

Predictive Value of EuroSCORE II in Contemporary Cardiac Surgery : Insights from the EPICARD Registry

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Abstract

Objective

The predictive performance of EuroSCORE II may have evolved over the last decade owing to major changes in cardiac surgery practice, including an ageing population, increasing comorbidity burden, and advances in perioperative management. We aimed to evaluate the contemporary performance of EuroSCORE II in a large nationwide French cohort.

Methods

We conducted a retrospective analysis of consecutive adult patients undergoing cardiac surgery between 2020 and 2024 in centers participating in the French EPICARD registry (French Society of Cardiothoracic and Vascular Surgery, Federation des Specialites Medicales, France). Patients undergoing heart transplantation, durable mechanical circulatory support implantation, cardiac tumor surgery, or with missing EuroSCORE II data were excluded. The primary endpoint was operative mortality, defined as in-hospital or 30-day mortality, identified through linkage with the French national mortality database (INSEE). Discrimination was assessed using the area under the receiver operating characteristic curve (AUC), while calibration was evaluated using the Hosmer–Lemeshow test and calibration plots.

Results

A total of 108,412 patients were included. Median EuroSCORE II was 1.7% [IQR 1.0–3.4], and overall operative mortality was 3.3% (n = 3,572). EuroSCORE II demonstrated acceptable discriminative performance (AUC 0.83, 95% CI 0.82–0.84). Calibration varied across surgical subgroups, with slight overestimation in low-risk patients and isolated CABG, and underestimation in high-risk settings, particularly acute aortic dissection and combined CABG-aortic procedures.

Conclusions

EuroSCORE II remains a valuable risk stratification tool in contemporary cardiac surgery but shows calibration limitations in specific high-risk populations, supporting the need for periodic recalibration and updated risk models.

Introduction

Accurate preoperative risk stratification remains essential in contemporary cardiac surgery to guide clinical decision-making, inform patients and families, optimize perioperative management, and enable benchmarking between institutions. Among the available risk models, the European System for Cardiac Operative Risk Evaluation (EuroSCORE)¹ rapidly became one of the most widely used tools for predicting operative mortality after adult cardiac surgery. Developed from the original EuroSCORE model, EuroSCORE II² was introduced in 2012 to provide more accurate risk estimates by reflecting contemporary surgical practice. The original EuroSCORE was mainly derived from patients undergoing coronary artery bypass grafting (CABG)³. However, it progressively overestimated operative mortality as surgical techniques, perioperative management, and postoperative care improved over time, leading to the development of EuroSCORE II to recalibrate risk prediction according to contemporary practice.

Since its development, cardiac surgery has continued to evolve substantially. Patients are older, present with a greater burden of comorbidities, and undergo increasingly complex procedures.^{4,5} Simultaneously, advances in surgical techniques, myocardial protection, cardiopulmonary bypass management, perioperative care, and the expansion of minimally invasive, transcatheter, and hybrid procedures have modified operative risk profiles.⁶

More recently, concerns have been raised regarding the long-term reliability of EuroSCORE II in contemporary cardiac surgery practice. In a retrospective study including patients operated between 2016 and 2022, Mastroiacovo et al.⁷ reported preserved discriminative performance of EuroSCORE II, with an AUC of 0.834, but observed significant calibration discrepancies according to surgical setting. The score tended to overestimate mortality in low-risk elective procedures while underestimating mortality in high-risk and emergency surgery patients, suggesting a progressive loss of calibration in contemporary populations.

Despite numerous international validation studies, contemporary nationwide data evaluating the performance of EuroSCORE II in French cardiac surgery remain scarce. The EPICARD registry is a nationwide multicenter database prospectively collecting perioperative and postoperative data from participating French cardiac surgery centers.

In this context, reassessment of EuroSCORE II calibration and discriminative ability appears warranted. Therefore, we sought to evaluate the contemporary predictive value of EuroSCORE II by comparing predicted operative mortality with observed postoperative mortality in patients undergoing cardiac surgery included in the EPICARD registry.

Materials and Methods

Ethics statement

This study was approved by the Ethics Committee of the French Society of Thoracic and Cardiovascular surgery (approval number IRB00012919). All patients have signed a consent form for the use of their anonymized health data for clinical research purposes in accordance with the General Data Protection Regulation.

Study design and population

This retrospective observational study included all consecutive adult patients (≥ 18 years) undergoing cardiac surgery between January 2020 to December 2024 in French cardiac surgery centers participating in the national EPICARD registry with a validated data quality index greater than 80% (French Society of Cardiothoracic and Vascular Surgery, Federation des Specialites Medicales, Paris, France). The EPICARD registry is linked to the national death registry (Institut National de la Statistique et des Etudes Economiques, Montrouge, France)⁸ allowing complete ascertainment of in-hospital and out-of-hospital mortality. EPICARD prospectively collects demographic, preoperative, operative, and postoperative data, and EuroSCORE II is calculated automatically within the registry. Patients undergoing heart transplantation, durable mechanical circulatory support device, cardiac tumor surgery or with missing or inconsistent EuroSCORE II data or missing 30-day mortality were excluded.

Surgical procedures were classified as isolated coronary artery bypass grafting (CABG), isolated valvular surgery, non-emergency thoracic aortic surgery, emergency surgery for acute aortic dissection, or combined procedures (CABG-valve, CABG-aortic, valve-aortic, or ≥ 3 procedures).

Study objectives and outcomes

The primary objective was to evaluate the discriminative performance of EuroSCORE II for predicting operative mortality. The primary endpoint was operative mortality, defined as death during the index hospitalization or within 30 days after surgery. Secondary objectives were to assess calibration in the overall cohort and predefined surgical subgroups, and to evaluate discrimination across these subgroups.

Statistical analysis

Continuous variables were expressed as mean $\pm$ standard deviation or median with interquartile range according to data distribution. Categorical variables were presented as numbers and percentages.

Discrimination was assessed using receiver operating characteristic (ROC) curve analysis and quantified by the area under the ROC curve (AUC) with its 95% confidence interval [$0.5 < \text{AUC} < 1$].

Calibration was evaluated using the Hosmer–Lemeshow goodness-of-fit test, calibration plots across risk deciles, and the observed-to-expected (O/E) mortality ratio with 95% confidence intervals derived from the Poisson distribution. Calibration analyses were performed in the overall cohort and predefined surgical subgroups.

Statistical analyses were performed using R software version 4.4.2 or later (R Foundation for Statistical Computing, Vienna, Austria). All tests were two-sided, with $P < 0.05$ considered statistically significant. Analyses were exploratory, with no adjustment for multiple comparisons, and no imputation was performed for missing data.

Results

Study population

Between January 2020 and December 2024, a total of 108,412 patients undergoing cardiac surgery in French cardiac surgery centers participating in the EPICARD registry were included (Fig. 1). Baseline characteristics are summarized in Table 1, and urgency status and procedure complexity in Table 2. The cohort was predominantly male (74.8%), with a median age of 68 years [IQR 60–73]. Isolated coronary artery bypass grafting (CABG) was the most frequently performed procedure (39.5%). Median EuroSCORE II was 1.7% (IQR, 1.0–3.4), and overall operative mortality was 3.3% ($n = 3,572$). The mean predicted operative mortality was 3.5%, compared with an observed mortality of 3.3%, corresponding to an overall O/E ratio of 0.93. The leading causes of death were multiorgan failure (37.0%), terminal cardiac failure (13.1%), neurological complications (8.3%), and cardiac causes (8.0%). Cardiopulmonary bypass (CPB) was used in 104,857 patients (96.7%).

Table 1
Baseline characteristics of global population and EuroSCORE II variables

Age, year, median[IQR]	All N = 108,412 (100%)	CABG N = 42,617	Valvular Surgery N = 24,944	Double valvular Surgery N = 16,443	Thoracic aortic Surgery (No emergency) N = 13,261	Aortic dissection N = 3,979	CABG + Valvular Surgery N = 7150	CABG + Aortic Surgery N = 759	Valvular + aortic Surgery N = 1,115	30-day mortality N = 1,115
	68.0 [60.0;73.0]	68.0 [61.0;73.0]	67.0 [60.0;73.0]	69.0 [62.0;74.0]	66.0 [57.0;73.0]	66.0 [57.0;73.0]	71.0 [66.0;75.0]	70.0 [64.0;75.0]	66.0 [57.0;73.0]	67.0 [57.0;73.0]
Sex, n(%)	27,334 (25.2)	6,659 (15.6)	8,432 (33.8)	4,877 (29.7)	3,431 (25.9)	1,399 (35.2)	1,349 (18.9)	158 (20.8)	327 (29.3)	2,111 (25.2)
Female			16,512(66.2)	11,566(70.3)	9,830 (74.1)			601 (79.2)	788 (70.7)	6,444 (77.1)
Male	81,078 (74.8)	35,958 (84.4)				2,580 (64.8)	5,801 (81.1)			6,444 (77.1)
BMI (kg/m ²), mean ± sd	26.8 ± 4.5	27.2 ± 4.2	26.7 ± 4.8	26.6 ± 4.7	26.6 ± 4.5	26.4 ± 4.6	27.3 ± 4.4	27.3 ± 4.5	26.4 ± 4.6	26.6 ± 4.5
EuroSCORE II (%)	1.7 [1.0;3.4]	1.2 [0.9;2.0]	1.3 [0.8;2.2]	2.6 [1.7;4.7]	3.2 [1.9;5.6]	6.4 [3.6;12.3]	2.4 [1.7;4.0]	3.6 [2.3;6.0]	3.1 [1.9;5.5]	5.1 [3.1;7.1]
GFR, (μmol/l), median[IQR]	80.0 [62.0;100.0]	82.0 [65.0;101.0]	80.0 [62.0;100.0]	75.0 [58.0;96.0]	84.0 [65.0;105.0]	76.0 [57.0;98.0]	76.0 [60.0;95.0]	78.0 [63.0;98.0]	82.0 [62.0;103.0]	78.0 [62.0;103.0]
Dialysis, n(%)	1,286 (1.2)	549 (1.3)	229 (0.9)	239 (1.5)	69 (0.5)	46 (1.2)	106 (1.5)	7 (0.9)	6 (0.5)	106 (1.2)
Diabetes n(%)	24,211 (22.3)	14,265 (33.5)	3,893 (15.6)	3,177 (19.3)	1,174 (8.9)	255 (6.4)	2,058 (28.8)	122 (16.1)	95 (8.5)	1,174 (11.3)
BPCO with treatment, n(%)	5,929 (5.5)	2,478 (5.8)	1,275 (5.1)	912 (5.5)	702 (5.3)	167 (4.2)	431 (6.0)	50 (6.6)	47 (4.2)	456 (4.5)
Active endocarditis, n(%)	4,146 (3.8)	65 (0.2)	2,243 (9.0)	1,103 (6.7)	395 (3.0)	81 (2.0)	178 (2.5)	11 (1.4)	39 (3.5)	481 (4.8)
Disabling neurological or musculoskeletal impairment, n(%)	2,441 (2.3)	777 (1.8)	571 (2.3)	424 (2.6)	259 (2.0)	191 (4.8)	159 (2.2)	16 (2.1)	14 (1.3)	281 (2.8)
Carotid stenosis > 50% and/or anterior carotid surgery, n(%)	5,740 (5.3)	3,523 (8.3)	631 (2.5)	772 (4.7)	284 (2.1)	180 (4.5)	557 (7.8)	22 (2.9)	19 (1.7)	331 (3.3)
Peripheral arterial disease, n(%)	7,620 (7.0)	4,941 (11.6)	809 (3.2)	937 (5.7)	371 (2.8)	165 (4.1)	671 (9.4)	36 (4.7)	30 (2.7)	331 (3.3)
Anterior thoracic or abdominal aorta surgery, n(%)	1,830 (1.7)	564 (1.3)	162 (0.6)	179 (1.1)	741 (5.6)	305 (7.7)	69 (1.0)	38 (5.0)	58 (5.2)	331 (3.3)
Extracardiac arteriopathy	12,691 (11.7)	7,384 (17.3)	1,406 (5.6)	1,599 (9.7)	1,242 (9.4)	556 (14.0)	1,082 (15.1)	86 (11.3)	93 (8.3)	856 (8.5)
Anterior cardiac surgery, n(%)	5,527 (5.1)	188 (0.4)	2,062 (8.3)	1,222 (7.4)	1,257 (9.5)	301 (7.6)	144 (2.0)	30 (4.0)	74 (6.6)	941 (9.4)
BMI : body mass index, ECMO : Extracorporeal Membrane Oxygenation ; GFR : glomerular filtration rate, NYHA : New York Heart Association ; LVEF : Left Ventricular Ejection Fraction										

Age, year, median[IQR]	All N = 108,412 (100%)	CABG N = 42,617	Valvular Surgery N = 24,944	Double valvular Surgery N = 16,443	Thoracic aortic Surgery (No emergency) N = 13,261	Aortic dissection N = 3,979	CABG + Valvular Surgery N = 7150	CABG + Aortic Surgery N = 759	Valvular + aortic Surgery N = 1,115	3 pr N
	68.0 [60.0;73.0]	68.0 [61.0;73.0]	67.0 [60.0;73.0]	69.0 [62.0;74.0]	66.0 [57.0;73.0]	66.0 [57.0;73.0]	71.0 [66.0;75.0]	70.0 [64.0;75.0]	66.0 [57.0;73.0]	67 [5
NYHA, n(%)	37,954 (35.0)	19,016 (44.6)	5,963 (23.9)	3,511 (21.4)	5,824 (43.9)	2,017 (50.7)	1,552 (21.7)	334 (44.0)	424 (38.0)	2,6 (2
1			11,521(46.2)	7,247 (44.1)	5,182 (39.1)			292 (38.5)	413 (37.0)	3,6 (3
2	44,928 (41.4)	17,844 (41.9)	6,158 (24.7)	4,606 (28.0)	1,878 (14.2)	844 (21.2)	3,544 (49.6)	118 (15.5)	225 (20.2)	2,5 (2
3	20,273 (18.7)	4,963 (11.6)	1,302 (5.2)	1,079 (6.6)	377 (2.8)	571 (14.4)	1,741 (24.3)	15 (2.0)	53 (4.8)	2,5 (2
4	5,257 (4.8)	794 (1.9)				547 (13.7)	313 (4.4)			71
Rest angina, n(%)	7,505 (6.9)	6,069 (14.2)	210 (0.8)	540 (3.3)	134 (1.0)	217 (5.5)	469 (6.6)	43 (5.7)	17 (1.5)	20
Myocardial infarction within 90 days, n(%)	7,848 (7.2)	6,382 (15.0)	178 (0.7)	447 (2.7)	74 (0.6)	70 (1.8)	385 (5.4)	31 (4.1)	4 (0.4)	18
Ventricular tachycardia or ventricular fibrillation within 24h before surgery, n(%)	415 (0.4)	138 (0.3)	44 (0.2)	33 (0.2)	8 (0.1)	39 (1.0)	20 (0.3)	6 (0.8)	4 (0.4)	34
Preoperative inotropic support, n(%)	2,396 (2.2)	291 (0.7)	466 (1.9)	348 (2.1)	165 (1.2)	312 (7.8)	105 (1.5)	8 (1.1)	26 (2.3)	34
Preoperative intra-aortic balloon pump, n(%)	620 (0.6)	230 (0.5)	46 (0.2)	57 (0.3)	7 (0.1)	4 (0.1)	38 (0.5)	2 (0.3)	1 (0.1)	44
Preoperative ECMO support, n(%)	508 (0.5)	36 (0.1)	28 (0.1)	38 (0.2)	9 (0.1)	12 (0.3)	14 (0.2)	0 (0.0)	0 (0.0)	86
Preoperative intubation, n(%)	1,276 (1.2)	103 (0.2)	318 (1.3)	194 (1.2)	53 (0.4)	190 (4.8)	59 (0.8)	8 (1.1)	12 (1.1)	12
Preoperative cardiopulmonary resuscitation, n(%)	453 (0.4)	102 (0.2)	52 (0.2)	38 (0.2)	14 (0.1)	78 (2.0)	15 (0.2)	3 (0.4)	4 (0.4)	38
Critical preoperative state, n(%)	3,743 (3.5)	666 (1.6)	685 (2.7)	510 (3.1)	223 (1.7)	540 (13.6)	163 (2.3)	18 (2.4)	40 (3.6)	47
LVEF (%), median[IQR]	60.0 [54.0;65.0]	60.0 [50.0;62.0]	60.0 [55.0;65.0]	60.0 [55.0;65.0]	60.0 [55.0;65.0]	60.0 [55.0;60.0]	60.0 [52.0;65.0]	60.0 [55.0;63.0]	60.0 [55.0;65.0]	60 [5
Systolic pulmonary artery pressure (mmHg), median[IQR]	25.0 [25.0;32.0]	25.0 [25.0;28.0]	25.0 [25.0;36.0]	30.0 [25.0;40.0]	25.0 [25.0;30.0]	25.0 [25.0;29.0]	25.0 [25.0;35.0]	25.0 [25.0;30.0]	25.0 [25.0;34.0]	30 [2
BMI : body mass index, ECMO : Extracorporeal Membrane Oxygenation ; GFR : glomerular filtration rate, NYHA : New York Heart Association ; LVEF : Left Ventricular Ejection Fraction										

Table 2
Urgency status and Procedure complexity

Urgency status, n(%)	
Elective	80,522 (74.3)
Urgent	21,750 (20.1)
Operation performed during the same hospital admission	
Emergency	5,561 (5.1)
Before the next working day	
Salvage	579 (0.5)
Ongoing CPR	
Procedure Complexity n(%)	
Isolated CABG	42,858 (39.5)
Single non-CABG procedure	32,945 (30.4)
Two-procedure surgery	23,640 (21.8)
Three or more concomitant procedures	8,969 (8.3)
CPR : Cardiopulmonary resuscitation	

Primary endpoint

EuroSCORE II demonstrated good discriminative performance for predicting operative mortality, with an AUC of 0.83 (95% CI, 0.82–0.84) (Fig. 2). Median EuroSCORE II was substantially higher among patients who died than among survivors (7.6% [IQR 3.2–18.4] vs 1.7% [IQR 1.0–3.2], respectively).

Calibration analysis

In the overall population, the Hosmer–Lemeshow test demonstrated statistically significant differences between predicted and observed mortality ($p < 0.001$) suggesting suboptimal calibration. Given the large sample size, this result should be interpreted cautiously because the test is highly sensitive to small deviations from perfect calibration. Calibration plots showed acceptable overall agreement, with slight overestimation in low-risk patients (0.60% predicted vs 0.15% observed in the first decile) and acceptable agreement in the highest-risk decile (16.95% predicted vs 16.98% observed). Overall calibration was further supported by an O/E mortality ratio of 0.93 (95% CI, 0.90–0.96), indicating only modest overestimation of mortality.

Subgroup analyses

Subgroup analyses demonstrated preserved discriminative performance of EuroSCORE II, whereas calibration varied according to procedure type in both calibration plots and O/E ratios.

In isolated CABG, EuroSCORE II generally overestimated mortality, particularly in lower-risk patients, consistent with an O/E ratio of 0.71 (95% CI, 0.66–0.77). Calibration improved across increasing risk levels, with close agreement in the highest decile (6.9% predicted vs 6.5% observed).

In isolated valvular surgery, EuroSCORE II overestimated mortality in lower-risk patients but underestimated mortality in the highest-risk decile (11.7% predicted vs 12.6% observed), resulting in an overall O/E ratio of 0.98 (95% CI, 0.91–1.07).

Conversely, EuroSCORE II consistently underestimated mortality in acute aortic dissection surgery, with observed mortality exceeding predicted mortality across most risk deciles. In the first decile, mortality was 6.8% versus 1.7% predicted, corresponding to an O/E ratio of 1.47 (95% CI, 1.36–1.59).

Calibration patterns were more heterogeneous in combined procedures. In patients undergoing combined CABG-valve surgery, predicted and observed mortality remained relatively close across risk deciles, with O/E ratio of 0.93 (95% CI 0.82–1.05) and a non-significant Hosmer-Lemeshow test ($p = 0.21$). Similarly, calibration appeared acceptable in combined valve-aortic procedures, with O/E ratio of 0.79 (95% CI 0.59–1.04), although the wide confidence interval reflects the small size of this subgroup (Hosmer-Lemeshow test $p = 0.22$). In contrast, EuroSCORE II underestimated mortality after combined CABG-aortic surgery, particularly in the highest-risk decile (28.9% observed vs 19.5% predicted; O/E ratio 1.46, 95% CI, 1.12–1.88). For procedures involving three or more concomitant operations, mortality was generally overestimated (35.5% predicted vs 27.1% observed in the highest decile), yielding an O/E ratio of 0.79 (95% CI, 0.73–0.85).

Detailed ROC curves, calibration plots, Hosmer–Lemeshow analyses, and O/E ratios for all predefined surgical subgroups are provided in the Supplementary Appendix.

Discussion

In this large contemporary nationwide cohort including more than 100,000 patients undergoing cardiac surgery in France, EuroSCORE II demonstrated good discriminative performance for predicting in-hospital or 30-day mortality even 14 years after its first publication, with an AUC of 0.83. However, calibration varied across surgical subgroups and patient risk profiles. EuroSCORE II slightly overestimated mortality among lower-risk patients and routine procedures such as isolated CABG, and it underestimated mortality in specific high-risk settings, particularly acute aortic dissection and combined procedures.

The rise of structural interventional cardiology procedures has profoundly transformed the indications for, and demographics of, patients referred for cardiac surgery over the past 15 years. Consequently, operative risk prediction has become a major determinant of surgical indications. The discriminative performance of EuroSCORE II observed in the present study is consistent with previous external validation studies^{9–12} reporting AUC values ranging from 0.79 to 0.84 across different surgical populations. Barili et al.¹³ reported a c-statistic of approximately 0.81 in a contemporary Italian cohort, while a large meta-analysis including more than 145,000 patients confirmed good discrimination across multiple healthcare systems¹⁴.

Our findings further support the long-term robustness of EuroSCORE II with respect to discrimination despite profound changes in clinical practice, with good ability to distinguish patients who died from those who survived after surgery. Calibration was more heterogeneous. Although the Hosmer–Lemeshow test suggested inadequate calibration in the overall cohort and most subgroups, these findings should be interpreted cautiously because the test is highly sensitive to small deviations in very large populations.

Visual assessment of calibration plots provided a more nuanced picture. In the overall cohort, EuroSCORE II slightly overestimated mortality among lower-risk patients, whereas predicted and observed mortality became closely aligned in intermediate and high-risk deciles. Similar patterns were observed for isolated CABG and isolated valvular surgery. These findings are consistent with previous reports suggesting that improvements in perioperative care and operative outcomes may progressively reduce mortality among lower-risk patients compared with populations used for derivation of EuroSCORE II^{15,16}.

Conversely, EuroSCORE II underestimated mortality in some high-risk clinical settings. The clearest example was acute aortic dissection surgery, where observed mortality exceeded predicted mortality across almost all risk deciles. A similar pattern was observed in patients undergoing combined CABG-aortic procedures. These findings are consistent with previous reports suggesting lower calibration accuracy of EuroSCORE II in emergency and complex surgical settings. In a contemporary retrospective study, Mastroiaco et al. reported that EuroSCORE II tended to underestimate mortality in high-risk and emergency patients despite preserved overall discrimination, highlighting a progressive loss of calibration in selected subgroups of contemporary practice⁷. More specifically, several authors have questioned the applicability of conventional cardiac surgery risk scores in acute type A aortic dissection surgery. Major determinants of postoperative mortality in this setting, including preoperative shock, cardiac tamponade and organ malperfusion, have been identified in the International Registry of Acute Aortic Dissection (IRAD) but are partially represented within the variables currently included in EuroSCORE II¹⁷.

From a clinical perspective, our results suggest that EuroSCORE II remains a valuable tool for preoperative risk stratification and patient counselling in contemporary cardiac surgery practice. However, clinicians should recognize that predicted mortality may be slightly overestimated in low-risk elective procedures and underestimated in emergency or highly complex surgery. The nationwide multicenter design of the present study is a major strength, including more than 100,000 contemporary cardiac surgical procedures collected in a real-world database representative of current French practice. Furthermore, the automatic calculation of EuroSCORE II within the EPICARD registry limited potential calculation errors and ensured standardized risk assessment across participating centers.

Several limitations should be acknowledged. First, the retrospective observational design is subject to the inherent limitations of registry-based analyses. Calibration discrepancies observed in specific subgroups may partly reflect prognostic factors not captured by EuroSCORE II rather than a true decline in model performance. Second, patients with missing or inconsistent data required for EuroSCORE II calculation were excluded ($n = 10,628$; 9% of the initial cohort). Although their baseline characteristics were comparable to those of the study population (Supplementary Table 2), reducing the likelihood of substantial selection bias, unmeasured differences cannot be excluded. Third, calibration assessment included the Hosmer–Lemeshow test, whose interpretation is limited in very large cohorts because of its sensitivity to small deviations from perfect calibration. We therefore complemented this analysis with calibration plots and O/E ratios, which confirmed the observed calibration patterns, including mild overestimation in isolated CABG and underestimation in acute aortic dissection surgery. Finally, although EPICARD reflects contemporary routine practice in France, these findings may not be directly generalizable to healthcare systems with different patient characteristics, case mix, or perioperative management strategies.

Conclusion

In this large contemporary French cardiac surgery cohort, EuroSCORE II maintained good discriminative performance for predicting in-hospital or 30-day mortality. Calibration performance was more heterogeneous and varied according to patient risk profile and surgical procedure, with a tendency toward overestimation in low-risk patients and underestimation in selected high-risk settings such as acute aortic dissection. The development of future risk models incorporating contemporary real-world data and procedure-specific risk factors may further improve the accuracy of operative risk prediction in cardiac surgery.

Abbreviations

AUC
Area under the Curve
CABG
Coronary artery bypass grafting
CPB

Cardiopulmonary bypass
IRAD
International Registry of Acute Aortic Dissection
ROC
Receiver Operating Characteristic

Declarations

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References

1. Nashef SA, Roques F, Michel P, Gauducheau E, Lemeshow S, Salamon R. European system for cardiac operative risk evaluation (EuroSCORE). *Eur J Cardiothorac Surg.* juill 1999;16(1):9–13. doi:10.1016/s1010-7940(99)00134-7 PubMed PMID: 10456395.
2. Nashef SAM, Roques F, Sharples LD, Nilsson J, Smith C, Goldstone AR, et al. EuroSCORE II†. *Eur J Cardiothorac Surg.* 1 avr 2012;41(4):734–45. doi:10.1093/ejcts/ezs043
3. Roques F, Nashef SA, Michel P, Gauducheau E, de Vincentiis C, Baudet E, et al. Risk factors and outcome in European cardiac surgery: analysis of the EuroSCORE multinational database of 19030 patients. *Eur J Cardiothorac Surg.* juin 1999;15(6):816–22; discussion 822–823. doi:10.1016/s1010-7940(99)00106-2 PubMed PMID: 10431864.
4. Friedrich I, Simm A, Kötting J, Thölen F, Fischer B, Silber RE. Cardiac Surgery in the Elderly Patient. *Dtsch Arztebl Int.* juin 2009;106(25):416–22. doi:10.3238/arztebl.2009.0416 PubMed PMID: 19623310; PubMed Central PMCID: PMC2704365.
5. Castillo JG, Silvay G, Chikwe J. Cardiac anesthesia and surgery in geriatric patients: epidemiology, current surgical outcomes, and future directions. *HSR Proc Intensive Care Cardiovasc Anesth.* 2009;1(2):6–19. PubMed PMID: 23439851; PubMed Central PMCID: PMC3484548.
6. Vahanian A, Beyersdorf F, Praz F, Milojevic M, Baldus S, Bauersachs J, et al. 2021 ESC/EACTS Guidelines for the management of valvular heart disease. *Eur Heart J.* 12 févr 2022;43(7):561–632. doi:10.1093/eurheartj/ehab395 PubMed PMID: 34453165.
7. Mastroiacovo G, Bonomi A, Ludergrani M, Franchi M, Maragna R, Pirola S, et al. Is EuroSCORE II still a reliable predictor for cardiac surgery mortality in 2022? A retrospective study study. *Eur J Cardiothorac Surg.* 1 sept 2023;64(3):ezad294. doi:10.1093/ejcts/ezad294
8. Guardiolle V, Bazoge A, Morin E, Daille B, Toublant D, Bouzillé G, et al. Linking Biomedical Data Warehouse Records With the National Mortality Database in France: Large-scale Matching Algorithm. *JMIR Med Inform.* 1 nov 2022;10(11):e36711. doi:10.2196/36711 PubMed PMID: 36318244; PubMed Central PMCID: PMC9667378.
9. Di Dedda U, Pelissero G, Agnelli B, De Vincentiis C, Castelvechio S, Ranucci M. Accuracy, calibration and clinical performance of the new EuroSCORE II risk stratification system. *Eur J Cardiothorac Surg.* 1 janv 2013;43(1):27–32. doi:10.1093/ejcts/ezs196
10. Garcia-Valentin A, Mestres CA, Bernabeu E, Bahamonde JA, Martín I, Rueda C, et al. Validation and quality measurements for EuroSCORE and EuroSCORE II in the Spanish cardiac surgical population: a prospective, multicentre study. *Eur J Cardiothorac Surg.* 1 févr 2016;49(2):399–405. doi:10.1093/ejcts/ezv090
11. Hogervorst EK, Rosseel PMJ, van de Watering LMG, Brand A, Bentala M, van der Meer BJM, et al. Prospective validation of the EuroSCORE II risk model in a single Dutch cardiac surgery centre. *Neth Heart J.* 1 nov 2018;26(11):540–51. doi:10.1007/s12471-018-1161-x

12. Chalmers J, Pullan M, Fabri B, McShane J, Shaw M, Mediratta N, et al. Validation of EuroSCORE II in a modern cohort of patients undergoing cardiac surgery. Eur J Cardiothorac Surg. 1 avr 2013;43(4):688–94. doi:10.1093/ejcts/ezs406

13. Barili F, Pacini D, Capo A, Rasovic O, Grossi C, Alamanni F, et al. Does EuroSCORE II perform better than its original versions? A multicentre validation study. Eur Heart J. 1 janv 2013;34(1):22–9. doi:10.1093/eurheartj/ehs342

14. Guida P, Mastro F, Scrascia G, Whitlock R, Paparella D. Performance of the European System for Cardiac Operative Risk Evaluation II: a meta-analysis of 22 studies involving 145,592 cardiac surgery procedures. J Thorac Cardiovasc Surg. déc 2014;148(6):3049–3057.e1. doi:10.1016/j.jtcvs.2014.07.039 PubMed PMID: 25161130.

15. Silverborn M, Nielsen S, Karlsson M. The performance of EuroSCORE II in CABG patients in relation to sex, age, and surgical risk: a nationwide study in 14,118 patients. J Cardiothorac Surg. 19 janv 2023;18(1):40. doi:10.1186/s13019-023-02141-4

16. Carino D, Denti P, Ascione G, Del Forno B, Lapenna E, Ruggeri S, et al. Is the EuroSCORE II reliable in surgical mitral valve repair? A single-centre validation study. Eur J Cardiothorac Surg. 1 avr 2021;59(4):863–8. doi:10.1093/ejcts/ezaa403

17. Berretta P, Patel HJ, Gleason TG, Sundt TM, Myrmel T, Desai N, et al. IRAD experience on surgical type A acute dissection patients: results and predictors of mortality. Ann Cardiothorac Surg. juill 2016;5(4):346–51. doi:10.21037/acs.2016.05.10 PubMed PMID: 27563547; PubMed Central PMCID: PMC4973119.

Figures

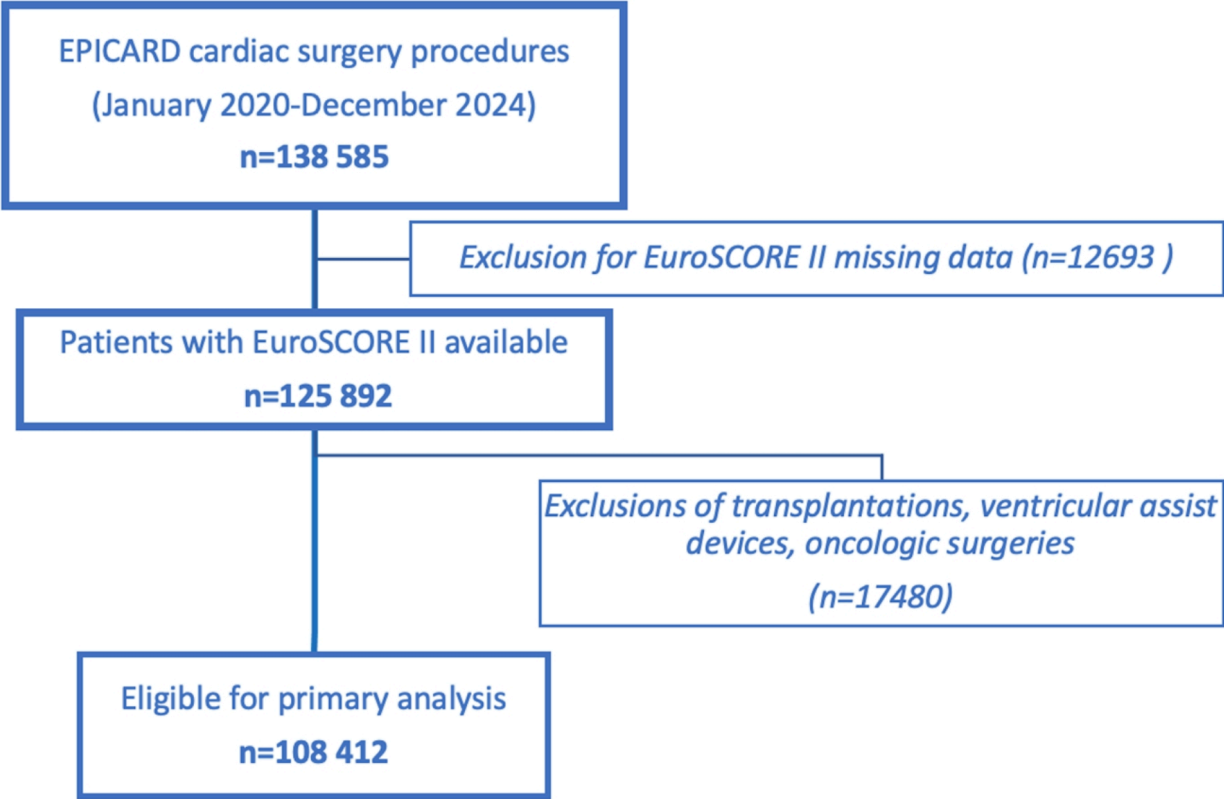


Figure 1

Flowchart

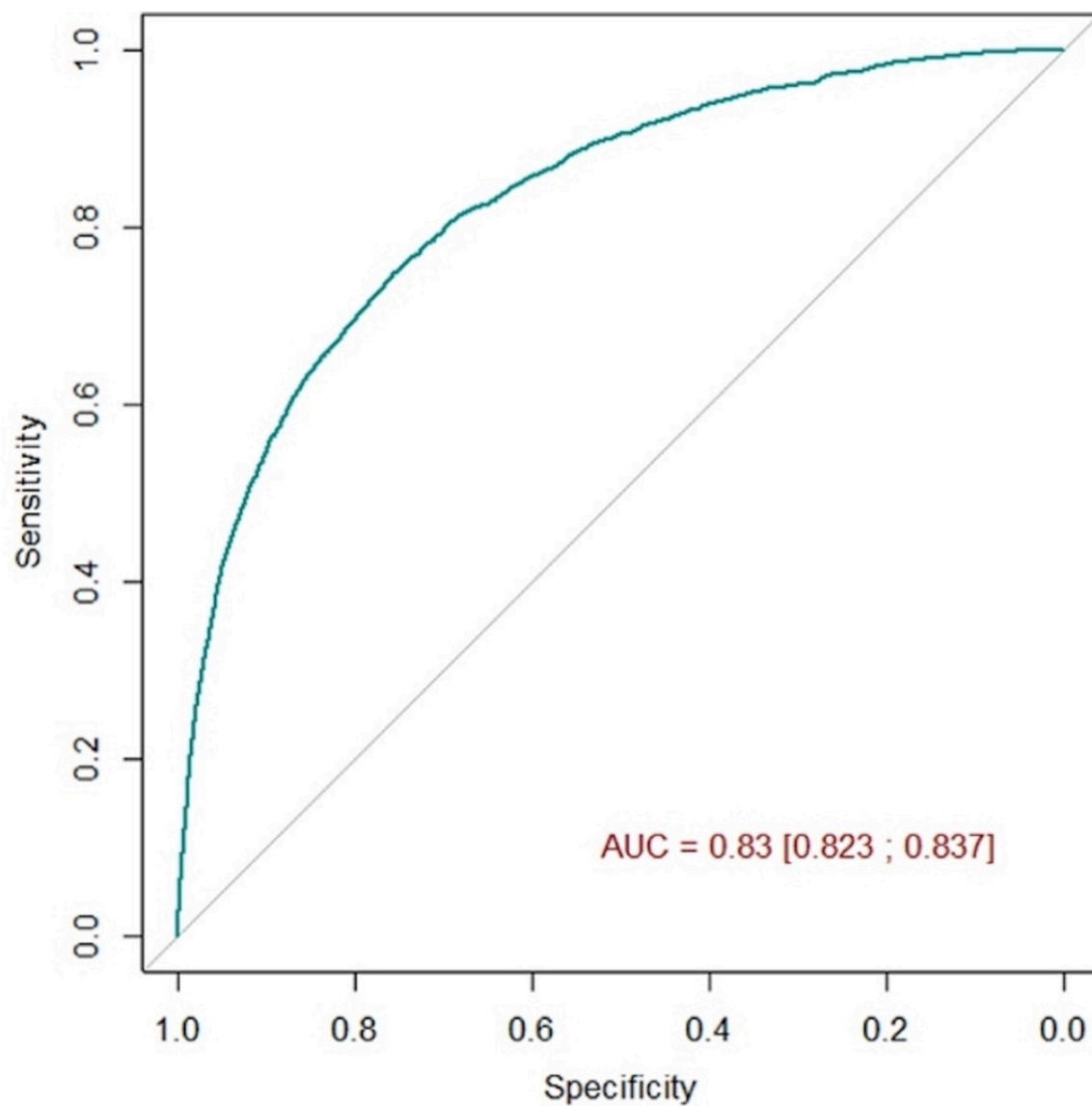


Figure 2

Overall population ROC curve

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