Development and validation of elective and non-elective risk prediction models for in-hospital mortality in proximal aortic surgery using the National Institute for Cardiovascular Outcomes Research (NICOR) database

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Abstract

Objectives

In order to facilitate patient choice and the risk adjustment of consultant outcomes in aortic surgery, reliable predictive tools are required. Our objective was to develop a risk prediction model for in-hospital mortality after surgery on the proximal aorta.

Methods

Data for 8641 consecutive UK patients undergoing proximal aortic surgery from the NICOR database from April 2007 to March 2013 were analysed. Multivariable logistic regression was used to identify independent predictors of in-hospital mortality. Model calibration and discrimination were assessed.

Results

In-hospital mortality was 4.6% in elective cases and 16.5% in non-elective. In the elective model, previous cardiac surgery and ejection fraction <30% were the strongest predictors of mortality (adjusted odds ratios: 4.1 [95% CI: 3.0 to 4.7] and 2.3 (95% CI: 1.7 to 3.1], respectively; p<0.001). The area under the receiver operating characteristic (AUROC) curve was 0.805 (95% CI: 0.802 to 0.807) with a bias-corrected value of 0.795. Model calibration was acceptable (p=0.427) based on the Hosmer–Lemeshow goodness-of-fit test. In the non-elective model, salvage operations and previous cardiac surgery were the strongest predictors of mortality (adjusted odds ratios: 9.9 [95% CI: 6.5 to 15.2] and 3.9 (95% CI: 3.0 to 5.0], respectively; p<0.001). The AUROC curve was 0.761 (95% CI: 0.761 to 0.765) with a bias- corrected value of 0.756, and model calibration was also found to be acceptable (p=0.616).

Conclusion

We propose the use of these risk models to improve patient choice, enhance patients' awareness of risks and risk-adjust aortic surgery outcomes for case-mix.

Introduction

The number of patients undergoing aortic surgery has increased greatly since the 1990's [1]. As the discipline has developed from a subsection of cardiovascular surgery to an established speciality with many individualised techniques and treatment models [2-4], there has naturally been a corresponding focus on clinical outcomes in both the overall patient group and within the individualised pathologies and treatments that are available. Several recent publications continue to demonstrate this important approach to surgical quality [5-7]. Meanwhile, the application of statistical models to produce risk adjusted outcomes has become an established practice in many healthcare disciplines [8-10], especially cardiac surgery [10, 11]. These models are typically used to inform patients, to give clinical assurance and to allow benchmark comparisons between institutions. Several risk adjustment models have been published which would allow risk prediction in certain types of aortic patient, or in patients undergoing vascular surgery [12-18].

We conducted a retrospective analysis of aortic surgery data submitted to the NICOR National Adult Cardiac Surgery Audit (NACSA) database by all cardiac centres in the UK. The primary aim of the study was to develop and validate a risk prediction model for post-operative mortality following open surgery on the proximal aorta (i.e. root, ascending or arch aortic segments). This will be the first publication of such a model using a large, contemporaneous European cardiac surgery dataset.

Methods

NICOR database

Prospectively collected data were extracted from NICOR's NACSA database (version 4.1.2), [19] on 20th November 2014 for all adult cardiac surgery procedures performed on NHS patients throughout the UK. NICOR manage the audit, and receive clinical direction and strategy from the Society for Cardiothoracic Surgery in Great Britain and Ireland (SCTS). As described elsewhere, reproducible cleaning algorithms were applied to the database [20]. Briefly, duplicate records and non-adult cardiac surgery entries were removed, transcriptional discrepancies harmonised and clinical and temporal conflicts and extreme values corrected or removed. The data are returned regularly to each unit for local validation.

For this study, records were included that met the following criteria: operation on one or more of the root, ascending or arch aortic segments that were performed in England and Wales between 1

April 2007 and 31 March 2013. As only non-identifiable patient data were used for this research, formal ethical approval was not required. This project was approved by the NICOR research board.

Study and outcome variables

For each operation, data are recorded on patient characteristics, comorbidities, surgical team, intraoperative factors and postoperative outcomes. For this study, we extracted data on patient age at the time of operation (years), gender, body mass index [BMI, defined as weight (kg) / height^2 (m^2)], Canadian Cardiovascular Society (CCS) angina class, dyspnoea (New York Heart Association (NYHA) grade), recent myocardial infarction (defined as within 90 days of surgery), history of cardiac procedures, diabetes (diet or insulin controlled), smoking status, history of hypertension, serum creatinine >200 µmol/l, history of renal dysfunction, history of pulmonary disease, history of neurological dysfunction, extracardiac arteriopathy, preoperative heart rhythm (classified for the purposes of this study as sinus rhythm or non-sinus rhythm. Non-sinus rhythm includes: atrial fibrillation, atrial flutter, complete heart block, presence of a pacing device, ventricular fibrillation, ventricular tachycardia or any other abnormal rhythm), left ventricular ejection fraction (LVEF, classified as <30, 30–50 and >50%), use of preoperative IV nitrates, IV inotropes prior to anaesthesia, preoperative ventilation, pre-operative cardiogenic shock, operative urgency, concomitant CABG and valve procedures. Further details of variable definitions are available at http://www.ucl.ac.uk/nicor/audits/adultcardiac/datasets.

Missing data were assumed to be absent for categorical variables or replaced with the mean value for continuous variables. Ejection fraction was the categorical variable with the highest incidence of missing data (3.5%). The proportions of missing data for continuous variables were: age, 0%; BMI, 3.6%; cardiopulmonary bypass time, 2.3%; and aortic cross clamp time, 2.9%. The outcome for this study was in-hospital mortality, defined as death due to any cause during admission to the operating hospital for cardiac surgery. Records were excluded from the analysis if in-hospital mortality status was missing. Data on cause of death were unavailable.

Developing the model

Continuous variables were dichotomised where appropriate; Age at operation was categorised as <40, 40-49, 50-59, 60-69, 70-79 and ≥80, LVEF of >50% was categorised as good, 30-50% moderate and <30% as poor. BMI and operative times were retained as continuous variables. Pre-operative heart rhythm was dichotomised into sinus rhythm (normal) and non-sinus rhythm as detailed above. Similarly, the pathology of the aortic segments was dichotomised into aneurysmal or normal

pathologies and other pathologies which included: chronic dissection, acute dissection, trauma, coarctation, penetrating atheromatous ulcer, pseudoaneurysm, intramural haematoma and "other" pathology. Ordinal variables were dichotomised as follows: NYHA category was grouped into no or mild symptoms (Class I and II) and moderate or severe symptoms (Class III and IV) and the CCS angina grade into stable (Class I to III) and unstable (Class IV). The data were split into an elective group and a non-elective group. The non-elective group included urgent, emergency and salvage surgery (salvage surgery is defined as "Patients requiring cardiopulmonary resuscitation en route to the operating theatre or prior to the induction of anaesthesia") . Separate multiple logistic regression models were fitted for elective and non-elective surgery using the backwards elimination procedure for variable selection; all preoperative patient variables listed above were offered to the analysis.

Assessing model performance

Model performance was assessed using bootstrap methodology, the complete datasets were sampled from repeatedly and the final multivariate logistic regression model was refit 100 times. Model performance summary statistics were calculated for each iteration with the average across all the bootstrapped samples then calculated. Model calibration was assessed in three ways. Firstly a Hosmer-Lemeshow goodness-of-fit test where the overall differences between the observed mortality rate and the mortality rate predicted by the risk model are evaluated using a χ^2 test [21]. The second method involved visual inspection of a calibration plot. The calibration plot shows the predicted probability of outcome against the observed proportion of outcomes with a locally weighted least squares regression (loess) smoother [22]. Thirdly, the datasets were divided into three groups based on their predicted risk of in-hospital death (low, medium and high risk). For each group the observed mortality rate was compared with the mortality rate predicted by the risk model and goodness-of-fit was evaluated using a χ^2 test. Model discrimination was evaluated by calculating the AUROC [23]. In all cases, $P < 0.05$ was considered significant. All statistical analyses were carried out using SAS software for Windows, version 9.3 (SAS Institute Inc., Cary, NC, USA).

Results

In total 8641 records were identified as meeting the study criteria. Two records were missing in-hospital mortality status and were excluded, leaving 8639 records for analysis. Over the six year study period 44 hospitals contributed data. The largest contribution from a single centre was 638 cases and the smallest contribution from a single centre was two. A summary of patient characteristics is shown in Table 1. There were 775 in-hospital deaths giving an in-hospital mortality rate of 9.0% (95% CI = 8.4% to 9.6%). There were 5463 elective patients identified with 250 deaths (4.6% (95% CI = 4.0% to 5.2%)) and 3176 non-elective patients with 525 deaths (16.5% (95% CI = 15.3% to 17.9%)).

Univariable and multivariable analyses

Risk factors for in-hospital mortality based on univariate analysis are shown in Tables 1 and 2. The final risk prediction models with estimated model coefficients, odds ratios, approximate 95% CI, corresponding P values, and the model equation itself are shown in Tables 3 and 4.

Overall performance of the risk models

Both models demonstrated good calibration according to the Hosmer–Lemeshow χ^2 (elective model P = 0.427 and non-elective model P = 0.616. The calibration plots for both models are shown in Figure 1 and demonstrate good calibration. It is worth noting that although the elective model does begin to over-predict towards the higher end of its distribution, there were only 35 (0.64%) patients who had a risk score proportion > 0.4, so performance is based on a relatively small number of cases. The low, medium and high risk group assessments also supported the assumption of satisfactory calibration for both models as shown in Table 5. The AUROC for the elective model was 0.805 (95% CI: 0.802 to 0.807), for the non-elective model the AUROC was 0.761 (95% CI: 0.761 to 0.765) with bias-corrected values calculated using the bootstrap method of 0.795 and 0.756, respectively, indicating good discrimination

Discussion

In this study, we developed and validated two predictive models for in-hospital mortality after surgery on the proximal aorta utilising a large national database. Both models include risk factors which are all directly collected within, or easily derived from, NICOR data variables. Model calibration has been assessed using three different methods and discrimination has been assessed

using standard methodology. All available data was used for model development, with internal model validation using bootstrapping adopted. All data was collected prospectively and regularly undergoes local validation.

Risk prediction models can be used to provide important information to both patients and clinicians about the risks of surgery. They may even be used to decide between different treatment options. Risk prediction models also have a vital role to play in clinical governance analyses. Currently, generic cardiac surgery risk prediction models are used for proximal aortic surgery. As these models were specifically developed for proximal aortic surgery they may be more accurate than generic models for informing patients and clinicians about the risks of in-hospital mortality following surgery on the aortic root, ascending aorta or aortic arch, and for risk-adjusting proximal aortic surgery outcomes analyses.

Separate models for elective and non-elective surgery were developed as it has previously been demonstrated that cardiac surgery models intended for use with both elective and non-elective surgery can perform poorly in emergency surgery [24]. The risk models share four common risk factors: age, additional CABG surgery, preoperative arrhythmia and previous cardiac surgery. These factors will be familiar to healthcare professionals involved in the care of patients with cardiac disease and are well represented in previously developed risk models [17, 25, 26, 27]. It is no surprise that older, sicker patients with more complicated presentation are at an increased risk of in-hospital mortality. Among the elective cohort, the remaining factors of lung disease, female gender, NYHA class, reduced LVEF, neurological disease, triple vessel disease, surgery on the aortic arch and more complicated pathologies are similarly understandable contributors to increased patient risk. Within the non-elective model: renal disease, peripheral vascular disease, cardiogenic shock and increasingly critical presenting priority are all intuitively reasonable inclusions.

Although surgical activity in proximal aortic cases is relatively low compared to cardiac bypass graft or valvular surgery, the procedure itself carries a greater risk of mortality. Consequently, a number of studies have previously attempted to quantify the risks involved. Williams et al [17] presented risk factor results of proximal aortic surgery based on the Society of Thoracic Surgeons (STS) Dataset for in-hospital mortality and mortality plus major morbidity, in overall and elective cohorts. The predictive power of their elective mortality model was slightly below the model developed in this study with an AUC of 0.77. As this study contained four separate models and was part of a wider review of North American outcomes an extended description of the model coefficients was not available.

Other work by Huijskes [25] and Nishida [28] incorporate the widely used EuroSCORE and EuroSCORE II algorithms [26, 27] in order to make comparisons with local models and to ascertain how the model performs in aortic surgery cohorts. A comparison of the models developed in this study with the generic models such as the EuroSCORE models would be useful and may be the subject of further work.

Limitations

This study has a number of limitations. Firstly, the retrospective nature of the data analysed means that thorough testing along with some necessary adjustments to risk factor weighting will be essential before this tool can be utilised in prospective cohorts, as model calibration is known to change significantly over time [29]. Secondly, although one of the strengths of the study is the multicentre, national data that is used, this brings with it questions of variable data quality and also the possibility of inconsistencies in how NICOR guidance is interpreted from one hospital to another. Thirdly, the NICOR dataset is primarily based on risk factors and operational details that cover the whole cardiac surgery speciality. It is likely that some predictors of mortality in patients undergoing surgery on the proximal aorta could come from other data sources such as imaging but these data were not available.

Tables and Figures

Table 1: Patient characteristics and univariable analysis of risk factors for in-hospital mortality after proximal aortic surgery

		No. of patients*	Odds ratio (95% CI) for in-hospital mortality	P
Age at operation [years]	< 40	932 (10.8)	0.55 (0.41, 0.73)	<0.001
	40 to 49	1064 (12.3)	0.50 (0.37, 0.66)	<0.001
	50 to 59	1441 (16.7)	0.69 (0.55, 0.86)	0.001
	60 to 69	2286 (26.5)	0.96 (0.81, 1.14)	0.67
	70 to 79	2405 (27.8)	1.83 (1.57, 2.13)	<0.001
	≥ 80	511 (5.9)	1.58 (1.21, 2.07)	0.001
	Continuous	64 (51, 73)	1.03 (1.02, 1.03)	<0.001
Gender	Male	5784 (67.0)	Reference	
	Female	2855 (33.0)	1.06 (0.91, 1.24)	0.48
Admission type	NHS patient	8269 (95.7)	Reference	
	Private patient	370 (4.3)	0.39 (0.23, 0.67)	<0.001
BMI	<30	6460 (74.8)	Reference	
	≥ 30	2179 (25.2)	0.90 (0.76, 1.07)	0.24
	Continuous	26.9 (24.1, 30.1)	1.00 (0.98, 1.01)	0.57
Angina CCS class	I to III	8232 (95.3)	Reference	
	IV	407 (4.7)	2.56 (1.98, 3.32)	<0.001
NYHA class	< III	6014 (69.6)	Reference	
	≥ III	2625 (30.4)	1.80 (1.55, 2.09)	<0.001
Previous myocardial infarction	No	7978 (92.3)	Reference	
	Yes	661 (7.7)	2.36 (1.91, 2.93)	<0.001
Myocardial infarction within last 90 days	No	8344 (96.6)	Reference	
	Yes	295 (3.4)	2.97 (2.23, 3.96)	<0.001
Previous angioplasty	No	8363 (96.8)	Reference	
	Yes	276 (3.2)	1.65 (1.16, 2.35)	0.005
Previous cardiac surgery	No	7419 (85.9)	Reference	
	Yes	1220 (14.1)	2.80 (2.37, 3.32)	<0.001
Diabetes	No	8042 (93.1)	Reference	
	Yes	597 (6.9)	1.46 (1.13, 1.88)	0.004
Current smoker	No	7671 (88.8)	Reference	
	Yes	968 (11.2)	1.10 (0.88, 1.39)	0.39
Hypertension	No	3335 (38.6)	Reference	
	Yes	5304 (61.4)	1.50 (1.27, 1.75)	<0.001
Creatinine > 200 µmol / L	No	8386 (97.1)	Reference	
	Yes	253 (2.9)	3.82 (2.86, 5.11)	<0.001
History of renal impairment	No	8471 (98.1)	Reference	
	Yes	168 (1.9)	2.96 (2.04, 4.30)	<0.001
History of pulmonary disease	No	7624 (88.3)	Reference	
	Yes	1015 (11.8)	1.35 (1.09, 1.66)	0.005
History of neurological disease	No	7913 (91.6)	Reference	
	Yes	726 (8.4)	2.04 (1.65, 2.53)	<0.001
Neurological dysfunction	No	8297 (96.0)	Reference	
	Yes	342 (4.0)	2.36 (1.77, 3.13)	<0.001
Peripheral vascular disease	No	7268 (84.1)	Reference	
	Yes	1371 (15.9)	1.79 (1.51, 2.14)	<0.001
Preoperative non-sinus rhythm	No	7604 (88.0)	Reference	
	Yes	1035 (12.0)	2.14 (1.77, 2.57)	<0.001
Triple vessel disease	No	8244 (95.4)	Reference	
	Yes	395 (4.6)	2.62 (2.02, 3.40)	<0.001
Left main stem disease	No	8472 (98.1)	Reference	
	Yes	167 (1.9)	1.99 (1.31, 3.03)	0.001
LVEF 30%-50%	No	6933 (80.3)	Reference	
	Yes	1706 (19.7)	1.78 (1.49, 2.12)	<0.001
LVEF <30%	No	8251 (95.5)	Reference	
	Yes	388 (4.5)	3.50 (2.69, 4.55)	<0.001
Presence of IV nitrates	No	8171 (94.6)	Reference	
	Yes	468 (5.4)	2.60 (2.04, 3.32)	<0.001
Presence of IV inotropes	No	8404 (97.3)	Reference	
	Yes	235 (2.7)	6.09 (4.61, 8.04)	<0.001
Cardiogenic shock	No	8253 (95.5)	Reference	
	Yes	386 (4.5)	6.32 (5.05, 7.90)	<0.001
Preoperative ventilation	No	8472 (98.1)	Reference	
	Yes	167 (1.9)	6.08 (4.39, 8.42)	<0.001

***With percentages in parentheses; non-normally distributed continuous data are presented as median (IQR)**

Table 2: Operative factors and univariable analysis of risk factors for in-hospital mortality after proximal aortic surgery

		No. of patients*	Odds ratio (95% CI) for in-hospital mortality	P
Operative details				
Priority	Elective	5461 (63.2)	Reference	
	Urgent	1412 (16.3)	2.52 (2.04, 3.11)	<0.001
	Emergency	1615 (18.7)	4.76 (3.98, 5.69)	<0.001
	Salvage	149 (1.7)	20.03 (14.18, 28.29)	<0.001
	MISSING	2 (0.02)		
Concomitant procedures	No CABG operation	7000 (81.0)	Reference	
	CABG operation	1639 (19.0)	2.10 (1.79, 2.47)	<0.001
	No Valve operation	2642 (30.6)	Reference	
	Valve operation	5997 (69.4)	0.59 (0.50, 0.68)	<0.001
	No Other operation	5841 (67.6)	Reference	
	Other operation	2798 (32.4)	1.02 (0.87, 1.19)	0.47
Aortic pathology				
Aneurysm	No	3604 (41.7)	Reference	
	Yes	5035 (58.3)	0.27 (0.23, 0.32)	<0.001
Chronic dissection	No	8299 (96.1)	Reference	
	Yes	340 (3.9)	1.37 (0.98, 1.93)	0.07
Acute dissection	No	7071 (81.9)	Reference	
	Yes	1568 (18.2)	3.02 (2.58, 3.54)	<0.001
Trauma	No	8603 (99.6)	Reference	
	Yes	36 (0.4)	3.94 (1.9, 8.21)	<0.001
Coarctation	No	8636 (99.97)	Reference	
	Yes	3 (0.03)	5.09 (0.46, 56.14)	0.18
Penetrating Atheromatous Ulcer	No	8599 (99.5)	Reference	
	Yes	40 (0.5)	2.97 (1.41, 6.26)	0.004
Pseudoaneurysm	No	8592 (99.5)	Reference	
	Yes	47 (0.5)	2.77 (1.37, 5.59)	0.005
Intramural haematoma	No	8611 (99.7)	Reference	
	Yes	28 (0.3)	1.70 (0.59, 4.90)	0.33
Other	No	7161 (82.9)	Reference	
	Yes	1478 (17.1)	1.51 (1.26, 1.80)	<0.001
Aortic segment				
Root	No	4354 (50.4)	Reference	
	Yes	4285 (49.6)	0.89 (0.76, 1.03)	0.11
Ascending	No	2214 (25.7)	Reference	
	Yes	6425 (74.4)	0.90 (0.76, 1.06)	0.22
Arch	No	7801 (90.3)	Reference	
	Yes	838 (9.7)	1.72 (1.39, 2.13)	0.004

***With percentages in parentheses; non-normally distributed continuous data are presented as median (IQR)**

Table 3: Final multivariable logistic regression model for risk prediction in elective patients

Parameter	Odds Ratio	95% CI	Co-efficient	P
Intercept	-	-	-4.8583	<0.001
Age at operation 70-79	2.30	1.70, 3.11	0.8335	<0.001
Age at operation ≥ 80	2.87	1.80, 4.58	1.0542	<0.001
Female gender	1.48	1.12, 1.97	0.3945	0.006
NYHA class > 2	1.43	1.07, 1.89	0.3549	0.014
Previous cardiac surgery	3.80	2.75, 5.24	1.3339	<0.001
Pulmonary disease	1.61	1.14, 2.26	0.4734	0.006
Neurological disease	2.11	1.45, 3.08	0.7473	<0.001
Preoperative non-sinus rhythm	1.57	1.12, 2.19	0.4491	0.009
Triple vessel disease	2.34	1.51, 3.61	0.8491	<0.001
LVEF 30-50%	1.37	1.01, 1.88	0.3169	0.047
LVEF < 30%	2.79	1.60, 4.87	1.0261	<0.001
Concomitant CABG operation	2.30	1.68, 3.15	0.8339	<0.001
Surgery on the arch segment of the aorta	2.42	1.70, 3.46	0.8852	<0.001
Aortic pathology other than 'Aneurysm'	1.83	1.26, 2.66	0.6036	0.002

Calculation of predicted risk using patient data and logistic regression coefficients: odds of in-hospital death = exp(-4.8583+[0.8335*Age at operation 70-79]+[1.0542*Age at operation ≥ 80]+[0.3945*Female gender]+[0.3549*NYHA class > 2]+[1.3339*Previous cardiac surgery]+[0.4734*Pulmonary disease]+[0.7473*Neurological disease]+[0.4491*Preoperative non-sinus rhythm]+[0.8491*Triple vessel disease]+[0.3169*LVEF 30-50%]+[1.0261*LVEF < 30%]+[0.8339*Concomitant CABG operation]+[0.8852*Surgery on the arch segment of the aorta]+[0.6036*Aortic pathology other than 'Aneurysm'])

Table 4: Final multivariable logistic regression model for risk prediction in non-elective patients

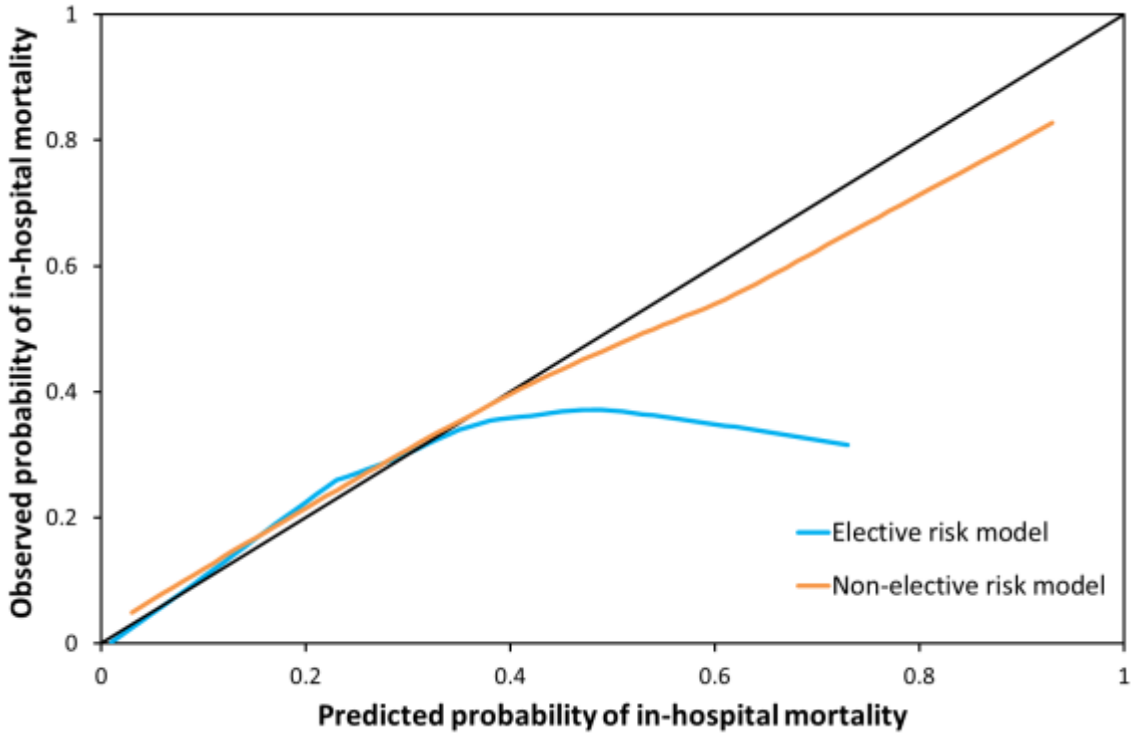
Parameter	Odds Ratio	95% CI	Co-efficient	P
Intercept	-	-	-3.3212	<0.001
Age at operation 70-79	1.79	1.43, 2.24	0.5822	<0.001
Age at operation ≥ 80	1.86	1.24, 2.79	0.6195	0.003
Previous cardiac surgery	3.87	3.00, 4.99	1.3537	<0.001
Creatinine > 200 µmol / L	1.73	1.21, 2.48	0.5482	0.003
Peripheral vascular disease	1.45	1.14, 1.86	0.3741	0.003
Preoperative non-sinus rhythm	1.83	1.38, 2.42	0.6029	<0.001
Pre-operative ventilation	1.52	1.02, 2.26	0.4179	0.039
Cardiogenic shock	1.81	1.36, 2.40	0.5916	<0.001
Emergency priority	2.74	2.15, 3.50	1.0073	<0.001
Salvage priority	9.13	5.93, 14.05	2.2113	<0.001
Concomitant CABG operation	2.30	1.79, 2.95	0.8319	<0.001

Calculation of predicted risk using patient data and logistic regression coefficients: odds of in-hospital death = exp(-3.3212+[0.5822*Age at operation 70-79]+[0.6195*Age at operation ≥ 80]+[1.3537*Previous cardiac surgery]+[0.5482*Creatinine > 200 µmol / L]+[0.3741*Peripheral vascular disease]+[0.6029*Preoperative non-sinus rhythm]+[0.4179*Pre-operative ventilation]+[0.5916*Cardiogenic shock]+[1.0073*Emergency priority]+[2.2113*Salvage priority]+[0.8319*Concomitant CABG operation])

Table 5: Risk group assessment

Risk Group	n	Score Range	Observed mortality	Predicted mortality	P
Elective cohort					
Low	4045	0%-5%	1.90	1.97	0.872
Medium	596	5%-8%	6.21	6.22	>0.999
High	822	>8%	16.55	16.22	0.894
Non-elective cohort					
Low	1462	0%-12%	6.91	6.96	>0.999
Medium	859	12%-20%	12.92	14.43	0.400
High	855	>20%	36.61	36.13	0.841

Figure 1: Calibration plot comparing observed and predicted in-hospital deaths, the bold black line represents perfect calibration



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