Does Preoperative B-Type Natriuretic Peptide Better Predict Adverse Outcome and Prolonged Length of Stay Than the Standard European System for Cardiac Operative Risk Evaluation After Cardiac Surgery?

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Objectives: Although B-type natriuretic peptide (BNP) strongly predicts cardiac morbidity and mortality, the European System for Cardiac Operative Risk Evaluation (EuroSCORE) has a modest predictive value to identify a composite operative risk after cardiac surgery. The authors tested the hypothesis that a single preoperative BNP measurement would be superior to standard EuroSCORE in predicting composite adverse outcomes after cardiac surgery.

Design: A prospective observational study.

Setting: A teaching university hospital.

Participants: Two hundred eight adult patients.

Interventions: Conventional cardiac surgery with cardiopulmonary bypass.

Measurements and Main Results: The preoperative additive EuroSCORE and BNP measurement were performed in all patients. Postoperative nonfatal major adverse cardiac events (malignant ventricular arrhythmia, myocardial infarction, and cardiac dysfunction), all-cause mortality, and prolonged lengths of stay were chosen as study endpoints. Predictive abilities of both EuroSCORE and BNP were assessed using logistic regression and compared with receiver operating characteristic (ROC) curves. Thirty-six (17%, 95% confidence interval [CI], 12%-22%) patients experienced 49 events over the study period. The areas under the ROC curves assessing the utility of EuroSCORE and BNP in predicting adverse outcome and prolonged in-hospital stay were 0.59 (95% CI, 0.48-0.69) versus 0.76 (95% CI, 0.68-0.85; $p < 0.001$) and 0.65 (95% CI, 0.57-0.74) versus 0.71 (95% CI, 0.63-0.80; $p = 0.147$), respectively. Using logistic regression, BNP considered as a dichotomized variable was the only independent predictor of adverse cardiac outcome (adjusted odds ratio = 10.7; 95% CI, 4.1-27.8; $p < 0.001$).

Conclusions: Preoperative BNP measurement is a strong, independent, and more accurate predictor of adverse outcome than EuroSCORE in patients undergoing cardiac surgery. BNP could be considered as a simple and objective tool for the detection of high-risk patients after cardiac surgery.

KEY WORDS: cardiac surgery, European System for Cardiac Operative Risk Evaluation, cardiac biomarkers, B-type natriuretic peptide, cardiac outcome

NUMEROUS MULTIFACTOR RISK SCORES have been developed in the cardiac surgical setting in order to stratify patients according to postoperative risk of death and/or nonfatal major cardiac morbidity.[1-5] Among them, the European System for Cardiac Operative Risk Evaluation (EuroSCORE) currently is acknowledged as a strong clinical model of risk prediction in cardiac surgery.[6] Although easy to calculate, the standard EuroSCORE has well-recognized limitations, especially for the prediction of nonfatal specific major adverse cardiac events (MACEs) or prolonged length of stay after surgery.[7] Even if a logistic model of EuroSCORE could be preferred in high-risk patients,[8] the global ability of EuroSCORE to accurately predict both a composite operative risk and prolonged length of stay remains debatable.[9]

Preoperative B-type natriuretic peptide (BNP) measurement recently has emerged as valuable in the cardiac surgical setting, and several well-designed studies previously reported its prognostic value on composite endpoints associating short- and long-term postoperative mortality and/or cardiac morbidity.[10-13] Recently, preoperative N-terminal pro-B-type natriuretic peptide (NT-proBNP) only showed a modest independent prognostic utility in predicting postoperative mortality after cardiac surgery when compared with conventional risk-prediction scores.[14] In contrast, preoperative BNP has been found much more accurate than the Revised Cardiac Risk Index in predicting in-hospital death and postoperative myocardial infarction after major noncardiac surgery,[15] and 2 recent meta-analyses confirmed that an elevated preoperative BNP measurement was a powerful and independent predictor of both MACEs and all-cause mortality in this setting.[16,17] The use of a biochemical test for risk stratification has several advantages because it avoids the difficulties inherent in applying complex scoring systems to individual patients and provides an objective measure, without the potential for subjective interpretation of clinical parameters. The prospective validation of an incremental prognostic value when compared with existing predictive models is, however, an obligatory hierarchical step in showing the clinical interest of BNP in the cardiac surgical setting. At the present time, no study compared preoperative BNP concentrations with standard EuroSCORE in predicting both a composite operative risk of cardiac morbidity and all-cause mortality and a prolonged length of stay after conventional cardiac surgery.

The objective of the current study conducted in unselected adult patients undergoing conventional cardiac surgery with cardiopulmonary bypass (CPB) was to compare the prognostic value provided by a single preoperative BNP measurement with the routine additive EuroSCORE in order to further clarify what BNP levels may add to existing methods of risk stratification. The authors tested the hypothesis that the use of preoperative BNP would enable a more powerful prediction of MACEs and/or in-hospital death and prolonged lengths of stay than standard EuroSCORE after cardiac surgery.

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METHODS

Consecutive adult patients undergoing cardiac surgery with CPB were enrolled prospectively into the study from October 2006 to April 2007 at the Saint-Martin Hospital (Caen, France). Institutional approval was obtained from the Institutional Review Board (Comité pour la Protection des Personnes, Pitié-Salpêtrière, Paris). Waived written informed consent was authorized because the study was solely observational, and preoperative BNP measurements were systematically performed from a blood sample withdrawn for other routine blood tests during routine care of patients, which conformed to standard procedures currently used in this institution. Inclusion criteria were elective cardiac surgical procedures with CPB, coronary artery bypass graft surgery, aortic or mitral valve replacement, and combined cardiac surgery. Emergency surgery (<24 hours), reoperative procedures, and unusual complex cardiac surgical procedures were excluded from the study.

Beta-blocking agents and statins were continued until the morning of surgery in chronically treated patients. Oral antiplatelet agents were stopped within 7 to 10 days before surgery and replaced by oral flurbiprofene (50 mg twice) until the day before surgery. An additive EuroSCORE was systematically established by the cardiac surgeon at the bedside before surgery. Preoperative and 24-hour postoperative measurements of cardiac troponin I (cTnI) were systematically assessed as a routine practice in cardiac surgery.[18] Standardized total intravenous anesthesia and monitoring techniques were used in all patients and complied with routine practice at this hospital. CPB was performed under normothermia. After the termination of CPB, catecholamines were used when necessary at the discretion of the attending anesthesiologist.[19] All patients were admitted postoperatively into the cardiac intensive care unit (ICU) for at least 48 hours and were assessed for tracheal extubation within 1 to 8 hours of arrival in the ICU. Standard postoperative care included blood glucose control,[20] intravenous heparin in patients with valve disease, and aspirin associated with low–molecular-weight heparin in patients with coronary artery disease beginning 6 hours after surgery if mediastinal bleeding did not exceed 50 mL/h. Beta-blocking agents and statins were given as soon as possible postoperatively in chronically treated patients.[21] Postoperative care was delivered by anesthesiologists in the ICU and by cardiac surgeons in the ward. All of them were blinded for BNP levels. Preoperative, intraoperative, and postoperative variables were collected for all patients.

Blood samples were drawn into dry tubes the day before surgery. BNP measurements were systematically performed from blood samples withdrawn for other routine blood tests. A technician who was unaware of the clinical and electrocardiogram data performed assays. BNP was analyzed with a sensitive and highly specific immunoenzymometric assay (AxSYM BNP MEIA Assay; Abbott Laboratories, Rungis, France). The assay allowed the detection of BNP within the range of 0 to 20,000 pg/mL with appropriate dilutions. Values greater than 100 pg/mL were considered abnormal. The within-run coefficient of variation was 6%, and the between-run coefficient of variation was 9%.

The duration of hospitalization, the length of stay in the ICU, nonfatal MACEs, and all causes of death were recorded postoperatively during the in-hospital stay. According to current procedures used in this institution, a prolonged length of stay in the ICU was defined as a stay in the ICU greater than 4 days and a prolonged length of stay in the hospital greater than 8 days. Nonfatal MACEs included (1) malignant ventricular arrhythmia defined as any sustained ventricular arrhythmia requiring treatment, (2) myocardial infarction defined as the appearance on 12-lead electrocardiographic recordings of new Q waves of more than 0.04 seconds and 1-mm deep or a reduction in R waves of more than 25% in at least 2 continuous leads of the same vascular territory and/or a postoperative serum cTnI release above the specific threshold value for each type of surgical procedure as previously described,[18] and (3) cardiac dysfunction defined as hemodynamic instability requiring inotropic support for at least 24 hours and/or a decrease of 20% or greater in preoperative-to-postoperative left ventricular ejection fraction during the postoperative period. In-hospital death was defined as death at any time during the hospital stay. Causes of death were

Table 1. Baseline Patient Characteristics

Patient Characteristic	Total Cohort (n = 208)	Patients With MACEs/Death (n = 36)	Patients Without MACEs/Death (n = 172)	*p* Value
Age (y)	70 ± 10	70 ± 11	70 ± 10	0.84
Sex ratio (M/F)	147/61	30/6	117/55	0.12
Body mass index (kg/m²)	27 ± 5	26 ± 5	27 ± 5	0.19
Left ventricular ejection fraction (%)	62 ± 11	55 ± 14	64 ± 10	<0.001
Preoperative cardiac troponin-I (ng/mL)	0.00 (0.00-0.02)	0.01 (0.00-0.04)	0.00 (0.00-0.01)	0.009
Preoperative serum creatinine (μmol/L)	93 (82-109)	93 (81-119)	93 (82-107)	0.44
EuroSCORE	5 (3-7)	6 (4-8)	5 (3-7)	0.06
Comorbidities				
Myocardial infarction <4 weeks	6 (3)	2 (6)	4 (2)	0.53
Hypertension	138 (66)	24 (69)	114 (66)	0.92
Chronic obstructive pulmonary disease	13 (6)	3 (9)	10 (6)	0.75
Diabetes mellitus	34 (16)	8 (23)	26 (15)	0.37
Stroke	10 (5)	1 (3)	9 (5)	0.95
Preoperative medications				
Nitrates	47 (23)	11 (31)	36 (21)	0.25
Calcium blockers	39 (19)	9 (26)	30 (17)	0.35
Beta-blockers	115 (55)	21 (60)	94 (54)	0.67
Renin-angiotensin system inhibitors	100 (48)	17 (49)	83 (48)	1.00
Diuretics	59 (28)	18 (51)	41 (24)	0.003
Statins	102 (49)	21 (60)	81 (47)	0.21
Preoperative BNP (pg/mL)	178 (74-428)	457 (327-1,022)	139 (67-321)	<0.001
Preoperative BNP >317 pg/mL*	70 (34)	27 (77)	43 (25)	<0.001

NOTE. Values are mean ± standard deviation, median (25th-75th), or number (%).

*Optimal cut-off as defined by the ROC curve.

Table 2. Intra- and Postoperative Data of Patients With and Without Postoperative MACEs and/or In-hospital Death

	Total Cohort (n = 208)	Patients With MACEs/Death (n = 36)	Patients Without MACEs/Death (n = 172)	*p* Value
Intraoperative data				
Aortic cross-clamping time (min)	70 ± 27	85 ± 30	66 ± 25	<0.001
Cardiopulmonary bypass time (min)	110 ± 32	132 ± 38	106 ± 29	<0.001
Type of surgery				
Coronary surgery	93 (45)	8 (22)	85 (49)	<0.001
Valve surgery	83 (40)	16 (44)	67 (39)	
Combined surgery	32 (15)	12 (34)	20 (12)	
Postoperative data				
Bleeding (mL)	560 ± 293	658 ± 515	540 ± 220	0.41
Postoperative cTnI (ng/mL)	1.8 (1.2-3.2)	4.2 (1.8-12.1)	1.7 (1.1-2.5)	<0.001
Inotropic support	25 (12)	25 (69)	0 (0)	<0.001
Length of stay in ICU (d)	3 (3-4)	4 (3-6)	3 (3-4)	<0.001
Discharge (d)	7 (7-8)	8 (7-14)	7 (7-8)	<0.001

NOTE. Values are mean ± standard deviation, median (25th-75th), or number (%).

recorded and classified as cardiac (heart failure, myocardial infarction, and ventricular arrhythmia) or not (other causes). Sudden death was considered as death from a cardiac cause.

Nonfatal MACEs, all-cause mortality, and prolonged lengths of stay in the ICU and in the hospital were chosen as study endpoints. Because of the rare occurrence of death, the primary endpoint was a composite endpoint defined as the occurrence of MACEs and/or death. Secondary endpoints were prolonged lengths of stay in the ICU and the hospital as defined earlier.

Data are expressed as mean ± standard deviation or median (25th-75th) for nonnormally distributed variables (Kolmogorov-Smirnov test) or number and percentage as appropriate. Continuous variables were analyzed with the unpaired Student *t* and Mann-Whitney *U* tests according to their distribution. Categoric variables were compared using Fisher exact tests.

To assess the discrimination of preoperative BNP and additive EuroSCORE in predicting MACEs and/or death and prolonged lengths of stay in the ICU and the hospital, the authors determined the empiric receiver operating characteristic (ROC) curves and calculated the areas under the ROC curves and their 95% confidence interval. Comparison of areas under the ROC curve was performed using a nonparametric paired technique as described previously.[22] The ROC curves also were used to determine the best thresholds for preoperative BNP concentration to predict the occurrence of MACEs and/or death and prolonged lengths of stay in the ICU and the hospital. The best threshold was the one that minimized the mathematic distance to the ideal point (sensitivity = specificity = 1) on the ROC curve. The assessment of the diagnostic performances of an elevated BNP in predicting adverse outcome and prolonged lengths of stay was performed by calculating the sensitivity, specificity, positive and negative predictive values, accuracy (defined as the sum of concordant cells divided by the sum of all cells in the 2×2 table), and their 95% confidence interval values. At last, positive and negative likelihood ratios and the Youden Index (defined as sensitivity + [specificity − 1]), which represents the difference between the diagnostic performance of the test and the best possible performance,[23] were calculated.

The authors performed a multiple forward stepwise logistic regression to assess variables associated with postoperative MACEs and/or death. The authors used a parsimonious approach and included only the significant preoperative variables in the univariate analysis (*p* value of entry = 0.10). The preoperative BNP concentration was entered as a dichotomous variable using optimal cutoff obtained with ROC curve analysis. The odds ratios and their 95% confidence interval of variables selected by the logistic model were calculated. Discrimination and calibration of the model were assessed by using calculation of the area under the ROC curve (c statistics) and Hosmer-Lemeshow statistics ($p > 0.05$ for no significant difference between the predictive model and the observed data),[24] respectively.

Table 3. Relationship Between Quartiles of Preoperative BNP, Clinical Characteristics, and Adverse Outcome

	BNP Quartile 1 (<74 pg/mL) n = 52	BNP Quartile 2 (74-177 pg/mL) n = 51	BNP Quartile 3 (178-428 pg/mL) n = 53	BNP Quartile 4 (≥428 pg/mL) n = 52	*p* Value
Age (y)	64 ± 11	69 ± 9	72 ± 8	74 ± 8	<0.001
Male	43	38	32	34	0.06
LVEF (%)	68 ± 8	65 ± 10	61 ± 12	56 ± 13	<0.001
Preoperative cTnI (ng/mL)	0.00 (0.00-0.00)	0.00 (0.00-0.00)	0.00 (0.00-0.02)	0.01 (0.00-0.06)	<0.001
Serum creatinine (μmol/L)	92 (82-100)	89 (79-104)	97 (83-113)	96 (81-119)	0.13
Hypertension	33	30	39	36	0.40
COPD	3	2	3	5	0.67
Diabetes	5	6	12	11	0.18
Diuretic use	6	5	18	30	<0.001
EuroSCORE	3 (2-5)	5 (3-5)	6 (4-8)	7 (6-8)	<0.001
MACEs/death	3	3	11	19	<0.001

NOTE. Values are mean ± standard deviation, median (25th-75th), or number.

Abbreviations: COPD, chronic obstructive pulmonary disease; LVEF, left ventricular ejection fraction.

Table 4. Analysis of the ROC Curves of Preoperative BNP and EuroSCORE Predicting the Occurrence of Postoperative MACEs and/or Death and Prolonged Lengths of Stay in the Hospital and the ICU

	Area Under the ROC Curve	95% CI	*p* Value
BNP			
MACEs and/or death	0.76	0.68-0.85	<0.001
Hospital stay >8 days	0.71	0.63-0.80	<0.001
ICU stay >4 days	0.60	0.49-0.71	0.036
EuroSCORE			
MACEs and/or death	0.59	0.48-0.69	0.052
Hospital stay >8 days	0.65	0.57-0.74	<0.001
ICU stay >4 days	0.60	0.49-0.71	0.037

A p value <0.05 was considered significant, and all p values were 2-tailed. Statistical analyses were performed using Analyse-it Method Evaluation edition version 2.09 for Microsoft Excel Software (Leeds, England).

RESULTS

During the study period, 231 consecutive adult patients were included prospectively. In all, 23 patients were excluded because of emergency/redo surgery (n = 6), unusual complex surgical procedures (n = 4), and incomplete data for analysis (n = 13). Baseline characteristics of the remaining 208 patients are shown in Table 1. Thirty-six (17%; 95% confidence interval, 12%-22%) patients experienced 49 MACEs and/or death over the study period. Seven (3%; 95% confidence interval, 1%-5%) patients died during the stay in the hospital, 2 patients died of cardiac causes (1 congestive heart failure and 1 sudden death), and 5 patients died of noncardiac causes (3 sepsis, 1 multiple organ failure, and 1 pancreatitis). MACEs were malignant ventricular arrhythmia in 5 cases, myocardial infarction in 12 cases, and cardiac dysfunction in 25 cases. Intraoperative and postoperative data for the whole cohort of patients are shown in Table 2. Interestingly, the threshold values used to define both prolonged lengths of stay in the ICU and the hospital agreed with the highest quartile of the total cohort of patients (Table 2).

The relationship between preoperative BNP and postoperative MACEs and/or death is shown in Table 1. The relationship among BNP quartiles, baseline characteristics, and adverse outcome of the study cohort is shown in Table 3. In comparison to patients with BNP levels in the first quartile, the odds ratio for developing postoperative MACEs/death increased to 9.40 (95% confidence interval, 2.57-34.34; $p < 0.001$) for patients in the highest quartile. The areas under the ROC curves assessing the utility of BNP in predicting MACEs and/or death and prolonged lengths of stay in the hospital and the ICU are shown in Table 4. Although BNP was accurate to predict adverse outcome and prolonged in-hospital stay, its discrimination to predict a prolonged length of stay in the ICU was of more limited value (Table 4). The optimal cutoffs as defined by ROC curves for preoperative BNP to predict postoperative MACEs and/or death and both prolonged lengths of stay in the hospital and the ICU were 317 pg/mL, 268 pg/mL, and 242 pg/mL, respectively (Table 5). The diagnostic performances of an elevated preoperative BNP above optimal thresholds as defined by ROC curves to predict adverse outcome and prolonged lengths of stay are reported in Table 5. If both area under the ROC curve and accuracy were compatible with a good diagnostic value for MACEs/death, positive and negative likelihood ratios and the Youden Index suggested a poor diagnostic value, meaning that the total diagnostic performance of BNP was moderate. Using logistic regression, the only independent predictor of MACEs and/or death among the 5 preoperative variables significantly associated with MACEs and/or death at $p < 0.10$ in univariate analysis was a preoperative BNP > 317 pg/mL (Table 6). In a further model that only included a preoperative BNP >317 pg/mL, preoperative cTnI, and standard EuroSCORE, preoperative BNP remained a strong independent predictor of adverse outcome (adjusted odds ratio = 10.7; 95% confidence interval, 4.1-27.8; $p < 0.001$). The model provided good discrimination (c statistics, 0.74 [95% confidence interval, 0.66-0.81]) and calibration (Hosmer-Lemeshow chi-square test not significant, $p = 0.35$).

There was a moderate correlation between preoperative BNP and EuroSCORE (rank correlation, $r = 0.52$; 95% confidence

Table 6. Predictors of Perioperative MACEs and/or Death Using Logistic Regression (n = 208)

Variable	Odds Ratio (95% CI)	*p* Value
EuroSCORE	0.93 (0.77-11.3)	0.481
Preoperative cTnI	0.45 (0.08-2.46)	0.356
Diuretic use	1.60 (0.62-4.10)	0.324
Left ventricular ejection fraction	0.97 (0.93-1.00)	0.064
Preoperative BNP >317 pg/mL	7.89 (2.88-21.58)	<0.001

Table 5. Assessment of the Diagnostic Performances of Elevated Preoperative BNP Levels Above Optimal Cut-offs as Defined by ROC Curves to Predict Postoperative MACEs and/or Death and Prolonged Lengths of Stay in the Hospital and the ICU

	MACEs/Death	Hospital Stay >8 Days	ICU Stay >4 Days
BNP (pg/mL)	317	268	242
Sensitivity	0.77 (0.60-0.89)	0.71 (0.56-0.83)	0.61 (0.42-0.78)
Specificity	0.75 (0.68-0.81)	0.69 (0.62-0.76)	0.62 (0.54-0.69)
PPV	0.38 (0.27-0.51)	0.41 (0.37-0.57)	0.22 (0.14-0.32)
NPV	0.94 (0.89-0.97)	0.89 (0.81-0.96)	0.90 (0.83-0.95)
Accuracy	0.75 (0.69-0.81)	0.70 (0.61-0.75)	0.61 (0.55-0.68)
Positive LHR	3.00	2.31	1.60
Negative LHR	0.33	0.42	0.63
Youden Index[23]	0.52	0.40	0.23

NOTE. Data are values (95% confidence interval).

Abbreviations: LHR, likelihood ratio; NPV, negative predictive value; PPV, positive predictive value.

interval, 0.41-0.61; $p < 0.001$). The areas under the ROC curves assessing the utility of EuroSCORE in predicting both postoperative adverse outcome and prolonged lengths of stay are reported in Table 4. The discrimination of EuroSCORE in predicting postoperative MACEs and/or death was significantly lower than preoperative BNP (Fig 1A). There was also a trend in a better discrimination of preoperative BNP to predict a prolonged in-hospital stay when compared with EuroSCORE, even if it did not reach statistical significance (Fig 1B). No significant difference was found between preoperative BNP and EuroSCORE in predicting a prolonged stay in the ICU after conventional cardiac surgery (Fig 1C).

DISCUSSION

The main findings of the present study are that (1) a single preoperative value of plasma BNP is a strong, independent, and more accurate predictor of postoperative adverse outcome than EuroSCORE; (2) the standard EuroSCORE alone has only a modest prognostic utility for the detection of a composite operative risk associating severe cardiac morbidity and all-cause mortality; and (3) BNP and EuroSCORE are of quite limited value to predict prolonged lengths of stay after conventional cardiac surgery. Using a cutoff point of 317 pg/mL for preoperative BNP differentiates patients with an almost 8-fold increased risk of adverse outcome in the early postoperative period. These findings could further support the routine use of preoperative BNP as a simple, objective, and relatively inexpensive tool for the early detection of high-risk patients in the cardiac surgical setting.

BNP measurement recently has emerged as being valuable in the cardiac surgical setting, and previous studies reported the prognostic value of preoperative[10-13] and postoperative[11,25] BNP concentrations on both mortality and/or cardiac morbidity. Pre- and postoperative NT-proBNP also showed an interesting prognostic value in predicting postoperative cardiac complications after off-pump coronary artery surgery.[26] Interestingly, the authors found a cut-off value of preoperative NT-proBNP (397 pg/mL) and quite similar diagnostic performances for postoperative cardiac adverse events.[26] Logistic regression models to assess the independent role of preoperative BNP and NT-proBNP in predicting postoperative adverse cardiac outcome and in-hospital mortality primarily are reported in 2 large prospective studies.[13,14] The results of the present study are in accordance with those previous reports because the authors found good discrimination and accuracy of a single preoperative BNP measurement in predicting postoperative adverse outcome in patients undergoing different types of conventional cardiac surgery, even if the total diagnostic performance of BNP was quite moderate. An elevated BNP value was the only univariable predictor of adverse outcome in the logistic models, meaning that a single preoperative plasma BNP measurement could be more helpful than the standard EuroSCORE in detecting a composite endpoint of severe postoperative cardiac morbidity and all-cause mortality in the cardiac surgical setting. Few previous studies assessed the discrimination of natriuretic peptides to predict prolonged lengths of stay after cardiac surgery.[27] A good discrimination, attested by an area under the ROC curve reaching 0.83, was reported with preoperative NT-proBNP when a composite endpoint as-

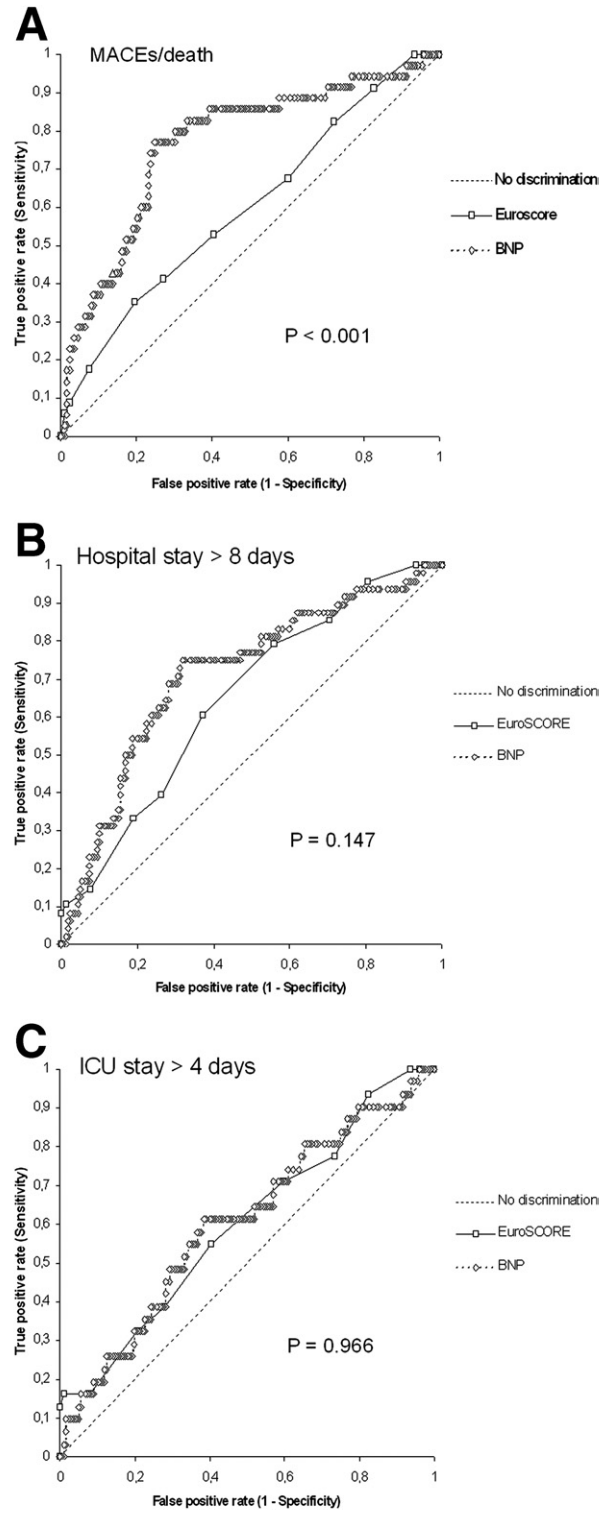

Fig 1. ROC curves showing (A) the relation between sensitivity and 1-specificity in determining the predictive value of EuroSCORE and preoperative BNP for the diagnosis of postoperative major adverse cardiac events and/or death, (B) prolonged in-hospital stay >8 days, and (C) prolonged stay in cardiac intensive care unit >4 days in 208 patients undergoing conventional cardiac surgery. The dotted diagonal line is the no-discrimination curve.

sociating length of stay in the ICU and all-cause mortality at 28 days was considered.[27] In the current study, a single preoperative BNP measurement was quite accurate in predicting prolonged in-hospital stay (area under the ROC curve at 0.71) but of more limited value to predict prolonged length of stay in ICU, meaning that the interest in BNP for the early prediction of intermediate endpoints as lengths of stay remains questionable for routine clinical practice.

Although the EuroSCORE has been validated as one of the most robust multifactor risk scores for cardiac surgical patients to predict short- and long-term mortality,[6] the authors found a poor discrimination of standard EuroSCORE in predicting a composite endpoint of severe cardiac morbidity and all-cause mortality in the present study. An explanation could be that the present cohort of patients was likely different from those initially described.[5] Standards of care at the present time also are somewhat different. Moreover, the profile of cardiac surgical patients has changed over the past 10 years, and preoperative evaluation has progressed markedly, better at using major chronic therapies like statins and/or oral antiplatelet agents.[21,28] The composite aspect of severe cardiac morbidity mainly could explain the disappointing results reported with EuroSCORE as a predictor of both postoperative nonfatal major cardiac events and all-cause death, the latter being much less frequent than the former at the present time. A single value of preoperative BNP was markedly superior to EuroSCORE in predicting MACEs and/or death in the present study. To the authors' knowledge, no previous study compared the discrimination of preoperative BNP with standard EuroSCORE in various cardiac surgical procedures, even if 2 recent studies addressed a similar question with preoperative NT-proBNP[27] and with logistic EuroSCORE for the prediction of short- and long-term mortality after elective aortic valve replacement.[29] BNP also has been found more accurate than the Revised Cardiac Risk Index in predicting perioperative cardiac events in patients undergoing major noncardiac surgery.[15] Thus, preoperative BNP measurement could be of great interest for the early identification of high-risk patients in cardiac and noncardiac surgery and may add to existing clinical models of risk stratification. The authors postulate that the ability of BNP to integrate differing facets of myocardial dysfunction makes it superior to EuroSCORE as an indicator of poor prognosis in the cardiac surgical setting.

Some remarks must be included to indicate the limitations of the current study. First, the study was conducted in a single center and included a relatively low number of patients. Therefore, the threshold values reported for preoperative BNP must be interpreted with caution. Although the logistic model was quite robust, reinforcing the internal validity of the present results, an external validation using other cohorts provided by other centers is mandatory. Second, the authors used an additive model of EuroSCORE in accordance with clinical routine practice in so many cardiac institutions. A logistic model could have been more discriminating for both postoperative severe cardiac morbidity and all-cause mortality. However, the logistic model is less easy to calculate at the bedside, and its discrimination for a composite operative risk remains questionable.[9] Third, the authors used a traditional biologic approach by using preoperative BNP alone. The authors recently showed that an integrating approach measuring postoperative multiple cardiac biomarkers associating BNP, cTnI, and C-reactive protein improved the risk assessment of cardiac adverse outcome within 12 months after elective cardiac surgery.[30] Further studies should compare pre- and postoperative multiple markers strategies in addition with clinical risk scores to better identify high-risk patients on a short- and long-term basis and definitely clarify what cardiac biomarkers may add to existing methods of risk stratification in the cardiac surgical setting. Because most preoperative biomarkers values are within the normal range (especially cTnI and C-reactive protein), a greater sample size should, however, probably be required. Last, the present study does not test appropriate strategies to improve outcomes in identified high-risk patients. Future studies should also prospectively address this important issue.

In conclusion, a single preoperative plasma BNP measurement is a strong and independent predictor of postoperative adverse outcome in patients undergoing conventional cardiac surgery. Its diagnostic performances are superior to standard EuroSCORE in this setting, likely because of the ability of BNP to integrate differing facets of myocardial dysfunction. Further works should now determine the utility of BNP in combination with different multifactor cardiac risk scores and assess whether interventions that reduce preoperative BNP levels can prevent postoperative adverse outcome before widely recommending the use of BNP as a clinically useful risk marker in the cardiac surgical setting.

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