD*

| Variable | Survivors | Non-survivors | P-value |
|---|---|---|---|
| Age in years | 44.51±13.22 | 49.90±12.11 | 0.235 |
| Sex (Female) | 49 (87.5%) | 7 (12.5%) | 0.339 |
| Body surface area | 1.81±0.20 | 1.80±0.12 | 0.747 |
| Atrial fibrillation | 32 (34.4%) | 3 (30%) | 1.000 |
| Diabetes mellitus | 11 (11.8%) | 3 (30%) | 0.135 |
| Hypertension | 9 (9.67%) | 0 (0.0%) | 0.594 |
| Previous cardiac surgery | 7 (7.52%) | 0 (0.0%) | 1.000 |
| Pulmonary hypertension | 41 (44.08%) | 5 (50%) | 0.749 |
| Ejection fraction | 61.66±8.04 | 54.10±9.72 | 0.015 |
| Hemoglobin | 12.04±1.42 | 11.85±0.71 | 0.721 |
| Platelets count ($X10^3$) | 232.32±64.41 | 285.40±67.42 | 0.020 |
| Total leucocyte count ($X10^3$) | 7.09±2.31 | 7.29±1.81 | 0.533 |
| Albumin | 3.83±0.31 | 3.68±0.40 | 0.229 |
| Bilirubin | 0.83±0.30 | 0.91±0.10 | 0.038 |
| Blood urea | 31.42±8.92 | 30.50±11.47 | 0.381 |
| Creatinine | 0.91±0.21 | 0.89±0.19 | 0.765 |
| INR | 1.10±0.09 | 1.10±0.09 | 0.345 |
| Prothrombin activity | 87.99±8.74 | 88.10±13.75 | 0.384 |
| pH | 7.47±0.07 | 7.44±0.03 | 0.100 |
| $PCO_2$ | 34.40±4.30 | 35.73±7.02 | 0.203 |
| $PO_2$ | 107.09±54.27 | 78.00±8.39 | 0.006 |
| $HCO_3$ | 26.19±3.99 | 25.79±2.99 | 0.738 |
| Serum potassium | 3.84±0.41 | 3.80±0.41 | 0.614 |
| EuroSCORE additive | 3.82±1.82 | 4.10±2.23 | 0.759 |
| EuroSCORE logistic | 3.42±2.30 | 3.77±2.50 | 0.880 |

*INR: International normalized ratio

complications. Twenty-seven over 103 patients (26.2%) had cardiac complications while 16/103 patients (15.5%) had respiratory complications. This explanation was consolidated by the results of the univariate analysis that identified preoperative EF and PO2 as predictors of postoperative mortality. Among the

Table 2: Intraoperative and postoperative data

| Variable | Survivors | Non-survivors | Z | P |
|---|---|---|---|---|
| APACHE II | 10.85±3.99 | 10.10±5.30 | 3.936 | 0.001 |
| Maximum SOFA | 5.91±2.54 | 10.44±3.05 | 3.754 | 0.001 |
| Maximum CASUS | 6.13±2.00 | 9.38±4.34 | 1.608 | 0.108 |
| Ischemic time | 89.02±38.82 | 107.25±36.30 | 1.394 | 0.163 |
| Total bypass time | 124.98±46.69 | 158.13±49.67 | 1.769 | 0.077 |
| ICU stay in days | 3.97±3.38 | 5.70±4.64 | 0.941 | 0.347 |
| Hours of ventilation | 8.53±8.87 | 78.44±122.22 | 2.239 | 0.025 |

preoperative data 34/103 patients (33%) had severe pulmonary hypertension which is considered a high surgical risk and associated with higher likelihood of cardiopulmonary complications.[14]

Many studies have been conducted on risk models after cardiac surgery estimating mortality and morbidity, but to date, there is no consensus regarding the best scoring system after cardiac surgery.[15] Our results showed that the preoperative score (EuroSCORE) underestimated the mortality risk in our patient population. The poor performance of the preoperative score could be attributed to the fact that EuroSCORE is limited to preoperative variables and does not take into account intraoperative or postoperative circumstances. It is possible that different patient populations, surgical interventions and postoperative management may affect a predictive ability of a scoring system.[13] On the other hand, the postoperative scores (APACHE II and SOFA scores) were predictors of mortality after cardiac surgery in our study. So, postoperative scores are necessary to evaluate the postoperative risk.

By comparing the postoperative scores, we found that both APACHE II and SOFA scores have similar predictive values (AUC: 0.878, P-value: 0.001) for mortality compared to the poor performance of CASUS score (AUC: 0.673, P-value: 0.108) that failed to predict mortality after cardiac surgery.

Our results regarding the APACHE II score are in accordance with Chang et al. (2017)[16] who studied 483 patients after coronary artery bypass grafting (CABG) and found that APACHE II score in the first ICU day was effective in prediction of mortality (AUC: 0.86, P-value <0.001). Other authors also demonstrated that APACHEII score at ICU admission successfully predicted 30-day mortality in 150 cardiac surgery patients (P-value<0.001).[13] This high predictive power may be attributed to the large number of variables (12 variable) that allows more accurate monitoring of organ dysfunction. The APACHE II score takes in consideration the age, patient co-morbidities and type of ICU admission which are important factors in determining prognosis and survival.[18] Despite of the good performance of the APACHE II score, it still cannot guide the clinical decision reliably after the first period of ICU admission as it is calculated only once in the early ICU admission. But, this still can be solved if APACHE II score have the ability to predict the risk on daily basis.[19]

The SOFA score had good ability to predict mortality (AUC: 0.878, P-value <0.001) in our study. Our results are supported by the results of Ceriani et al. (2003)[20] who calculated SOFA score for the first 10 postoperative days in cardiac

*Table 3: Results of Recipient Observer Characteristics (ROC) curve for the scores as predictors for mortality*

| Variables | SOFA 1st day | SOFA 2nd day | SOFA 3rd day | SOFA 4th day | SOFA Max. | CASUS 2nd day | CASUS 4th day | CASUS Max. | APACHE II |
|---|---|---|---|---|---|---|---|---|---|
| Area | 0.774 | 0.835 | 0.918 | 0.899 | 0.878 | 0.598 | 0.831 | 0.673 | 0.878 |
| P | 0.005 | 0.002 | 0.001 | 0.002 | 0.001 | 0.359 | 0.012 | 0.108 | 0.001 |
| Cut off value | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 | 4.5 | 10.5 | 25.0 | 13.5 |
| Sensitivity | 70.0% | 50.0% | 71.4% | 66.7% | 88.9% | 75.0% | 83.3% | 62.5% | 80.0% |
| Specificity | 76.3% | 91.4% | 92.6% | 93.1% | 74.2% | 21.6% | 96.7% | 95.7% | 78.5% |

surgery patients and Patila et al. (2006)[21] who evaluated 857 cardiac surgery patients and found that the SOFA score predicted mortality accurately in the first three days (AUC: 0.76). In a more recent study, the SOFA score has the good predictive value for 30-day mortality (P-value <0.001) as reported by Exarchopoulos et al. (2015)[13]. A word of caution about SOFA score is that the cardiovascular component of the SOFA score is based on the administration of vasoactive medication using specific protocols such as dopamine being administered before noradrenaline to treat hypotension. In many centers, clinicians know that these patterns of drug administration are not followed and this may lead to diminished confidence in the SOFA score despite reports of good performance in multiple studies.[13,21,22] Despite the good performance of the SOFA score, only the APACHE II score was identified as an independent predictor of mortality after cardiac surgery by the multivariate analysis (P-value= 0.029). This disagrees with the results of Chang et al. (2017)[16] who also highlighted the strong power of both SOFA and APACHE II scores in predicting mortality but the multivariate analysis identified the SOFA score as an independent predictor of mortality (P-value <0.001).

*Table 4: Multivariate logistic regression analysis of variables affecting survival*

| Variable | T | P |
|---|---|---|
| **Maximum SOFA** | 1.707 | 0.103 |
| **APACHE II** | 2.346 | 0.029 |
| **Platelets count** | 2.598 | 0.017 |
| **$PO_2$** | 0.108 | 0.923 |
| **Bilirubin** | 1.834 | 0.079 |
| **Ejection fraction** | 0.098 | 0.923 |
| Hosmer-Lemeshow $X^2$ 1.49, df 8, p-value 0.99 | | |

In our study the CASUS score failed to predict mortality after cardiac surgery (AUC: 0.673, P-value=0.108). On the contrary to our results, the CASUS score was validated for prediction of 30-day mortality by Doerr at al. (2011)[22] and performed well in the first 6 postoperative days after cardiac surgery (AUC: >90) with

*Table 5: Risk scores and morbidity*

| Variable | ICU stay | | Hours on ventilation | | Hospital stay | |
|---|---|---|---|---|---|---|
| | r | P | r | P | r | P |
| **APACHE II** | 0.294 | 0.003 | 0.478 | 0.001 | -0.054 | 0.657 |
| **Maximum SOFA** | 0.499 | 0.001 | 0.427 | 0.001 | 0.150 | 0.218 |
| **Maximum CASUS** | 0.591 | 0.001 | 0.522 | 0.001 | 0.182 | 0.135 |

the largest AUC on the second ICU day (AUC= 0.97). Also, Exarchopoulos et al. (2015)[13] found that CASUS score showed good performance in the first postoperative day after cardiac surgery (AUC 0.89). The poor results of CASUS score in our study in comparison to other studies may be attributed to the fact that CASUS score takes in consideration the lactic acid level and pressure adjusted heart rate which are thought to be volatile variables and may change continuously.[23] Another reason is the difference in populations as it lacks its application in different countries and it has not been tested in multicenter studies and accordingly has not yet gained much popularity.[7] In fact, these differences in the reported results among several studies indicate the importance of testing the scoring systems in the local environment of each surgical center.

The superiority of APACHE II score in our population coincides with an earlier study conducted in our center that investigated several (trauma-specific and general severity of illness) scores for risk stratification of mortality in 400 patients after thoracic trauma.[17] Among the investigated scores, APACHE II score yielded the highest predictive value of mortality in our patient population.

Another factor that was identified as an independent predictor of mortality is the preoperative platelet count. In the past years the main interest was focused on thrombocytopenia and the risk of bleeding after cardiac surgery. But recently, The platelet count has been proved to play a major role in the outcome of thromboembolic events such as myocardial infarction and stroke.[24] During cardiopulmonary bypass multiple processes occur involving platelets, coagulation factors and vascular endothelium promoting the shift of risk from bleeding to thrombosis that manifest as multi-organ complications and worsens the outcome.[25] In 2000, Vuylsteke and his colleagues[26] found that the increased preoperative platelet count was associated with increased heparin resistance due to the increased capacity to produce platelet factor 4 that neutralizes heparin, the platelet count in patients who showed heparin resistance was {252 (221 - 270) X $10^3/mm^3$} while normal patients platelet count was {194 (165–223) X $10^3/mm^3$}. In our study we found that the preoperative platelet count was higher in non survivors {296.87 ± 66.05 X $10^3/mm^3$} compared to survivors {236.79 ± 66.92 X $10^3/mm^3$} and this was supported by the results of Unal et al. (2013)[25] who reported that the increased platelet count was correlated with adverse events after CABG with The reported platelet count in their patients with adverse events being 262 ± 66 X $10^3/mm^3$. The increased preoperative platelet count is still an area of debate and needs more extensive research.

Regarding other outcome measures, our results showed that all the three scores are significantly correlated with postoperative length of ICU stay and duration of mechanical ventilation but none of the scores was correlated with the postoperative hospital stay. This may be

explained by our protocol of patient discharge that recommends the discharge of patients after valve surgery when INR reaches at least 2 to avoid complications because of the nature of our patients and unavailability of healthcare in many rural areas. This will lead eventually to prolongation of the hospital stay that is not related to morbidity events.

## Limitations of the study:

The small number of cases as well as single center experience might limit the generalization of the findings and the results to different populations.

The scoring systems used were calculated at different time points in the postoperative course of the patient and this may affect the results due to the possible dynamic changes of the postoperative patient status

Lastly, it is well known that mortality in the ICU is multifactorial and is dependent on practice. It is possible that other several factors that are not included in the scoring systems could affect the outcome of the patients.

## Conclusion:

Both APACHE II and SOFA scores showed a high power in predicting mortality but APACHE II score rises as the best tool for risk stratification in our patients. It can be used as a guide to develop a local risk model but still more extensive studying is needed for generalization of the results.

Results validating the score is a must before its use in daily practice and to choose a score, patients' characteristics must be considered. Larger studies to validate the scores is recommended.

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## References

1. Nilsson J, Algotsson L, Hoglund P et al. Comparison of 19 pre-operative risk stratification models in open-heart surgery. Eur Heart J. 2006; 27: 867-874.
2. Osswald BR, Tochtermann U, Schweiger P et al. Minimal early mortality in CABG–simply a question of surgical quality?, Thorac Cardiovasc Surg. 2002; 50: 276-280.
3. Mehta RH, Suzuki T, Hagan PG et al. Predicting death in patients with acute type a aortic dissection. Circulation 2002; 105(2): 200-206.
4. Siregar S, Groenwoldb RH, De Mol Bas AJM. et al. Evaluation of cardiac surgery mortality rates: 30-day mortality or longer follow up? Eur J Cardiothorac Surg. 2013; 44: 875-883.
5. Chang CH, Lee CC, Chen SW et al. Predicting acute kidney injury following mitral valve repair. Int J Med Sci. 2016; 13(1): 19–24.
6. Geissler HJ, Hölzl P, Marohl S et al. Risk stratification in heart surgery: comparison of six score systems. Eur J Cardiothorac Surg. 2000; 17(4): 400-406.
7. Tamayo E, Fierro I, Munguira J B et al. Development of the Post Cardiac Surgery (POCAS) prognostic score. Crit Care Med. 2013; 17: 209-218.
8. Vincent JL, Moreno R, Takala J et al. The sofa (sepsis-related organ failure assessment) score to describe organ dysfunction/failure. on behalf of the working group on sepsis-related problems of the european society of intensive care medicine. Intens Care Med. 1996; 22: 707-710.
9. Hekmat K, Kroener A, Stuetzer H et al. Daily assessment of organ dysfunction and survival in intensive care unit

cardiac surgical patients. Ann Thorac Surg. 2005; 79(5): 1555-1562.
10. Knaus WA, Draper EA, Wagner DP et al. APACHE II: a severity of disease classification system. Crit Care Med. 1985; 13(10): 818-829.
11. Curiel-Balsera E, Mora-Ordonez JM, Castillo-Lorente E et al. Mortality and complications in elderly patients undergoing cardiac surgery. J Crit Care. 2013; 28(4): 397-404.
12. Junior JAM, Nakazone M, Machado MN et al. Predictors of mortality in cardiac surgery: brain natriuretic peptide type B. Braz J Cardiovasc Surg. 2015; 30(2): 182-187.
13. Exarchopoulos T, Charitidou E, Dedeilias P et al. Scoring System for Outcome Prediction in a Cardiac Surgical Intensive Care Unit: A Comparative Study. Am J Crit Care. 2015; 4: 327-334.
14. Denault A, Deschamps A, Tardif J-C et al. Pulmonary Hypertension in Cardiac Surgery. Current Cardiology Reviews. 2010; 6(1): 1-14.
15. Ryan TA, Rady My, Bashour CA et al. Predictors of Outcome in Cardiac Surgical Patients With Prolonged Intensive Care Stay. CHEST 1997; 112: 1035-1042.
16. Chang CH, Chen SW, Fan PC et al. Sequential organ failure assessment score predicts mortality after coronary artery bypass grafting. BMC Surgery 2017; 17: 22-28.
17. Shoeib M, Serag A, Abo Elnasr M et al. Risk stratification of outcome in chest trauma patients. M.Sc. thesis in General Surgery submitted to Faculty of Medicine – Tanta University 2016.
18. Ho K. M, Lee K. Y, Williams T et al. Comparison of Acute Physiology and Chronic Health Evaluation (APACHE) II score with organ failure scores to predict hospital mortality. Anaesthesia. 2007; 62: 466-473.
19. Howitt SH, Grant SW, Riding DM et al. Risk Models That Use Postoperative Patient Monitoring Data to Predict Outcomes in Adult Cardiac Surgery: A Systematic Review. J Cardiothorac Vasc Anesth. 2016; 10: 12-23.
20. Ceriani R, Mazzoni M, Bortone F, et al: Application of the sequential organ failure assessment score to cardiac surgical patients. Chest 2003; 123: 1229-1239.
21. Pätilä T, Kukkonen S, Vento A et al. Relation of the Sequential Organ Failure Assessment Score to Morbidity and Mortality After Cardiac Surgery. Ann Thorac Surg. 2006; 82: 2072-2079.
22. Doerr F, Badreldin AMA, Heldwein B et al. A comparative study of four intensive care outcome prediction models in cardiac surgery patients. J Cardiothorac Surg. 2011; 6: 21-28.
23. Hekmat K, Doerr F, Kroener A et al. Prediction of mortality in intensive care unit cardiac surgical patients. Eur J Cardiothorac Surg. 2010; 38(1): 104-109.
24. Kerati MD, Zhou S, Karhausen JA et al. Platelet Counts, Acute Kidney Injury, and Mortality after Coronary Artery Bypass Grafting Surgery. Anesthesiology 2016; 124: 339-52.
25. Unal EU, Ozen A, Kocabeyoglu S et al. Mean platelet volume may predict early clinical outcome after coronary artery bypass grafting. J Cardiothorac Surg. 2013; 8: 91-97.
26. A. Vuylsteke, R. J. Mills, A. E. Crosbie et al. Increased pre-operative platelet counts are a possible predictor for reduced sensitivity to heparin, BJA. 2000; 85(6): 896-898.