Major risk stratification models do not predict perioperative outcome after coronary artery bypass grafting in patients with previous percutaneous intervention

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Abstract

Objective: To investigate whether common risk stratification models in cardiac surgery predict perioperative outcome of coronary artery bypass grafting (CABG) in patients with previous percutaneous coronary interventions (PCIs). Methods: We retrospectively analyzed the perioperative mortality and morbidity of 367 patients with prior elective PCI versus 2361 patients without prior PCI, who underwent first-time isolated CABG between 2001 and 2009 at our institution. Receiver operating characteristics (ROC) were used to describe the performance and accuracy of the European System for Cardiac Operative Risk Evaluation (EuroSCORE) and the Society of Thoracic Surgeons (STS) risk model in predicting mortality and morbidity. Results: Both groups were comparable concerning preoperative logistic EuroSCORE (PCI: 4.9 ± 6.57, non-PCI: 4.60 ± 5.45, p = 0.51). Patients with previous elective PCI had increased perioperative mortality (PCI: 3.8% vs non-PCI: 2.1%, p = 0.01) and higher rates of major adverse cardiac events (8.4% vs 4.5% respectively, p = 0.003). Discriminatory power for 30-day mortality was higher in the non-PCI group (EuroSCORE area under the curve (AUC): 0.875 vs 0.552 in the PCI group). Logistic EuroSCORE predicted 30-day mortality in the non-PCI group (confidence interval (CI) = 0.806—0.934, p = 0.0004) but not in the PCI group (CI = 0.301—0.765, p = 0.8). Discriminatory power for morbidity or mortality (M&M) was lower in the PCI group (AUC: 0.980 vs 0.713 for the non-PCI group). The STS risk model had a lower discriminatory power for predicting M&M in PCI patients (AUC: 0.611 vs 0.686 for the non-PCI group, p < 0.001). Conclusions: The EuroSCORE and the STS risk model were inaccurate in predicting perioperative mortality after CABG in patients with history of elective PCI. There is a need for modification of risk models to improve risk assessment for surgical candidates with prior PCI.

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1. Introduction

Risk stratification for surgical intervention is of great importance in the current surgical practice and especially in well-standardized high-volume procedures, such as cardiac interventions [1,2]. Most existing models consider assessment of perioperative morbidity and mortality as the index outcome parameters, which can be used for evaluation of the quality of medical care provided. Moreover, prediction of risk is useful to estimate clinical outcome [3], the need for resources, evaluation of new procedures and technologies [4], as well as for providing proper informed consent for patients [5].

Coronary artery bypass grafting (CABG) and percutaneous coronary intervention (PCI) are two treatment modalities

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Society of Thoracic Surgeons (STS) Score, to predict mortality and morbidity in patients with a history of PCI undergoing CABG.

2. Materials and methods

2.1. Patient groups

The study was designed as an observational, single-center, retrospective study. All consecutive patients with a history of prior PCI, who underwent primary isolated CABG (group 1, \( n = 367 \)) between January 2001 and December 2009, were retrospectively compared with contemporary patients, who underwent CABG without a history of PCI (group 2, \( n = 2361 \)). Patients with (1) an indication for cardiac operation other than isolated CABG (on an intent-to-treat basis), (2) cardiac re-operation, (3) history of emergent or salvage PCI, (4) time interval of PCI to CABG > 24 months, (5) hybrid cases after PCI, and (6) primary PCI failure were excluded from the analysis (Table 1). Risk adjustment was performed by means of predicted linear and logistic EuroSCORE as well as STS Score in both groups.

2.2. Data collection

Data used in the analysis were collected from the institutional database from the Department of Cardiac Surgery, Innsbruck Medical University, which was based on the data collection form of the Society of Thoracic Surgeons (Adult Cardiac Surgery Database Data Collection Form Version 2.25.1). The data were collected anonymously using a commercial database (Cardiac, S2 Engineering, Austria) endorsed by the Austrian Society of Thoracic and Cardiovascular Surgery. Patients were followed by contacting the family practitioners or themselves directly. Mortality was additionally assessed using the social security death database.

2.3. Study end points

The primary end points of the study included perioperative mortality defined as the incidence of death episodes that occurred during hospitalization for surgery.

The secondary end points included the following parameters of perioperative outcome defined according to the definition criteria of the Society of Thoracic Surgeons Database (STS Adult Cardiac Surgery Database v2.61, Data specifications at www.sts.org):

1. prolonged ventilation was defined as mechanical ventilation for a period >24 h after surgery and
2. morbidity included long length of stay, permanent stroke, prolonged ventilation, deep sternal wound infection, renal failure, or re-operation.

2.4. Perioperative management

Perioperative management of the patients has been described in a previous publication [7].

2.5. Statistical analysis

Categorical variables are presented as absolute numbers and frequencies in percentage, and both groups were compared using the Pearson’s chi-square test. Continuous variables were expressed as mean ± SD and the groups were compared by unpaired \( t \)-test. Logistic and linear EuroSCORE were used to calculate risk of perioperative mortality. In addition, the STS Score was calculated for every patient to assess perioperative morbidity and mortality (Dataset 2.61). Comparisons between observed and expected morbidity and mortality were performed by means of unpaired \( t \)-test.

Receiver operating characteristics (ROC) curves were used to describe the performance and predictive accuracy for the different algorithms. The discriminatory power was evaluated by calculating the areas under ROC curves. The areas under curves (AUCs) are presented with 95% confidence limits. An area of 1.0 under the ROC curve indicates perfect discrimination, whereas an area of 0.50 indicates complete absence of discrimination. Any intermediate value is a quantitative measure of the ability of the risk predictor model to distinguish between survivors and non-survivors. A level of significance of \( <0.05 \) (two-sided) was chosen for statistical comparisons. Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS) 17.0 statistical package (SPSS, Chicago, IL, USA).

3. Results

Patients’ preoperative and perioperative characteristics are summarized in Table 1.

3.1. Perioperative mortality and morbidity

Preoperative assessment of perioperative mortality using the logistic EuroSCORE was 4.9 ± 6.57 for patients with previous PCI and 4.6 ± 5.45 for patients without previous PCI (\( p = 0.35 \)). Assessment of perioperative mortality using the
STS Score predicted a probability of perioperative death of 4.3 ± 5.13% for PCI and 4.9 ± 4.1% for non-PCI patients (p = 0.47). Observed perioperative and 30-day mortality were significantly higher for patients with a history of previous PCI (3.8% and 3.5%, respectively) versus patients without a history of previous PCI (2.1% and 1.7%, respectively; p = 0.003).

Probability of morbidity, including long length of stay, permanent stroke, prolonged ventilation, deep sternal wound infection, renal failure, or re-operation, assessed by the STS Score was 23.5% for PCI and 25.3% for non-PCI patients (p = 0.35). Observed morbidity was significantly lower than predicted morbidity and mortality for non-PCI patients (21.9%, p = 0.014). On the other hand, observed morbidity was significantly higher (27.8%) than the predicted one in PCI patients (p = 0.023).

### 3.2. Discriminatory power for 30-day mortality

Discriminatory power for 30-day mortality using logistic EuroSCORE (Fig. 1) was higher for patients without a history of previous PCI (AUC = 0.875, confidence interval (CI) = 0.806–0.934) as compared with patients with a history of previous PCI (AUC = 0.552, CI = 0.301–0.765). Similar results were observed for discriminatory power for mortality using the STS score: as shown in Fig. 2, the AUC at the ROC curves was significantly lower in PCI (AUC = 0.553, CI = 0.398–0.669, p = 0.68) versus non-PCI patients (AUC = 0.914, CI = 0.860–0.967, p = 0.002), reflecting a significantly lower discriminatory power of the score in patients with a history of PCI before CABG.

### 3.3. Discriminatory power for cumulative morbidity and mortality

Cumulative morbidity or mortality was estimated using the STS Score and occurred in 31.6% of the PCI patients (predicted value = 27.8%, p = 0.026) and in 24% (predicted value = 27.4%, p = 0.013) of the non-PCI patients. As depicted in Fig. 3, the STS Score was not predictive for assessment of morbidity and mortality in patients, who underwent PCI before CABG (AUC = 0.529, CI = 0.425–0.633, p = 0.55). On the other hand, the same score had a high discriminatory capacity in CABG patients without a history of PCI (AUC = 0.628, CI = 0.569–0.687, p = 0.03).

### 3.4. Discriminatory power for prolonged ventilation

Prolonged ventilation (>24 h) was observed in 5.6% of the PCI group and in 1.1% of the non-PCI group. The STS Score was used to evaluate prediction of prolonged ventilation in CABG patients with and without a history of PCI (Fig. 4). The AUC was significantly higher in the second group of patients (AUC = 0.637, CI = 0.552–0.723, p = 0.004), revealing a low discriminatory capacity of the score in patients with previous PCI (AUC = 0.325, CI = 0.183–0.624, p = 0.32).
and a low one for patients with previous PCI (Fig. 5).

discriminatory capacity for patients without a history of PCI operative risk factors\[8]. The predictive ability of logistic algorithm to derive risk from the same preoperative and CABG and valve- or high-risk surgery. It uses a complex predictive ability of the additive EuroSCORE for combined logistic EuroSCORE was introduced to respond to the limited produce a risk model, which reflects operative mortality in by allocating incremental risk points to 17 risk factors to prolongation ventilation, and re-operation.

5. Discriminatory power for re-operation

Risk of re-operation for bleeding was assessed by the STS Score and occurred in 5.9% of PCI and in 3.8% of non-PCI patients. The AUC for the first group was 0.410, CI = 0.277—0.542, \( p = 0.16 \) whereas the AUC for the second group was 0.742, CI = 0.623—0.836, \( p = 0.026 \), which reveals a high discriminatory capacity for patients without a history of PCI and a low one for patients with previous PCI (Fig. 5).

4. Discussion

Our study investigated whether EuroSCORE and STS Score predicted the outcome of CABG in patients after previous PCI. Our results provide evidence that the perioperative outcome of CABG is worse in patients with previous PCI than in patients without previous PCI. The discriminatory power of two major risk stratification models to assess operative risk for these patients was inadequate. Therefore, according to our results, these models are not suitable for assessing perioperative risk in patients with previous PCI, who undergo CABG.

To elaborate on the different outcome aspects, two well-validated tests were chosen for assessment. Evaluation of test predictability included well-validated parameters, such as prediction of perioperative mortality and morbidity, prolonged ventilation, and re-operation.

The additive EuroSCORE was introduced in the late 1990s by allocating incremental risk points to 17 risk factors to produce a risk model, which reflects operative mortality in patients, who undergo cardiac surgical procedures [2]. The logistic EuroSCORE was introduced to respond to the limited predictive ability of the additive EuroSCORE for combined CABG and valve- or high-risk surgery. It uses a complex algorithm to derive risk from the same preoperative and operative risk factors [8]. The predictive ability of logistic EuroSCORE for complex and high-risk procedures has proved to be excellent, and does not differ from the one observed in isolated coronary and valve patients [9]. Still, a history of PCI before CABG is not being considered as a risk factor for mortality either by additive or by logistic EuroSCORE. As a consequence, perioperative risk for patients with a history of PCI is not considered to be higher as compared with patients without a history of PCI, unless one of the following conditions exists: critical preoperative state, impaired left-ventricular function, and emergency, PCI accident with unstable angina, myocardial infarction, and/or emergency. Such patients are indirectly allocated to a high-risk group by adding a risk coefficient of 0.55, 0.56, and 0.71, respectively. In comparison, patients with previous cardiac surgery as single risk factor have a coefficient of 1 [10].

The STS algorithm is more complicated and has been developed by pooling the results of hundreds of thousands patients operated upon in North America. Based on the STS Database, the developed risk stratification models provide scores for predictability of mortality and morbidity including several complications [11]. Although this score has been initially developed in the early 1990s, it underwent several revisions and evaluations, including the last one in 2008. The current STS algorithm considers patients, who underwent CABG within 6 h after PCI, as a high-risk procedure [12]. On the contrary, the risk of surgical revascularization in patients with a longer PCI interval is considered to be equivalent to normal population. Operative mortality was more than three times higher in PCI patients, who had to be operated within 6 h after the index procedure. In this case, patients with PCI complications, such as coronary dissections or acute stent thrombosis, were included. Nevertheless, the estimated risk of CABG surgery is still lower than in patients with acute myocardial infarction (odds ratio (OR) = 5) or with a history of previous cardiac surgery (OR = 3.13).

There may be some evidence that previous PCI has a negative influence on perioperative morbidity and mortality after elective CABG. Other investigators have shown, in a single and a multicenter retrospective analysis of CABG patients, a significant association of two or more previous PCIs with in-hospital mortality and major adverse cardiac events with OR of 2.0 and 1.5, respectively [13,14]. Perioperative results of a sub-population of CABG patients with diabetes and triple-vessel disease after PCI were significantly worse, with an observed mortality of 7.8% versus 2.9% (OR = 2.97) and a major adverse cardiac events (MACE) rate of 14.1 versus 6.1 (OR = 2.46) [15]. Similarly, Tran et al. reported an increased risk of operative death, perioperative complications, and additionally decreased age-adjusted survival at 2 years’ follow-up in patients with diabetes mellitus and a history of coronary stenting before coronary artery bypass surgery [16]. In contrast to the previous literature, Yap et al. recently found, for unclear reasons, no differences in short- or midterm mortality in patients with prior PCI who undergo CABG. [17]

With regard to morbidity, the higher incidence of MACE in CABG patients with prior PCI is well documented, as mentioned above. We demonstrated that the incidence of cumulative mortality and morbidity was significantly higher in patients with previous PCI. Moreover, the discriminatory power of the STS Score for prediction of the combined end point of morbidity and mortality was low. The existing literature provides little information with regard to morbidity differences between CABG patients with and without a history of PCI. Tran reported a higher incidence of MACE, prolonged ventilation, postoperative renal failure, and atrial fibrillation in the first group of patients, which is in agreement with our results [16]. In this study, we were able to show that the STS score was inappropriate to predict the
incidence of two additional outcome parameters, namely re-operation for bleeding and prolonged ventilation.

None of the previously mentioned studies provides adequate explanation for the worse short and intermediate outcome of coronary surgery in patients with a history of previous PCI. However, there are several mechanisms worthy of consideration that might help to explain the cause behind this increased risk. The hypothesis that patients, who require CABG after PCI, might have a more progressive form of coronary artery disease may be part of the explanation, as shown by the need for repeat PCI. Although more than a third of the study population received one or more drug eluting stents, the incidence of myocardial infarction during the interval between PCI and CABG was 44%. This shows that prior PCI might not only be a proxy marker of more aggressive disease, but the presence of a stent might itself induce deleterious mechanisms inside the coronary artery, such as inhibition of protective collateralization \[18\] and induction of a local inflammatory reaction \[19\]. The latter may result in platelet and leukocyte activation, as well as plaque destabilization, the effects of which might extend to the target vessel \[20\]. Long-term events could be attributed to incomplete revascularization \[21\], stent thrombosis as a result of inflammatory reaction, insufficient anti-platelet therapy, or resistance to clopidogrel therapy, aspirin therapy, or both \[22\]. The presence of a previous stent might force graft anastomoses to be inserted more distally into target vessels with smaller diameters, thereby compromising runoff and patency rates.

Worse prediction ability of the evaluated scores can only be explained on a speculative basis: the EuroSCORE was developed on data in the late 1990s, and surgical practice has changed since then, with increasing numbers of patients with coronary disease treated percutaneously. Advances in surgery and anesthetic and intensive care have led to overall reductions in surgical mortality, despite higher predicted operative mortality. The advent of drug eluting stents has allowed a significant decrease of in-stent restenosis, but the characteristics of these stents during coronary surgery and their interactions with cardiopulmonary bypass and heparin as well as protamin administration are unknown. On the other hand, the development of the STS Score requires a very complex algorithm, and to gain large participation is performed on a very broad base. This fact has been associated with auditing difficulties, which can easily affect soft evaluation parameters, such as previous PCI.

4.1. Study limitations

Several limitations exist with this study. This was a non-randomized retrospective study at a single center, which might limit the ability to extrapolate these results to other institutions. To avoid bias, a strict selection policy was adopted. Exclusion criteria were other than isolated CAGB procedures, cardiac re-operations, history of emergent or salvage PCI, time interval of PCI to CAGB >24 months, planned hybrid cases, and primary PCI failure. This fact may cause some sort of selection bias. However, the strength of this study is that patients included were analyzed by using standardized definitions and without periprocedural exclusions, which minimizes recall bias. As randomization was not possible because of the existing or not existing history of PCI, the EuroSCORE and the STS-predicted risk of mortality and morbidity were used for risk stratification. Although perioperative management is standardized, differences may occur in certain cases.

5. Conclusions

We conclude that both widely used risk stratification models for modern cardiac surgery do not seem to be adequate in predicting perioperative risk of mortality in patients with a history of elective PCI, who undergo CABG within 24 months from the index procedure. Similarly, predictive ability of the STS Score for morbidity and perioperative complications is quite low, suggesting that both end points are being underestimated by the existing risk stratification. After taking into consideration the fact that previous PCI is not included in risk stratification of either the EuroSCORE or the STS Score (with the exception of PCI performed <6 h before CABG), there should be a change in clinical practice and management: The underestimation of perioperative risk by using the existing scores should be considered during risk stratification of CABG patients. Ideally, recalibration of both scores should be performed using high-case-load studies to incorporate the increasing literature evidence of the effects of prior PCI on CABG.

References


