Performance of EuroSCORE II and logistic EuroSCORE in Bangladeshi population undergoing off-pump coronary artery bypass surgery: A prospective cohort study

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Abstract

Introduction: European System for Cardiac Operative Risk Evaluation (EuroSCORE) was developed to identify patients who may have a greater postoperative risk for adverse effects following adult cardiac surgery. This study evaluated the discriminatory potential of using the EuroSCORE system in predicting the early, as well as late, postoperative outcomes following coronary artery bypass graft surgery in Bangladesh.

Methods: A total of 865 patients who underwent isolated coronary artery bypass graft surgery were evaluated with the EuroSCORE risk scoring system. Moreover, we also compared the discriminatory potentials between the EuroSCORE II and the original logistic EuroSCORE.

Results: Operative mortality was best predicted by EuroSCORE II (area under the curve (AUC) 0.863, Brier score 0.030) compared to the original logistic EuroSCORE (AUC 0.849, Brier score 0.033). However, the overall expected-to-observed mortality ratio for EuroSCORE II was 1.1, whereas the observed ratio for the original logistic EuroSCORE was 1.7. EuroSCORE II was predictive of an intensive care unit stay of five days or more (AUC 0.786), prolonged inotropes use (AUC 0.746), stroke (AUC 0.646), de novo dialysis (AUC 0.810), and low output syndrome (AUC 0.715). Moreover, a high EuroSCORE II quintile significantly predicted the risk for late mortality ($p < 0.0001$).

Conclusions: EuroSCORE has an important role in predicting the early, as well as late, postoperative outcomes following coronary artery bypass surgery. However, the performance of EuroSCORE II is significantly better than the original logistic EuroSCORE in predicting postoperative morbidity and mortality after isolated coronary artery bypass graft surgery among Bangladeshi patients.

Introduction

The European System for Cardiac Operative Risk Evaluation (EuroSCORE) scoring system has been demonstrated to be an important measure for predicting immediate, as well as late, postoperative morbidity and mortality following adult heart surgery.[1,2] This score has been robustly demonstrated in patients undergoing surgical myocardial revascularization via either off-pump coronary artery bypass surgery (OPCABG) or on-pump coronary artery bypass

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surgery (CABG).[3,4] The EuroSCORE II scoring system has standard calibration and discrimination to predict mortality following OPCABG. However, the incidence of intraoperative conversion to on-pump CABG is a major disadvantage of OPCABG surgery, and the probability of requiring conversion to on-pump CABG is greatly influenced by a higher EuroSCORE II score.[5] Furthermore, there is an increased risk of postoperative complications, as well as poor life expectancy rates, in elderly patients.[6,7]

In clinical research, the EuroSCORE system has been identified as a significant tool for measuring both operative and postoperative risks in adult heart surgery.[8–10] For this purpose, the presence of comorbidities that might influence the postoperative outcome, especially postoperative care, should always be considered. However, the quality of prediction for a risk scoring system has great influence on the study outcome, and a perfect evaluation of a risk scoring system should include all relevant variables of the study population.[10] Furthermore, this risk scoring system is observed to be most acceptable when both preoperative variables and treatment strategies are comparable within the study population, which is the basis on which the scoring system was developed.[5–9,11] Therefore, the risk scoring system should be evaluated in a regional study population to confirm its validity and patient management strategies and to identify any substantial changes that may arise after using the risk scoring system.[10–12] The aim of this study was to evaluate the effectiveness of the EuroSCORE system in predicting both the early and late postoperative outcomes of patients who have undergone CABG surgery in Bangladesh.

Materials and methods

During the period from January 2011 to December 2017, a total of 1403 consecutive patients underwent isolated OPCABG surgery at Bangabandhu Sheikh Mujib Medial University in Bangladesh, and these patients were enrolled in this prospective study. Patient records were prospectively reviewed to obtain data on the variables according to the EuroSCORE risk scoring system. The analysis was restricted to 865 patients due to the unavailability of data on New York Heart Association (NYHA) functional class or Canadian Cardiovascular Society (CCS) class for a few of our study populations. Furthermore, patients with a lack of data regarding active endocarditis, low left ventricular ejection fraction (<30%), and utilization of a double internal mammary artery graft were classified as having incomplete data and were thus excluded from this study. Both the preoperative and

operative data regarding the variables of the study patients are shown in Table 1.

Baseline characteristics and operative data for variables were collected from the institutional clinical registry, and they were grouped into a database. Moreover, complete medical records (including preoperative, operative, and postoperative data) of the eligible population were evaluated to predict both the preoperative and postoperative incidence of adverse effects. Operative risk was predicted by the utilization of both the original logistic EuroSCORE and EuroSCORE II scoring systems. The primary endpoints of this study were early postoperative mortality and in-hospital mortality. Late mortality was also included as a principal outcome variable. The secondary study endpoints were length of intensive care unit (ICU) stay, perioperative MI, 30-day postoperative mortality, prolonged use of inotropes, low cardiac output syndrome, stroke, de novo dialysis, chest reopening, and mediastinitis.

Operative techniques

All procedures were performed through a standard median sternotomy, and a cardiopulmonary bypass (CPB) circuit was kept on standby for all procedures. Systemic infusion of heparin was used just before completing the left internal mammary artery harvest to maintain an activated clotting time of more than 350 s. Nearly, all of the operations were performed as OPCABG surgery, and a few of the operations required the utilization of the CPB circuit. We utilized mechanical stabilizers, such as the suction type and the compression type, in order to immobilize the target coronary artery during grafting.

Statistical analysis

The statistical analysis was performed using SPSS software (SPSS version 10.0.5, Chicago, IL). Continuous variables are presented as the mean and standard deviation. Moreover, the chi-square test and Fisher's exact test were utilized for the univariate analysis. A receiver operating characteristics (ROC) curve was used to identify the best cut-off value for predicting the continuous variables of 30-day mortality rate and mortality at one-year follow-up. The area under the curve (AUC) and corresponding 95% confidence interval (CI) were used to calibrate each risk scoring system. The Brier score demonstrated the accuracy of the risk scoring system – the mean squared difference between the true incidence and predicted probability of operative mortality. Furthermore, the Brier score should be as close to zero as possible, and an acceptable upper cut-off value of the score is 0.25. This study compared

Table 1. Preoperative and operative variables study population.

Variables	Complete data (n = 865)	Incomplete data (n = 538)
Age (years)	57.0 ± 8.5	56.0 ± 7.5
Females	211 (24.40%)	114 (21.19%)
Body mass index	27 ± 7.5	28 ± 5.5
Renal function, eGFR mL/min/1.73 m^2	87 ± 34	91 ± 32
Dialysis	11 (1.3%)	6 (1.12%)
Extra cardiac arteriopathy	81 (9.36%)	51 (9.48%)
Poor mobility	21 (2.43%)	12 (2.23%)
Previous cardiac surgery	7 (0.81%)	4 (0.73%)
Chronic lung disease	92 (10.63%)	57 (10.59%)
Active endocarditis	7 (0.81%)	–
Critical preoperative status	81 (9.36%)	39 (7.25%)
Atrial fibrillation	104 (12.02%)	64 (11.90%)
Unstable angina	146 (16.88%)	73 (13.57%)
Recent myocardial infarction	391 (45.20%)	241 (44.80%)
History of coronary angioplasty	112 (12.95%)	62 (11.52%)
Pulmonary hypertension		
31–55 mmHg	11 (1.27%)	6 (1.12%)
>55 mmHg	–	–
Surgery on thoracic aorta		
Yes	0 (0%)	0 (0%)
No	865 (100%)	538 (100%)
Diabetes		
Non-insulin dependent	139 (16.10%)	92 (17.10%)
Insulin dependent	98 (11.33%)	57 (10.59%)
New York Heart Association classes		
I	0 (0%)	–
II	298 (34.45%)	–
III	384 (44.39%)	–
IV	183 (21.16%)	–
CCS Class IV		
Yes	172 (19.88%)	–
No	693 (80.12%)	–
Left ventricular ejection fraction		
>50%	482 (55.72%)	327 (60.78%)
30–50%	281 (32.48%)	–
<30%	102 (11.80%)	–
Type of surgery		
Elective	457 (52.83%)	256 (47.58%)
Urgent	322 (37.23%)	241 (44.80%)
Emergency	86 (9.94%)	41 (7.62%)
Salvage	0 (0%)	0 (0%)
Internal mammary artery graft		
Single	814 (94.1%)	492 (91.45%)
Double	28 (3.24%)	–
Radial artery graft	78 (9.02%)	46 (8.55%)
Off-pump heart surgery	814 (94.1%)	492 (91.45%)
Number of distal anastomoses	3.25 ± 1.75	3.5 ± 1.5

eGFR: estimated glomerular filtration rate; CCS class: Canadian Cardiovascular Society class.

the Brier scores of these risk scoring systems using the Wilcoxon test. Moreover, the predicted-to-observed operative mortality rate was also observed to estimate the effectiveness of each individual risk scoring system. Optimal performance of the risk scoring system is defined by a calculated ratio of one. The Kaplan–Meier (K–M) method, as well as survival analysis, was used to demonstrate the effect of single variables on the long-term outcome. Furthermore, the reference to the log-rank test ($p < 0.0001$) was used to compare K–M curves. Nonetheless, p-values ≤ 0.05 were considered statistically significant.

Results

Operative mortality

In this study, the 30-day postoperative mortality was 3.58%, and the in-hospital mortality rate was approximately 2.89%. However, the predicted postoperative mortality rate by the original logistic EuroSCORE was 6.5%±9.6%, and according to the EuroSCORE II system, the mortality rate was 4.4%±6.5%. EuroSCORE II showed better stratification of the risk score for predicting postoperative mortality (AUC 0.863, 95% CI 0.804–0.921) than the original

logistic EuroSCORE (AUC 0.849, 95% CI 0.784–0.913). Furthermore, the Brier scores of the two systems were statistically significantly different (p-value = 0.0001); the scores were 0.033 and 0.030 for the original logistic EuroSCORE and EuroSCORE II systems, respectively. Figure 1 demonstrates the predicted and observed operative mortality rates according to the EuroSCORE II quintiles. The predicted-to-observed mortality ratio for EuroSCORE II was 1.1, and that for the original logistic EuroSCORE, the predicted-to-observed mortality ratio was 1.7. Figure 2 illustrates the
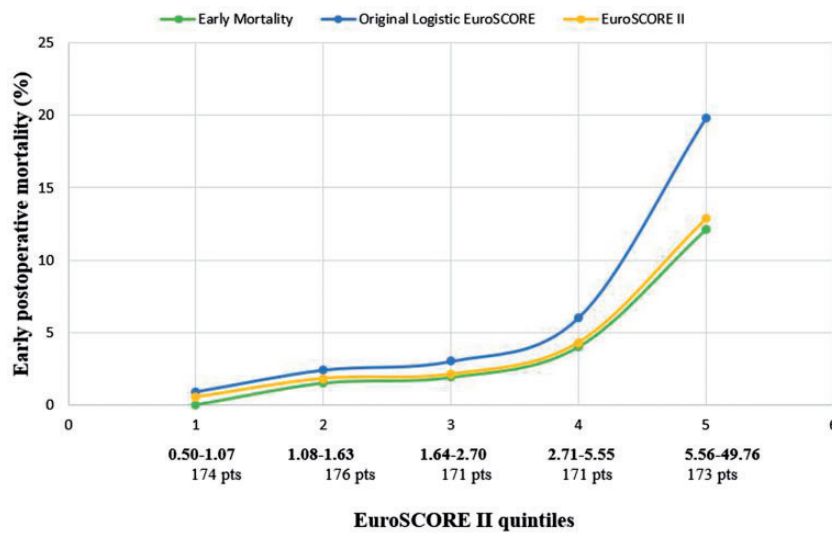

Figure 1. Observed and predicted operative mortality rates according to the original logistic European system for cardiac operative risk evaluation (EuroSCORE), and EuroSCORE II according to quintiles of the EuroSCORE II. Early mortality represents postoperative 30-day mortality.
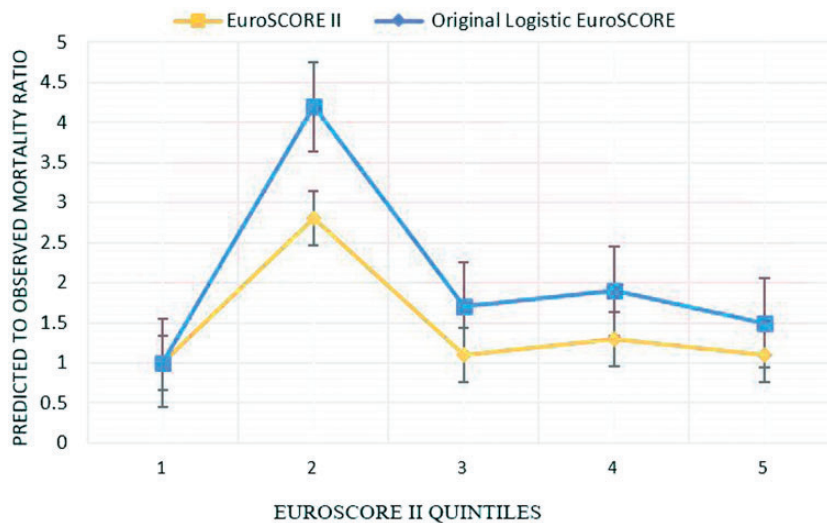

Figure 2. Line diagram demonstrating the predicted-to-observed operative mortality ratio between the EuroSCORE II, and the original logistic EuroSCORE. However, EuroSCORE II has a prediction of optimal performance in the third highest quintiles.

predicted-to-observed mortality ratio for each EuroSCORE II quintile, and it shows that the EuroSCORE II system performance was optimum in its three highest quintiles (range in these quintiles: 1.04 to 1.16). The ideal cut-off value of EuroSCORE II for predicting operative mortality was 10% (<10%, 13 of 774 patients: 1.7% versus ≥10%, 19 of 91 patients: 20.9%, p < 0.0001). Nonetheless, this cut-off value had 91.6% sensitivity and 61.4% specificity, a 91.2% accuracy rate, and a 98.2% negative predictive value.

Early postoperative outcome

EuroSCORE II was better at predicting postoperative major adverse effects than the original EuroSCORE system, which is shown in Table 2 and Figure 3.

During in-hospital stay, this study observed major morbidity incidence, in which 11.7% of the patients required a prolonged ICU (≥5 days) stay; 0.81% had a stroke, 1.50% required de novo dialysis, and approximately 13% developed low cardiac output syndrome. Due to excessive hemorrhage, chest re-exploration was required in 2.80% of the patients. This risk scoring system predicted outcomes well, especially in the patients with an ICU stay ≥5 days (AUC 0.786, 95% CI 0.749–0.823), prolonged inotropes use (AUC 0.746, 95% CI 0.714–0.778), low cardiac output syndrome (AUC 0.715, 95% CI 0.671–0.760), de novo dialysis (AUC 0.810, 95% CI 0.737–0.883), stroke (AUC 0.646, 95% CI 0.534–0.757), and the combined endpoint (AUC 0.751, 95% CI 0.721–0.781).

Table 2. Postoperative adverse outcome after isolated off-pump coronary artery bypass surgery.

Outcome Endpoints	Total patients N=865 (%)	Original logistic EuroSCORE (AUC, 95% CI)	EuroSCORE II (AUC, 95% CI)
Intensive care unit stay ≥5 days	101 (11.7%)	0.759 (0.719–0.798)	0.786 (0.749–0.823)
Postoperative acute MI	29 (3.35%)	0.837 (0.775–0.906)	0.854 (0.814–0.927)
Prolonged use of inotropes	267 (30.90%)	0.739 (0.709–0.769)	0.746 (0.714–0.778)
Reopen due to Bleeding	24 (2.80%)	0.557 (0.481–0.632)	0.564 (0.492–0.636)
30-day mortality	31 (3.58%)	0.849 (0.784–0.913)	0.863 (0.804–0.921)
In-hospital mortality	25 (2.89%)	0.861 (0.787–0.935)	0.873 (0.799–0.946)
One-year mortality[a]	74 (8.95%)	0.771 (0.721–0.822)	0.772 (0.720–0.823)
Low cardiac output syndrome	112(12.95%)	0.709 (0.664–0.754)	0.715 (0.671–0.760)
De novo dialysis	13 (1.50%)	0.732 (0.621–0.842)	0.810 (0.737–0.883)
Stroke	7 (0.81%)	0.629 (0.519–0.739)	0.646 (0.534–0.757)
Mediastinitis	14 (1.62%)	0.691 (0.578–0.803)	0.696 (0.597–0.794)
Combined endpoint	326 (37.69%)	0.740 (0.709–0.771)	0.751 (0.721–0.781)

AUC: area under the receiver operating characteristics curve; CI: confidence interval; EuroSCORE: European system for cardiac operative risk evaluation; MI: myocardial Infarction.
[a]Analysis included with a possible follow-up of more than one year.
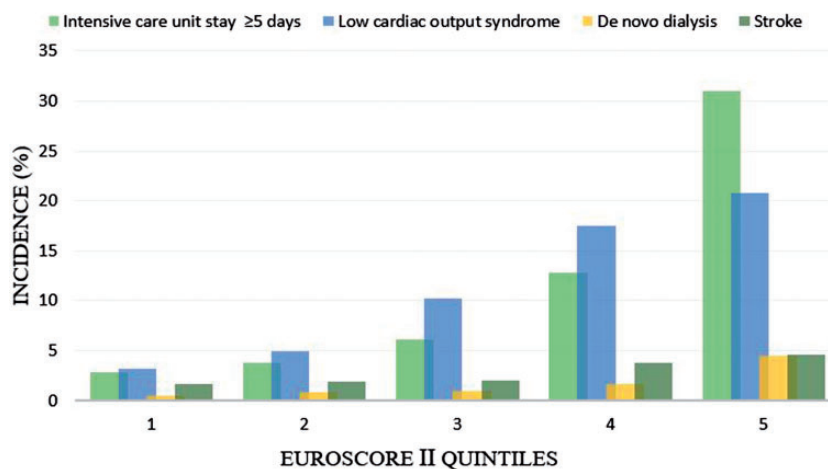

Figure 3. Major postoperative adverse events according to the quintiles of the European system for cardiac operative risk evaluation II (EuroSCORE II).
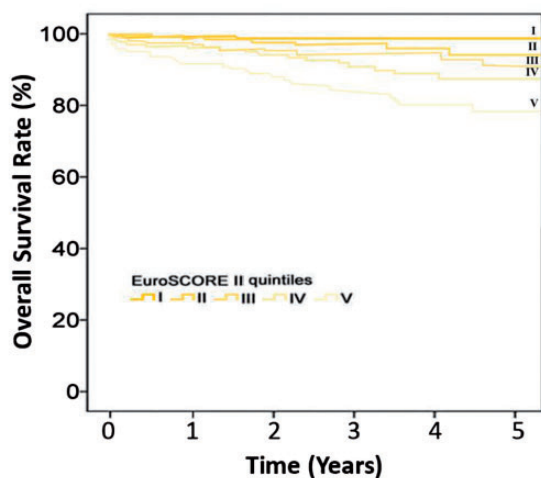
Figure 4. Overall survival rate after coronary artery bypass graft surgery, according to EuroSCORE quintiles (EuroSCORE II) by Kaplan–Meier estimation curve. Note: Log-rank test p-value < 0.0001.

Long-term outcome

The mean follow-up period was 2.5 ± 1.5 years, and the overall survival rate at five years was 89.5%. The ROC curve analysis shows that the two risk scoring systems performed similarly in predicting the one-year operative mortality rate (Table 2). The K–M analysis graph demonstrates a marked reduction in the overall survival rate with increasing EuroSCORE II quintiles (log-rank test: p < 0.0001). Patients in the higher EuroSCORE II quintile demonstrated a diminished survival rate, especially during the first postoperative year. Patients with a EuroSCORE II of 10% or more had, overall, a markedly poorer five-year survival rate (p-value < 0.0001) (Figure 4).

Discussion

In this study, it was observed that the performance of the EuroSCORE risk scoring system was significantly effective at predicting postoperative morbidity as well as mortality in the high-risk group patients. The AUC results obtained from the ROC analysis showed a marked discrimination between the original logistic EuroSCORE and EuroSCORE II scoring systems. However, EuroSCORE II is more specific and sensitive in risk score stratification than the original logistic EuroSCORE, particularly in certain groups of patients. Myocardial revascularization with CABG surgery improves survivability in patients with coronary artery disease; however, the surgical revascularization itself, as well as several perioperative characteristics, may influence postoperative adverse events. Therefore, it is necessary to perform risk prediction

and stratification prior to the surgery in order to reduce the rate of, as well as to prevent the perioperative complications.[5–8,10]

The EuroSCORE risk scoring system was first introduced in 1993, but data regarding the system was first collected in 1995. Moreover, the original logistic EuroSCORE was first described in 2003 using the same patient database.[8–11] There are few studies that have demonstrated the effectiveness of the EuroSCORE system in predicting the outcome of OPCABG surgery. In United Kingdom, Al-Ruzzeh et al. observed the validity of the additive EuroSCORE system in OPCAB surgery, demonstrating an in-hospital mortality rate of only 1.3%.[11] However, in another study, Berman et al. also analyzed the additive EuroSCORE in both patients undergoing either OPCABG or on-pump CABG at Tel Aviv University, Israel, and they showed ROCs (ROCs of 0.74 and 0.76 in OPCABG and on-pump CABG surgery, respectively) similar to those from the findings of other studies.[8,10–13] Furthermore, in a Korean study by Youn et al. reported an obvious discrimination for both the original logistic and additive EuroSCORE systems for OPCABG patients, which is supported by Farrokhyar et al., who demonstrated a fair discrimination from the original logistic EuroSCORE system in risk prediction for Canadian patients undergoing either OPCABG (AUC of 0.79, 95% CI 0.71–0.88) or on-pump CABG (AUC of 0.81, 95% CI 0.71–0.90).[14,15]

However, several research articles have also demonstrated an overprediction of postoperative mortality following CABG surgery, which was performed by utilizing old fashioned original EuroSCORE data.[16–18] So that an updated version of the EuroSCORE II risk scoring system has become available, and it has proven to be more effective with an updated calibration system than the original EuroSCORE system.[19] Recently, Garcia-Valentin et al. performed a multicenter study to evaluate the performance of EuroSCORE II system among Spanish population and found that observed mortality rate was 6.5%, while 5.7% was predicted mortality rate according to EuroSCORE II risk score evaluation system.[20] Furthermore, the ROC curves demonstrated good discriminative ability (AUC = 0.79, 95% CI 0.76–0.82) and concluded that the EuroSCORE II system can be utilized for risk assessment and quality assurance as far as a probable insignificant underprediction of the mortality rate is contemplate. In Argentina, Borracci et al. evaluate the performance of EuroSCORE II system on postoperative mortality rate following cardiac surgery and demonstrate a good discriminative capacity and calibration of EuroSCORE II risk scoring system. Nonetheless, their overall in-hospital mortality rate was 4.2%, while the predicted mortality rate was

3.18% (p = 0.402), which is concordance to current study findings.[21]

In a recent study, Provenchère et al. observed that the EuroSCORE II has a better predictive performance than the original logistic EuroSCORE system in patients with an age younger than 80 years.[22] Moreover, the EuroSCORE II system demonstrates an acceptable calibration up to a 10% predicted mortality rate, which is also similar to the other study results.[8,15–19] In another study, Kieser et al. evaluate operative outcomes of 1125 patients undergoing total arterial coronary artery bypass graft surgery at the University of Calgary, Canada, and observe a fair discrimination for EuroSCORE II system while the overall operative mortality rate was 3.2%.[23] In Italy, Di Dedda et al. evaluate the effectiveness of EuroSCORE II system among adult cardiac surgery patients and demonstrate that the accuracy rate of the risk scoring system was acceptable for isolated coronary artery bypass graft surgery patients.[24] Moreover, the statistical difference between observed mortality (3.75%) and expected mortality (3.1%) in the overall study population was not significant for the EuroSCORE II tertiles. In this current study, the EuroSCORE II scoring system was an independent predictor for early comorbidities as well as late mortality in the high-risk group patients which is also concordance to other published results.[16,20,22–24]

In conclusion, the performance of EuroSCORE II was precise and more accurate in predicting postoperative morbidity and mortality for certain groups of Bangladeshi population, specifically for patients with a low ejection fraction and for those with multiple comorbidities. Furthermore, in spite of having a good discriminative capacity and calibration, caution is advised in using the EuroSCORE II as a risk scoring system to compare postoperative outcomes amongst different surgeons or hospitals. Moreover, limited data and a small sample size impeded this study's credibility as well as reproducible sub-analyses. This demonstrated that EuroSCORE should undergo re-evaluation of either recalibration or re-engineering for the regional study population to adopt a better scoring system.

Limitations of the study

Although this study has some limitations, especially its small number of patients in the study population, availability of limited data, and cohorts including real-life patients, the EuroSCORE system might be useful as a tool for routine practice when attempts are made to assess both early and long-term risks for patients undergoing isolated coronary artery bypass graft surgery. Furthermore, the characteristics of study population that included as well as excluded from the statistical analysis are similar and probably the conclusions would not significantly differ if the analysis would have included the overall population. In this study, in-hospital mortality served as an indicator for early mortality, defined as death occurring anytime during hospitalization for surgery.

Conclusion

The performance of EuroSCORE II is significantly better than that of the original logistic EuroSCORE in predicting postoperative morbidity and mortality after isolated CABG surgery among Bangladeshi population. Furthermore, EuroSCORE II can be safely used as a risk assessment tool and can guide the decision of whether to perform surgery or provide conservative treatment for specific groups of patients.

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