Heart Vessels (2015) 30:227–234
DOI 10.1007/s00380-014-0472-0

ORIGINAL ARTICLE

Comparison of contemporary risk scores for predicting outcomes after surgery for active infective endocarditis

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Received: 22 October 2013 / Accepted: 10 January 2014 / Published online: 25 January 2014

Abstract Decision making regarding surgery for acute bacterial endocarditis is complex given its heterogeneity and often fatal course. Few studies have investigated the utility of operative risk scores in this setting. Endocarditis-specific scores have recently been developed. We assessed the prognostic utility of contemporary risk scores for mortality and morbidity after endocarditis surgery. Additive and logistic EuroSCORE I, EuroSCORE II, additive Society of Thoracic Surgeon's (STS) Endocarditis Score and additive De Feo-Cotrufo Score were retrospectively calculated for patients undergoing surgery for endocarditis during 2005–2011. Pre-specified primary outcomes were operative mortality, composite morbidity and mortality during follow-up. A total of 146 patients were included with an operative mortality of 6.8 % followed for 4.1 ± 2.4 years. Mean scores were additive EuroSCORE I: 8.0 ± 2.5, logistic EuroSCORE I: 13.2 ± 10.1 %, EuroSCORE II: 9.1 % ± 9.4 %, STS Score: 32.2 ± 13.5 and De Feo-Cotrufo Score: 14.6 ± 9.2. Corresponding areas under curve (AUC) for operative mortality 0.653, 0.645, 0.656, 0.699 and 0.744; for composite morbidity were 0.623, 0.625, 0.720, 0.714 and 0.774; and long-term mortality 0.588, 0.579, 0.686, 0.735 and 0.751. The best tool for post-operative stroke was EuroSCORE II: AUC 0.837; for ventilation >24 h and return to theatre the De Feo-Cotrufo Scores were: AUC 0.821 and 0.712. Pre-operative inotrope or intra-aortic balloon pump treatment, previous coronary bypass grafting and dialysis were independent predictors of operative and long-term mortality. In conclusion, risk models developed specifically from endocarditis surgeries and incorporating endocarditis variables have improved prognostic ability of outcomes, and can play an important role in the decision making towards surgery for endocarditis.

Keywords Endocarditis · Valve surgery · Risk modelling · EuroSCORE

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Introduction

Infective endocarditis remains a heterogeneous disease with high mortality, despite advances in diagnostic and treatment over the last few decades [1]. During the active phase of endocarditis when patients are on intravenous antibiotics, surgery is recommended for treatment of resultant heart failure or haemodynamic instability, uncontrolled infection or prevention of systemic embolism [2, 3]. Surgery, however, comes with significant risks, so the decision to operate is often complex. Prognostic scoring tools, if accurate, can be of help to clinicians and researchers.

Few studies have investigated the utility of additive [4] and logistic [5] EuroSCORE I for patients undergoing surgery for endocarditis, and only for detecting operative mortality [6–8]. EuroSCORE II [9] had since been developed and validated for cardiac surgery, predominantly coronary artery bypass grafting and valve surgery [10, 11]. More recently, Gaca et al. [12] developed a risk score specific to endocarditis surgery using 13,617 patients from the Society of Thoracic Surgeon's (STS) database, given that the original STS score [13] cannot be used in

Table 1 Baseline characteristics

	All	Death	Alive	*p* value
Number	146	10	136	
Demographics				
Age (years)	48.8 (16.0)	55.9 (15.0)	48.2 (16.0)	0.125
Male	70.5 % (103)	80.0 % (8)	69.9 % (95)	0.724
Body mass index (kg/m^2)	27.8 (6.4)	29.2 (5.0)	27.7 (6.4)	0.244
Presentation				
Congestive heart failure	47.3 % (69)	60.0 % (6)	46.3 % (63)	0.517
Unstable angina	1.4 % (2)	0.0 % (0)	2.9 % (4)	1.000
Inotrope or intra-aortic balloon pump treatment	23.3 % (34)	60.0 % (6)	20.6 % (28)	**0.011**
New complete heart block	6.2 % (9)	0.0 % (0)	6.6 % (9)	1.000
New embolic event	40.4 % (59)	50.0 % (5)	39.7 % (54)	0.526
New cerebral event	27.4 % (40)	20.0 % (2)	27.9 % (38)	0.728
Structures involved				
Aortic valve	64.4 % (94)	60.0 % (6)	64.7 % (88)	0.744
Mitral valve	42.5 % (62)	40.0 % (4)	42.6 % (58)	1.000
Tricuspid valve	7.5 % (11)	0.0 % (0)	7.5 % (11)	1.000
Pulmonary valve	0.7 % (1)	0.0 % (0)	0.7 % (1)	1.000
Device	3.4 % (5)	10.0 % (1)	2.9 % (4)	0.302
More than one of above	14.4 % (21)	0.0 % (0)	14.4 % (21)	0.358
Prosthetic valve	33.6 % (49)	30.0 % (3)	33.8 % (46)	1.000
Intracardiac Abscess	27.4 % (40)	40.0 % (4)	26.5 % (36)	0.462
Blood culture				
Staphylococcus aureus	29.5 % (43)	50.0 % (5)	27.9 % (38)	0.160
Streptococcus species	31.5 % (46)	20.0 % (2)	32.4 % (44)	0.506
Enterococcus faecalis	8.9 % (13)	10.0 % (1)	8.8 % (12)	1.000
Other	21.9 % (32)	10.0 % (1)	22.8 % (31)	0.692
Negative	8.2 % (12)	10.0 % (1)	8.1 % (11)	0.588
Operation status				0.171
Emergency	2.0 % (3)	10.0 % (1)	1.5 % (2)	
Urgent	96.6 % (141)	90.0 % (9)	97.0 % (132)	
Elective	1.4 % (2)	0.0 % (0)	1.5 % (2)	
Past medical history				
Previous endocarditis	11.0 % (16)	0.0 % (0)	11.8 % (16)	0.602
Rheumatic heart disease	7.5 % (11)	10.0 % (1)	7.4 % (10)	0.555
Congenital heart disease	6.2 % (9)	0.0 % (0)	6.2 % (9)	1.000
Cardiac valve operation	28.1 % (41)	30.03 % (3)	27.9 % (38)	1.000
Coronary artery bypass grafting	2.7 % (4)	20.0 % (2)	1.5 % (2)	**0.024**
Myocardial infarction	4.8 % (7)	0.0 % (0)	5.1 % (7)	1.000
Congestive heart failure	28.8 % (42)	20.0 % (2)	29.4 % (40)	0.724
Hypercholesterolaemia	26.0 % (38)	30.0 % (3)	25.7 % (35)	0.720
Hypertension	28.1 % (41)	30.0 % (3)	27.9 % (38)	1.000
Diabetes mellitus	11.6 % (17)	30.0 % (3)	10.3 % (14)	*0.094*
Current smoker	18.5 % (27)	40.0 % (4)	16.9 % (23)	*0.088*
Atrial fibrillation	21.2 % (31)	30.0 % (3)	20.6 % (28)	0.443
Cerebrovascular accident	20.5 % (30)	20.0 % (2)	20.6 % (28)	1.000
Peripheral vascular disease	5.5 % (8)	10.0 % (1)	5.1 % (7)	0.441
Chronic respiratory disease	7.5 % (11)	10.0 % (1)	7.4 % (10)	0.555
Dialysis	8.2 % (12)	30.0 % (3)	6.6 % (9)	**0.037**

Table 1 continued

	All	Death	Alive	p value
Investigations				
Ejection fraction				0.971
Normal (>60 %)	81.5 % (119)	80.0 % (8)	81.6 % (111)	
Mild (46–60 %)	11.0 % (16)	10.0 % (1)	11.0 % (15)	
Moderate (30–45 %)	6.8 % (10)	10.0 % (1)	6.6 % (9)	
Severe (<30 %)	0.7 % (1)	0.0 % (0)	0.7 % (1)	
Valve regurgitation	72.6 % (106)	60.0 % (6)	73.5 % (100)	0.462
Valve stenosis	13.0 % (19)	20.0 % (2)	12.5 % (17)	0.619
Pulmonary arterial systolic pressure (mmHg)				0.612
Normal (<31)	80.5 % (95/118)	80.0 % (8/10)	80.6 % (87/108)	
Moderate (31–55)	13.6 % (16/118)	20.0 % (2/10)	13.0 % (14/108)	
Severe (>55)	4.8 % (7/118)	0.0 % (0/10)	6.5 % (7/108)	
Creatinine clearance (mL/min) using Cockcroft-Gault formula	90 (47)	81 (51)	91 (47)	0.403
Risk scores				
EuroSCORE I additive	8.0 (2.5)	9.3 (2.6)	7.9 (2.5)	0.103
EuroSCORE I logistic (%)	13.2 % (10.1 %)	17.5 % (12.5 %)	12.9 % (9.9 %)	0.126
EuroSCORE II (%)	9.1 % (9.4 %)	14.1 % (11.6 %)	8.7 % (9.2 %)	0.100
Society of Thoracic Surgeon's Score	32.2 (13.5)	41.7 (15.3)	31.5 (13.2)	**0.033**
De Feo-Cotrufo Score	14.6 (9.2)	23.1 (10.4)	14.0 (8.8)	**0.010**

Bold refers to significant p values <0.05

Italics are p between 0.05 and 0.10

endocarditis patients having surgery. De Feo et al. [8] also developed a risk score in their single-centred piloted study of 440 native-valve endocarditis patients undergoing surgery. The external validities of these novel endocarditis-specific scores have not been fully assessed. We aimed to assess the prognostic utility of the EuroSCOREs I and II, STS Endocarditis Score and De Feo-Cotrufo Score for mortality and morbidity after surgery for active endocarditis.

Materials and methods

Patient selection and data collection

Consecutive patients undergoing cardiac surgery for active endocarditis during 2005–2011 at Auckland City Hospital were identified from the adult cardiothoracic surgical unit database. All surgeries were undertaken after discussion at a multi-disciplinary cardiac conference, taking into account international guidelines, important indications of heart failure, severe sepsis, haemodynamic instability and embolic prevention, patient's co-morbidities and surgical risks. Endocarditis was defined as active if patients were on intravenous antibiotic therapy for endocarditis at the time of surgery with confirmatory intra-operative findings of endocarditis. Relevant clinical characteristics, operative variables and post-operative outcomes were retrospectively collected from computerised hospital records. Additive [4] and logistic [5] EuroSCORE I, EuroSCORE II [9], additive STS Endocarditis Score [12] and additive De Feo-Cotrufo Score [8] were calculated for all patients, blinded to outcomes.

Definitions of presentation with congestive heart failure, unstable angina, urgency of surgery, history of hypertension, cerebrovascular accident, peripheral vascular disease and chronic respiratory disease are identical to corresponding parameters in the STS score [13]. Inotrope or intra-aortic balloon pump treatment refers to cardiac support therapies that were initiated pre-operatively in the same admission. Valve regurgitation or stenosis need to be graded moderate or severe to be counted.

The primary outcome of the study was operative mortality, defined as in-hospital death or death within 30 days of operation. Secondary outcomes include mortality during follow-up and composite morbidity, consisting of the five post-operative complications of permanent stroke, renal failure, prolonged ventilation over 24 h, deep sternal wound infection and return to theatre for any reason as defined by the STS score [13]. Mortality data were checked against New Zealand's national registry up till 31 December 2012.

Table 2 Operative characteristics and post-operative outcomes

	All	Death	Alive	*p* value
Number	146	10	136	
Operation				
Valve repair	29.5 % (43)	10.0 % (1)	30.9 % (42)	0.282
Annuloplasty	13.7 % (20)	10.0 % (1)	14.0 % (19)	1.000
Valve replacement	77.4 % (113)	80.0 % (8)	77.2 % (105)	1.000
Mechanical	45.9 % (67)	50.0 % (5)	42.5 % (62)	1.000
Biological	31.5 % (46)	40.0 % (4)	30.9 % (42)	0.725
Coronary artery bypass grafting	8.9 % (13)	20.0 % (2)	8.1 % (11)	0.219
Operation time (min)	261 (105)	339 (149)	255 (99)	*0.072*
Cardiopulmonary bypass time (min)	152 (75)	233 (134)	146 (66)	**0.017**
Cross-clamp time (min)	113 (61)	155 (102)	110 (56)	0.189
In-hospital outcomes				
Operative mortality	6.8 % (10)			
Composite morbidity	33.6 % (49)	90.0 % (9)	29.4 % (40)	**<0.001**
Permanent stroke (%)	4.1 % (6)	30.0 % (3)	2.2 % (3)	**0.004**
Renal failure (%)	6.2 % (9)	20.0 % (2)	5.1 % (7)	0.117
Ventilation >24 h (%)	28.8 % (42)	80.0 % (8)	25.0 % (34)	**0.001**
Deep sternal wound infection (%)	1.4 % (2)	10.0 % (1)	0.7 % (1)	0.133
Return to theatre (%)	14.4 % (921)	40.0 % (4)	12.5 % (17)	**0.038**
Operation to discharge time (days)	15.4 (10.2)	9.5 (7.8)	15.9 (10.2)	**0.042**

Bold refers to significant *p* values <0.05

Italics are *p* between 0.05 and 0.10

Statistical analyses

Continuous and categorical variables are presented as mean (standard deviation) and percentages (frequency), respectively. Mann–Whitney *U* test and Fisher's exact test were used for univariate analyses. Discriminative powers for post-operative outcomes for all 5 risk scores were assessed using the area under the receiver-operative characteristics curve (AUC). Logistic regression and Cox proportional hazards regression were used to identify predictors of pre-specified end-points, calculating odds ratios (OR) or hazards ratios (HR) and their 95 % confidence intervals (95 % CI). Only pre-operative variables with $p < 0.10$ in univariate analyses, excluding risk scores, were incorporated in these multivariate models. Statistical analyses were performed using SPSS (Version 17.0, SPSS Inc., Chicago, IL, USA) and Prism (Version 5, GraphPad Software, San Diego, CA, USA). *P* values less than 0.05 were deemed statistically significant and all statistical tests were two-tailed. Ethical approval was attained from our institution's research office.

Results

Patient characteristics

A total of 146 patients had surgery for active endocarditis during the 7-year study period and Table 1 presents the baseline characteristics including mean risk scores. Mean age was 48.8 ± 16.0 years and 70.5 % (103/146) were male. Mean additive EuroSCORE I was 8.0 ± 2.5, logistic EuroSCORE I was 13.2 ± 10.1 %, EuroSCORE II was 9.1 % ± 9.4 %, additive STS Endocarditis Score was 32.2 ± 13.5 and additive De Feo-Cotrufo Score was 14.6 ± 9.2.

In-hospital outcomes

Table 2 shows the operative and post-operative outcomes. Operative mortality was 6.8 % (10/146). Both logistic scores (EuroSCORE I and EuroSCORE II) significantly overestimated operative mortality ($p < 0.001$ and $p = 0.004$). Composite morbidity occurred in 33.6 % (49/146), predominantly ventilation >24 h in 28.8 % (42/146) and return to theatre in 14.4 % (21/146).

AUCs for each risk score for detecting mortality and morbidity after surgery are listed in Table 3. Only STS Endocarditis Score with AUC 0.699 ($p = 0.036$) and De Feo-Cotrufo Score with AUC 0.744 ($p = 0.010$) reached statistical significance for detecting operative mortality. The optimal cut-points for detecting operative mortality are STS Score of 36 (sensitivity 70.0 %, specificity 66.9 %) and De Feo-Cotrufo Score of 25 (sensitivity 60.0 %, specificity 86.0 %).

EuroSCORE II, STS Endocarditis Score and De Feo-Cotrufo Score were good discriminators of composite morbidity with AUC 0.720 ($p < 0.001$), 0.714 ($p < 0.001$)

Table 3 Receiver-operative characteristics analysis (area under curve and 95 % confidence intervals)

Outcomes	EuroSCORE I additive	EuroSCORE I logistic	EuroSCORE II	STS Score	De Feo-Cotrufo Score
Operative mortality	0.653 (0.487–0.819)	0.645 (0.487–0.803)	0.656 (0.466–0.846)	0.699 (0.534–0.865)	0.744 (0.590–0.899)
Mortality during follow-up	0.588 (0.439–0.737)	0.579 (0.433–0.725)	0.686 (0.558–0.814)	0.735 (0.616–0.855)	0.751 (0.649–0.852)
Composite morbidity	0.632 (0.537–0.727)	0.625 (0.530–0.720)	0.720 (0.632–0.808)	0.714 (0.630–0.799)	0.774 (0.692–0.855)
Permanent stroke	0.649 (0.452–0.846)	0.645 (0.455–0.835)	0.837 (0.742–0.931)	0.681 (0.517–0.845)	0.770 (0.605–0.936)
Renal failure	0.448 (0.306–0.590)	0.431 (0.288–0.573)	0.520 (0.381–0.659)	0.429 (0.275–0.583)	0.622 (0.499–0.744)
Ventilation >24 h	0.680 (0.586–0.775)	0.663 (0.568–0.759)	0.769 (0.683–0.855)	0.758 (0.675–0.841)	0.821 (0.740–0.901)
Deep sternal wound infection	0.311 (0.006–0.616)	0.344 (0.134–0.553)	0.455 (0.000–0.965)	0.681 (0.000–1.000)	0.592 (0.204–0.980)
Return to theatre	0.630 (0.513–0.746)	0.618 (0.499–0.736)	0.613 (0.478–0.748)	0.683 (0.572–0.794)	0.712 (0.595–0.823)

and 0.774 ($p < 0.001$). The best discriminator of permanent stroke was EuroSCORE II with AUC 0.837 ($p = 0.005$). De Feo-Cotrufo Score had the highest AUC for ventilation >24 h of 0.821 ($p < 0.001$) and return to theatre of 0.712 ($p = 0.002$). None of the scores were statistically significant at detecting renal failure or deep sternal wound infection.

Longitudinal outcomes

Mean follow-up was 4.1 ± 2.4 years and all patients had at least 1-year follow-up. One-, 3- and 5-year survival of the entire cohort was 92.5, 91.4 and 89.0 %, respectively. The scores statistically significant at detecting mortality during follow-up were EuroSCORE II with AUC 0.686 ($p = 0.013$), STS Endocarditis Score with AUC 0.735 ($p = 0.002$) and De Feo-Cotrufo Score with AUC 0.751 ($p = 0.001$), as shown in Table 3.

Multivariate analyses

Predictors of mortality and morbidity in multivariate analyses are indicated in Table 4. Independent predictors of both operative mortality and mortality during follow-up were inotrope or intra-aortic balloon pump treatment, previous coronary artery bypass grafting and dialysis. Predictors of composite morbidity included inotrope or intra-aortic balloon pump treatment and coronary artery bypass grafting performed during operation.

Discussion

This is the first study to validate both the STS Endocarditis Score and De Feo-Cotrufo Score as prognostic of operative mortality after surgery for active endocarditis, and better predictors than the EuroSCOREs in our cohort. Our second finding was that all five risk scores discriminated post-operative morbidity, however, EuroSCORE II, STS Score and De Feo-Cotrufo Score were better predictors than both EuroSCORE I, particularly for permanent stroke and ventilation >24 h. We also identified several independent predictors of mortality and morbidity after endocarditis surgery. The operative mortality of 6.8 % was comparable to previously reported rates of 2.7–28.8 % reported in various studies [6–8, 12, 14–20], reflecting the heterogeneity of the disease.

Additive and logistic EuroSCORE I are the only risk scores whose performance have been previously assessed in endocarditis surgery in three studies [6–8]. These found good discrimination of additive EuroSCORE I with AUC 0.83 and 0.75 and logistic EuroSCORE I with AUC 0.84, 0.74 and 0.84 for operative mortality. Our results showed that EuroSCORE I both overestimated and failed to discriminate operative mortality for endocarditis surgery. One reason may be that EuroSCORE I, based on cardiac surgery undertaken in 1995 [4, 5], is out-dated in the contemporary context of ever-improving surgical and peri-operative care, as observed in other studies of cardiac surgery [21, 22]. Both additive and logistic EuroSCORE 1, however, did discriminate post-operative morbidities, particularly ventilation >24 h, similar to that reported for other cardiac surgeries [23].

For detecting operative mortality, EuroSCORE II was no better than EuroSCORE I. EuroSCORE II, however, did discriminate mortality during follow-up which EuroSCORE I did not, and was able to detect post-operative morbidity, also shown in one other study [24], particularly permanent stroke. What could then be limiting the utility of EuroSCOREs in our setting is probably because these were derived predominantly from coronary and valve surgeries rather than patients with endocarditis.

STS Endocarditis score was constructed specifically from endocarditis operations [14] and was able to detect operative mortality, mortality during follow-up and post-operative morbidities in our cohort. Its constituents are quite similar to the EuroSCORE [4, 9]. The use of pre-

Table 4 Multivariate predictors with $p < 0.10$ for mortality and morbidity

Predictors	Odds ratio	95 % confidence interval	p value
Operative mortality			
Inotrope or intra-aortic balloon pump treatment	8.17	1.54–43.3	0.014
Diabetes mellitus	4.38	0.726–26.5	0.097
Current smoker	4.26	0.832–21.8	0.082
Previous coronary artery bypass grafting	5.08	2.13–12.4	0.002
Dialysis	7.25	1.23–42.9	0.029
Composite morbidity			
Inotrope or intra-aortic balloon pump treatment	7.04	2.68–18.5	<0.001
Intracardiac abscess	2.32	0.929–5.80	0.072
Diabetes mellitus	2.85	0.84–9.73	0.094
Coronary artery bypass grafting performed	4.68	1.04–21.0	0.044
Return to theatre			
Inotrope or intra-aortic balloon pump treatment	3.30	1.11–9.82	0.032
Cerebral event from endocarditis	6.29	1.18–33.3	0.032
Intracardiac abscess	2.62	0.921–7.43	0.071
Peripheral vascular disease	6.53	1.04–40.9	0.045
Permanent stroke			
History of cerebrovascular accident	8.10	0.849–77.3	0.069
Peripheral vascular disease	5.33	1.47–19.3	0.009
Ventilation >24 h			
Male	3.39	0.842–13.6	0.086
Inotrope or intra-aortic balloon pump treatment	7.98	2.80–22.7	<0.001
Negative blood culture	8.20	0.985–68.3	0.052
Hypercholesterolaemia	3.79	1.02–14.1	0.047
Peripheral vascular disease	7.92	1.04–60.4	0.046
Predictors	Hazards ratio		
Mortality during follow-up			
Inotrope or intra-aortic balloon pump treatment	5.17	1.64–16.3	0.005
Diabetes mellitus	6.33	1.68–23.9	0.006
Current smoker	3.91	1.31–11.7	0.015
Previous coronary artery bypass grafting	9.24	2.02–42.9	0.002
Dialysis	10.0	1.60–62.4	0.014

operative inotropes or intra-aortic balloon pump is a similar variable to the critical pre-operative state parameter of other scores, and shown to be an important predictor of mortality and morbidity in our study, as was renal failure. The STS score also distinguishes previous coronary artery bypass grafting from previous valve surgery unlike other scores, with exponential effect if both are present [12]. The former is an important predictor of mortality in our study suggesting that underlying ischaemic heart disease and potentially heart failure are important risk factors. Unlike the EuroSCORE II, STS score includes all diabetes as parameters, not just those on insulin, which we and other studies [16, 19] have found to be associated with higher mortality, and this could explain why the STS Score appeared to have the highest AUC for deep sternal wound infection.

The De Feo-Cotrufo Score was derived from a smaller single-centred pilot study of native-valve endocarditis surgery patients as a preliminary to multicentre development [8]. It was a good discriminator for adverse outcomes after endocarditis surgery in our cohort, not inferior to the STS score, suggesting that it may also be applicable to prosthetic valve endocarditis. Its unique feature is incorporating endocarditis variables such as lack of pre-operative attainment of blood culture negativity and perivalvular involvement as parameters, which were not collected in the EuroSCORE [4, 9] or STS databases [12, 13]. Although these were not predictors of mortality in our study, they were associated with three of five post-operative complications that nearly reached statistical significance in multivariate analysis. Furthermore, De Feo-Cotrufo Score is relatively simple with only 6 parameters, putting a lot of weight on critical pre-operative state, which is a strong predictor of adverse outcomes. Further developments underway with the De Feo-Cotrufo Score will likely improve on its existing strengths.

Apart from the parameters of existing risk scores and characteristics we identified, there are several other variables associated with adverse outcomes after surgery for endocarditis reported in the literature. Prosthetic valve endocarditis was associated with higher mortality after surgery than native-valve endocarditis in some studies [17]. The De Feo-Cotrufo Score in particular was derived entirely from native-valve endocarditis, so its application can be widened if prosthetic valve and device infections are added into the model. Staphylococcus aureus grown from blood culture also predicted mortality in several cohorts [16, 19] but not ours, and the De Feo-Cotrufo Score instead had negative blood culture as a parameter. Another study found pre-operative neurological impairment due to endocarditis to be associated with mortality [18].

We can infer from our results several aspects on how best to improve on existing risk scores for endocarditis surgery in the future. Firstly, the mechanisms of adverse outcomes are more complex in endocarditis, involving sepsis, inflammation and higher risk of embolic phenomenon in addition to ischaemia and heart failure, so the model may be best constructed from cardiac operations for endocarditis only. Secondly, many of the existing parameters of cardiac surgery risk scores, particularly pre-operative inotrope, intra-aortic balloon pump and/or ventilation, previous cardiac operations, renal function and diabetes are important risk factors and should be retained. Thirdly, variables unique to endocarditis such as valvular type and complications, blood culture results and embolic phenomenon should be tested in the model. Finally, as per all prognostic models, constant revision and large populations are required to strengthen the calibration of the score to match the ever-evolving clinical practice and assist in treatment selection, identification of adverse prognostic factors and patient counselling [25–27].

Study limitations

This was a single-centred retrospective observational study. We could not obtain sufficient information to investigate the efficacy of the logistic models of the STS and De Feo-Cotrufo Scores. The moderate sample size meant we only had a limited number of post-operative adverse events. Follow-up was limited given that we studied a contemporary cohort. We focused on patients having surgery for active endocarditis so our results do not necessarily apply to patients having surgery for treated endocarditis or having medical treatment only. Of note, 51 % of the STS and 83 % of the De Feo-Cotrufo Scores derivation cohort had active endocarditis contributing to their higher AUCs for adverse outcomes.

Conclusion

STS endocarditis Score and De Feo-Cotrufo Score detected mortality after operations for active endocarditis. Both of these and EuroSCORE II were also good discriminators for post-operative morbidities particularly permanent stroke and ventilation >24 h. To optimise discriminative efficacy for post-operative outcomes after endocarditis surgery, operative risk scores should be derived and applied specifically to endocarditis surgeries, incorporate endocarditis variables as parameters and be constantly revised to fit contemporary outcome.

Conflict of interest No conflicts of interests to declare.

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