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European System for Cardiac Operative Risk Evaluation II and brain natriuretic peptide hormone as predictors of outcome in high-risk patient undergoing coronary artery bypass graft surgery on mechanical support by intra-aortic balloon pump

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Abstract

EuroSCORE is one of the risk scoring systems used in adult cardiac surgery for better prediction of outcome. High Preoperative BNP levels are associated with poor outcome but added benefit to EuroSCORE II is still under investigation. To evaluate the validity of EuroSCORE II in patients undergoing CABG and the added value of BNP levels. Also, evaluation of the impact of prophylactic IABP on outcome. Our study was a prospective observational cohort study conducted on 40 high risk patients undergoing CABG supported with IABP. Patients were enrolled from April 2022 till July 2023 at critical care department, faculty of medicine, Beni-Suef University and National Heart Institute, Cairo, Egypt. These patients were followed up after surgery to note in-hospital mortality and ICU course. Of 40 studied patients, mean EuroSCORE II was 3.72 ± 2.21% and mean BNP was 203.75 ± 136.51 pg/ml. The AUROC of EuroSCORE II was 0.82 (95%CI 0.66–0.97; p-value < 0.0001). The AUROC of BNP was 0.77 (95%CI 0.54–1.001; p0.02). The combined model with an AUROC of 0.81 (95%CI 0.65–0.97, p = 0.0001). There was statistically significant positive correlation between EuroSCORE II as well as preoperative BNP with duration of IABP support, M.V, and ICU stay. Shorter duration of IABP support, M.V, and ICU stay was noted in patients with preoperative IABP insertion with P value 0.001, 0.001 and 0.036 respectively with no difference in mortality. Both EuroSCORE II and BNP were good predictors of outcome. However, BNP didn't add a prognostic value to EuroSCORE II alone. Prophylactic IABP insertion was associated with shorter duration of IABP support, M.V, ICU stay with no significance in mortality.

Keywords: EuroSCORE II, BNP, CABG, risk prediction, IABP

Full length article **Corresponding Author*, e-mail: Sayed_584@yahoo.com

1. Introduction

Perioperative mortality in cardiac surgery is considered one of the primary causes of mortality in affluent nations, with a range of 2.9 to 6.2% [1]. Therefore, Risk stratification scoring systems in adult cardiac surgery are gaining more importance in current clinical practice as they provide a reliable estimation of the risks associated with surgical procedures. EuroSCORE is one of these systems that was validated in many studies to predict the outcome in cardiac surgery [2]. However, in recent years, different publications have highlighted that this model could be overestimating the postoperative risk in some subgroups of patients [3-5]. To improve the predictivity of this model, some variables were modified with the most recent EuroSCORE II system [6]. Following CABG, heart failure continues to be one of the leading reasons of mortality [7]. Heart failure severity is not effectively captured by EuroSCORE II, with the exception of LVEF and NYHA functional class [8]. The use of BNP levels as a risk assessment technique in patients undergoing heart surgery has gained popularity during the past ten years [9]. Poorer results from cardiac surgery have already been linked to elevated BNP plasma concentrations [10]. The benefits of IABP in reducing myocardial ischemia among critical ischemic patients undergoing CABG are unquestionable [11]. Despite this, there has been disagreement on the preventive use of preoperative IABP in high-risk patients having CABG;

some studies have demonstrated benefits, while others have shown no benefits, and yet others have demonstrated harms [12-14]. We aim to evaluate the predictivity of EuroSCORE II in high-risk patients for short term outcome including the in-hospital mortality and ICU course. Also, the added value of BNP when combined to EuroSCORE II in one model. Meanwhile, we evaluating the impact of prophylactic IABP on short term outcome.

2. Materials and Methods

Our study was a prospective observational cohort study conducted on 40 high risk patients underwent CABG and received an intra-aortic balloon pump (IABP) either prior to surgery (group A) or post operatively (group B). IABP insertion decision was made by the surgical team. Patients were enrolled from April 2022 till July 2023 at critical care department, faculty of medicine, Beni-Suef university and National Heart Institute, Cairo, Egypt. The patients' written informed consent was requested. Prior to surgery, the patient was assessed [Table 1], and an online calculator at www.EuroSCORE.org was used to determine Euro SCORE II.

2.1. Inclusion criteria (any of the following)

- Significant left main coronary artery disease; > 50% stenosis.
- Unstable angina (CCS III-IV).
- Left ventricular dysfunction with (LVEF) less than 35%.
- Recent acute myocardial infarction (Myocardial infarction within 90 days).
- Congestive heart failure (NYHA III-IV).

2.2. Exclusion criteria (any of the following)

- Patients with significant peripheral vascular disease.
- Patients with severe aortic valvular insufficiency.
- Patients with aortic dissection.
- Patients less than 18 years old or diagnosed as end stage malignancy case.

2.3. Statistical Analysis

The statistical software for the social sciences (SPSS) version 28 (IBM Corp., Armonk, NY, USA) was used to code and enter the data. The mean, standard deviation, and frequencies (number of cases) and relative frequencies (percentages) for categorical variables, and the median and interquartile range for quantitative variables that were not normally distributed, were used to summarize the data. For normally distributed quantitative variables, group comparisons were performed using the unpaired t test; for non-normally distributed quantitative variables, the non-parametric Mann-Whitney test was employed (Chan, 2003a). We used the Chi square (2) test to compare categorical data. When the anticipated frequency is less than five, an exact test was utilized instead (Chan, 2003b). The Spearman correlation coefficient was used to perform correlations between quantitative variables (Chan, 2003c). In order to determine the optimal BNP cutoff value and EuroSCORE threshold for mortality detection, a ROC curve was built using area under the curve analysis. The threshold of 0.05 for a P-value was deemed statistically significant.

3. Results and discussion

3.1. Basic demographic data

Our study enrolled 40 high risk patients who underwent CABG. Patients were divided into 2 main groups (20 patients each) according to the timing of IABP insertion. The study revealed non-significant difference between the two studied groups regarding basic demographic data (table 2).

3.2. Risk factors and comorbidities

Risk factors enrolled in our study population: 67.5% were smokers, 60% were IDDM, 55% were hypertensive, 40% were in NYHA class III, 40% had recent ACS, 57.5% had previous MI, 17.5% had CKD and 32.5 had COPD (table 3). The median of EuroSCORE II was 3.14% (IQR 1.74-5.72). Levels of BNP were checked in all patients within 48 hours preoperatively. The median of preoperative BNP was 165.5 ng/ml (IQR 71.0- 336.0). There was no statistically significant difference between the two studied groups regarding EuroSCORE II and BNP levels (table 4).

3.3. Correlation of EuroSCORE II and BNP with ICU course

Regarding the ICU course; the mean IABP duration was 58.98 ± 30.94 hours, mean duration of M.V was 45.05± 60.52 hours and mean duration of ICU stay was 4.25± 1.37 days. There was positive correlation between EuroSCORE II and ICU course including duration of IABP, MV and ICU stay (table 6). In the same context, levels of preoperative BNP were correlated well with these ICU parameters (table 7).

3.4. Predictive value of EuroSCORE II and BNP with regard to in hospital mortality

According to ROC analysis, the distribution of AUC for EuroSCORE II as a mortality predictor in the study group was 0.818 with 95% CI (0.66–0.97), 75% sensitivity, and 84.4% specificity at the cut-off value of 5.63% [Fig. 1]. AUC is substantially higher ($p < 0.001$) in predicting death, according to ROC analysis. Regarding preoperative BNP, ROC analysis revealed the BNP was good predictor of mortality with AUC 0.771with 95% CI (0.54–1.001; *p* 0.02) with 75% sensitivity and 87.5% specificity at cut-off value 336 pg/ml (table 7).

3.5. Performance of a combined model

With an AUC of 0.818 (95%CI 0.65–0.97, P value > 0.001), ROC analysis demonstrated that a combination model of EuroSCORE II and preoperative BNP sufficiently distinguished postoperative mortality. The AUC of the combined model was not superior than that of EuroSCORE II by itself. So, this combined model didn’t add a prognostic value when compared to EuroSCORE II alone (figure 1).

3.6. Impact of IABP insertion time on postoperative outcome

By comparing both groups, there was statistically significant shorter duration of IABP, MV and ICU stay with P value < 0.001, < 0.001 and 0.036 respectively (table 8,9). However, no statistically significant difference in mortality was noted. In spite of the proven role of the standard EuroSCORE to stratify and predict the operative risk, it was criticized for significantly overestimating mortality in high-risk patients is understated and in low-risk patients (EuroSCORE <6) (EuroSCORE >13) [6]. Some original EuroSCORE variables were either modified or complemented to improve and optimize its ability to predict mortality in adult cardiac surgery creating the new model EuroSCORE II. Heart failure severity is an established predictive factor for cardiac surgery, although EuroSCORE II does not account for it [8]. So, serum level of BNP was used to stratify HF severity [14]. Although IABP is well known for its ability to reduce myocardial ischemia in critical ischemic patients [11], its prophylactic use in high-risk patients undergoing CABG has been the subject of controversy. Some studies have demonstrated a benefit [12], while others have shown no benefit [13], and still others have demonstrated harm from its use [14]. Our findings confirmed that there was statistically significant positive correlation between EuroSCORE II and duration of M.V with mean 45.05 hours and P value < 0.001 as well as, duration of ICU stay with mean of 4.25 days and P value 0.002. In consistent with our findings, a study conducted by GU et al. on 265 patients admitted to ICU post cardiac surgery from 2016 to 2017. They concluded that EuroSCORE II ≥ 1.065% was significantly correlated with the ICU stay (mean duration of 52.5 hours) with P value 0.001. Based on that EuroSCORE II could predict the length of ICU stay. In the same study they found that EuroSCORE II ≥ 1.065% was correlated well to the increased ventilation duration with P value 0.034 [16]. In the same context; similar results were obtained by Bauer et al. [17]. On the contrary; Rianda et al. conducted retrospective study of 39 Patients who underwent CABG surgery from 2016 to 2017. From their results they found that patients with a low EuroSCORE II score of 2.64% require 43 days in the hospital, whereas patients with a higher score of 14.43% only needed 31 days. They came to the conclusion that EuroSCORE II is insufficient to forecast morbidity based on that (including ICU stay and mechanical ventilation duration) and considered less effective [18]. We looked into how well the EuroSCORE II discriminated among high-risk CABG patients when used as a risk stratification tool. ROC analysis in our study showed a cut-off value of 5.63% with 75% sensitivity and 84.4% specificity (95%CI 0.66–0.97; p-value < 0.001). Therefore; we found in our study that EuroSCORE II had good predictive value for the postoperative mortality. Silverborn et al. studied 14,118 patients undergoing isolated CABG in Sweden during 2012–2017 and found a good predictive value of EuroSCORE II in high-risk patients for mortality with AUC was 0.82 (95% CI 0.79-0.85) [19]. Similar results were obtained by Liu et al. [20]. Also, Ranjan et al. conducted a study and made up similar conclusions [21]. In contrast to our results; Widyastuti et al. conducted a single observational study from collected data of 1833 adult patients who underwent cardiac surgery and conclusion was that EuroSCORE II was unsuitable tool for risk prediction of mortality in their center as it underestimated the mortality with estimated risk of 2.1% whereas the actual mortality was 3.8% with AUC 0.774 (95% CI 0.714–0.834) [22]. These disparate outcomes could be the result of variations in the perioperative environment and preoperative patient screening delays brought on by Indonesia's small number of cardiac clinics, which could aggravate the patients' conditions by the time they have surgery. Cerda-Núnez et al. carried out a systematic review and they found that EuroSCORE II was underestimating mortality [23]. Our findings confirmed revealed a positive statistically significant connection existed between BNP and duration of M.V with mean 45.05 hours and P value < 0.001. Also, it was evident that there was positive correlation between BNP and duration of ICU stay with mean of 4.25 days and P value 0.008. In our results ROC analysis showed a cut-off value of BNP 336 pg/ml with 75% sensitivity and 87.5% specificity (95%CI 0.54–1.001; p value 0.02) accordingly preoperative BNP was adequately discriminating postoperative mortality in our study. Goes hands in hands with our results, Maria et al. conducted a systematic evaluation of studies published between 1946 and August 2022 using OVID, MEDLINE, EMBASE, SCOPUS, and PUBMED. They discovered that the preoperative BNP level, with a median cut-off value of 145.5 pg/mL (IQR 95-324.25 pg/mL), is a strong predictor of death in patients who underwent CABG [24]. Murad et al. evaluated 488 patients that underwent cardiac surgery and concluded same results [25]. In the same context; Fellahi et al. had similar conclusions [26]. Opposite to our findings, Mohamed et al. perform a prospective study of 65 patients underwent off-pump elective CABG with mean preoperative BNP levels of 312.41 ± 329.93 pg/mL. They concluded that there was no significant correlation between preoperative BNP levels and postoperative length of ICU stay and prolonged mechanical ventilation as well as in-hospital mortality following off-pump elective CABG with P value > 0.05 B [27]. The effectiveness of a hybrid model that incorporates preoperative BNP and EuroSCORE II was investigated in our study for prediction of mortality in high-risk patient underwent CABG. In our results; ROC analysis showed a cut-off value of 0.352 with 75% sensitivity and 87.5% specificity (95%CI 0.65–0.97, P value < 0.001) which made the combined model a good predictor for postoperative mortality. Nevertheless, with an AUROC of 0.818 in both cases, the combined model's performance was no better than that of EuroSCORE II alone. Therefore, when compared to EuroSCORE II alone, Preoperative BNP did not add prognostic information. Similar results were shown by Suc et al. who carried out a prospective registry of 4,980 heart surgery patients. With an AUROC of 0.67 (95%CI 0.63–0.71) and a P value of 0.0001, the study demonstrated that a combination model of EuroSCORE II and preoperative BNP adequately predicted postoperative mortality. The combined model's AUROC, however, was not superior to that of EuroSCORE II by itself, which had an AUROC of 0.82 (95%CI 0.79–0.85) with P < 0.0001. Therefore, BNP did not contribute to EuroSCORE II's risk assessment [28].

Table 1. Parameters in EuroSCORE II

Patient-related factors	Cardiac related factors	Operation related factors
Age Gender Renal impairment Extra cardiac arteriopathy Poor mobility Previous cardiac surgery Chronic lung disease Active endocarditis Critical preoperative state Diabetes on insulin	NYHA CCS class 4 angina LV function Recent MI Pulmonary Hypertension	Urgency Weight of the intervention Surgery on thoracic aorta

Table 2. Demographic data of both groups

		Group A		Group B	
		Mean	±SD	Mean	±SD
Age		54.90	6.76	55.10	6.73
BMI		33.23	2.84	33.62	2.67
		Group A		**Group B**	
		No	**%**	**No**	**%**
Sex	**M**	14	70.0%	14	70.0%
	F	6	30.0%	6	30.0%

Table 3. Comorbidities and risk factors

Risk factor		Group A		\Group B	
		Number	%	Number	%
Smokers	**Yes**	13	65.0%	14	70.0%
Comorbidities					
IDDM	**Yes**	12	60.0%	12	60.0%
HTN	**Yes**	11	55.0%	11	55.0%
CKD	**Yes**	4	20.0%	3	15.0%
Heart failure	**NYHA III**	8	40.0%	8	40.0%
COPD	**Yes**	7	35.0%	6	30.0%
Previous MI	**Yes**	12	60.0%	11	55.0%
Recent ACS	**Yes**	6	30.0%	10	50.0%

Table 4. EuroSCORE II and BNP of the two groups

	Group A			Group B		
	Median	1st quartile	3rd quartile	Median	1st quartile	3rd quartile
EuroSCORE II	2.87	1.62	5.81	3.32	1.98	5.64
Serum BNP	165.50	66.00	336.00	160.50	79.00	324.50

Table 5. Correlation between EuroSCORE II and postoperative outcome

		IABP duration (hours)	M.V. duration (hours)	I.CU stay (days)
EuroSCORE II	**Correlation Coefficient**	0.435	0.609	0.465
	P value	0.005	< 0.001	0.002
	N	40	40	40

Table 6. Correlation between preoperative BNP and postoperative outcome

		IABP duration (hours)	M.V. duration (hours)	I.CU stay (days)
Serum BNP	**Correlation Coefficient**	0.402	0.543	0.415
	P value	0.010	< 0.001	0.008
	N	40	40	40

Table 7. Prediction of mortality using EuroSCORE II, preoperative BNP and combined model.

	AUC	P value	95% Confidence Interval		Cut off	Sensitivity %	Specificity %
			Lower Bound	Upper Bound			
EuroSCORE II	0.818	< 0.001	0.660	0.977	5.635	75	84.4
Serum BNP	0.771	0.020	0.542	1.001	336	75	87.5
Combined EuroSCORE II+BNP	0.818	< 0.001	0.658	0.979	0.3519749	75	87.5

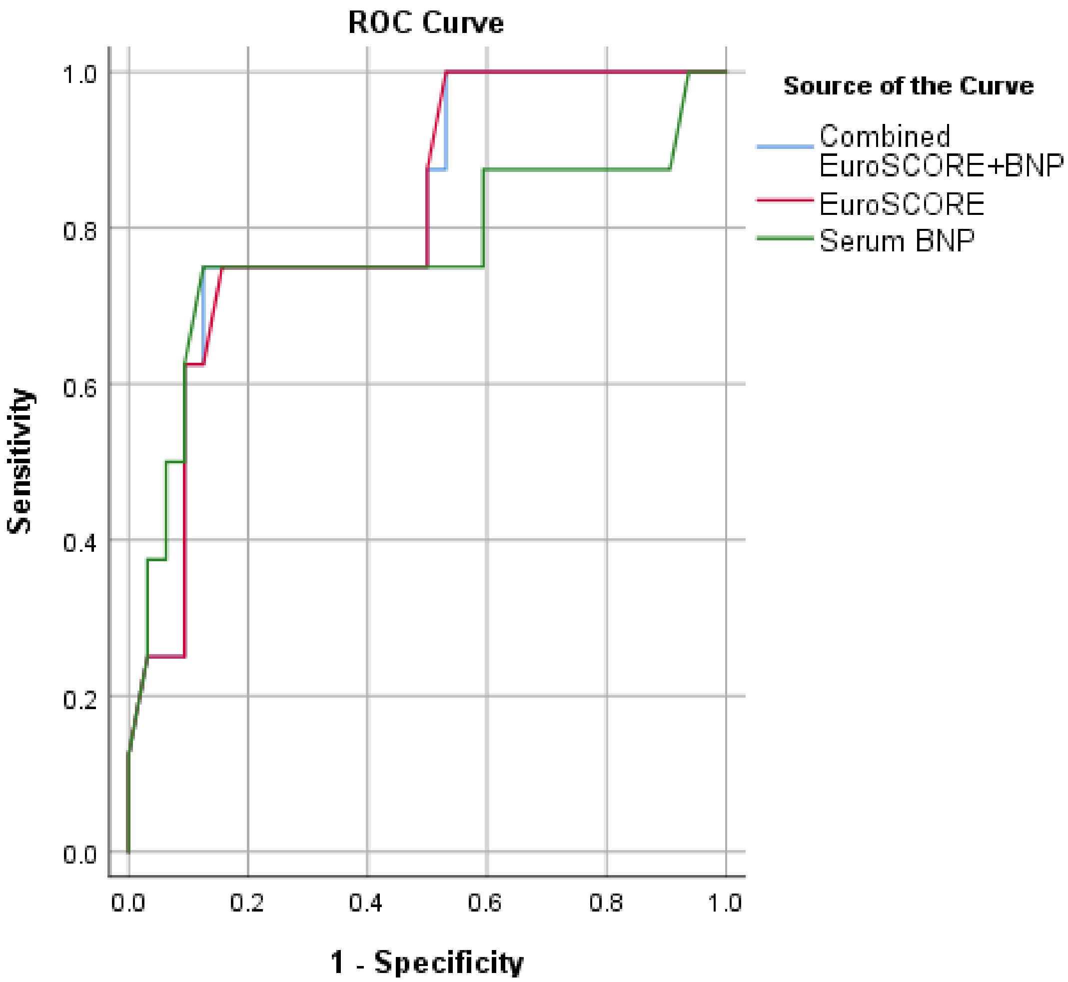

Figure 1. ROC curve for prediction of mortality using EuroSCORE II, preoperative BNP and their combination

Table 8. Durations of IABP and M.V in both groups

	Group A			Group B			P value
	Median	**1st quartile**	**3rd quartile**	**Median**	**1st quartile**	**3rd quartile**	
IABP duration (hours)	35.50	32.50	42.00	68.00	54.00	81.00	< 0.001
M.V. duration (hours)	12.00	10.00	16.50	28.00	17.50	105.50	< 0.001

Table 9. Durations of IABP and M.V in both groups

	Group A		Group B		
	Mean	**±SD**	**Mean**	**±SD**	**P value**
I.CU stay (days)	3.80	1.36	4.70	1.26	0.036

In contrast to our study, Holm et al. studied 365 patients with acute coronary syndrome (ACS) underwent isolated CABG prospectively. When compared to EuroSCORE II alone, which had an AUROC of 0.87 (95%CI 0.76–0.98) with P value 0.001, the study found that combining EuroSCORE II and preoperative BNP appears to improve risk prediction in isolated CABG. Thus, BNP could add a predictive value to the EuroSCORE II in postoperative risk estimation [29]. The different results obtained in this study compared to ours can be addressed to the patients' preoperative clinical condition. Our study population was high risk patients supported with IABP. So, they had relatively high EuroSCORE II and serum BNP levels. Prophylactic preoperative IABP implantation was studied for its effect on mortality and short-term prognosis in high-risk CABG patients. With a P value of 0.121, our data showed that there was no statistically significant difference in mortality between the two groups. Consistent with our result, Samanidis et al. did an observational study of 322 patients who underwent CABG. The findings showed that there was no correlation between preoperative IABP implantation and decreased mortality when compared to intraoperative insertion with P value 0.63 [30]. Opposite to our results, Andrej et al. A prospective data set from 2009 to 2019 showed that 207 patients with LVEF ≤30% had elective isolated CABG, and 136 of those patients had prophylactic IABP insertion. They came to the conclusion that patients who had an IABP prior to surgery (4.4%) had a considerably lower death rate ($P < 0.001$) than patients who received an IABP during or after surgery (37.5%) [31]. Sohail et al. concluded similar results [32]. We found statistically significant shorter duration of ICU stay with mean of 3.8± 1.36 days and shorter duration of M.V support with median of 12 (IQR 10-16.5) hours in group A compared to group B with P values of 0.036 and 0.001 respectively. Our results were supported by study results obtained by Yang et al. With no cardiogenic shock, 421 patients with acute myocardial infarction were recruited. Shorter postoperative lengths of stay (median of 8 (IQR 6-11) days) were more common in patients with preoperative intra-aortic balloon pumps than in those without. 10 (IQR 6-15) days, $p = 0.02$) Conclusion was that preoperative IABP insertion improved outcome as demonstrated by a noticeably shorter postoperative hospital stay [33]. On contrary to our results; Shah et al. 1216 patients' records were gathered who underwent CABG between 2017 and 2019. In 11.1% of cases, an IABP insertion was made. 6.7% of patients in the IABP group and 1.1% of patients in the non-IABP group, with a P value of 0.00001, respectively, experienced extended breathing. Moreover, 5.5% of patients in the non-IABP group with prolonged ICU stay had a P value of 0.0003, whereas 13.3% of patients in the IABP group needed a lengthy ICU stay. The study revealed that the use of IABP was associated with prolonged ICU stay and prolonged ventilation. This may be explained by the critical preoperative clinical condition of patients with IABP [34].

4. Conclusions

In this cohort, EuroSCORE II system had a good discriminative accuracy to predict in hospital mortality in high-risk patients undergoing CABG. Also, it was correlated well with postoperative outcomes including durations of IABP, M.V and ICU stay. Preoperative BNP could adequately predict the postoperative mortality. However, the combined model of EuroSCORE II and BNP did not show a better prognostic value than EuroSCORE II alone. So, Preoperative BNP did not add prognostic information when added to EuroSCORE II. Prophylactic preoperative insertion of IABP in high-risk patients undergoing CABG is associated with good postoperative outcome including duration of IABP support, duration of M.V and duration of ICU stay when compared to postoperative insertion. However, there is no difference in mortality between both groups.

Recommendations

More studies with larger sample size could precisely evaluate the correlations studied in our study. Wide variety of high-risk patients should be included in future studies like patients with redo surgery, infective endocarditis and cardiogenic shock. In the new era of LVAD and their great advantage in supporting hemodynamics, more studies are needed to estimate the efficacy of the available operative risk stratification models in the presence of these models.

Study limitations

Small sample size, which reduces the statistical validity of some of the differences between the groups. In our study, we used in-hospital mortality, defined as death within the same hospital admission for surgery, as indicator for mortality among study population. Another important indicator is the 30-day mortality, defined as death within 30 days of operation. In addition, this might affect the observed mortality rate.

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