Predicted and observed in-hospital mortality after left main coronary artery stenting in 204 patients

Adam Sukiennik, Joanna Ostrowska-Nowak, Joanna Wiśniewska-Szmyt, Marek Radomski, Marcin Rychter, Miroslaw Jabłoński, Tomasz Białożyński, Marek Kozĩński, Tomasz Fabiszak, Ryszard Dobosiewicz, Ewa Zabielska, Tamara Sukiennik, Aldona Kubica, Anna Król, Krzysztof Demidowicz, Maciej Chojnicki, Zofia Grąbczewska, Iwona Świątkiewicz, Maria Bogdan, Grzegorz Grześk and Jacek Kubica

Department of Cardiology and Internal Medicine, Nicolaus Copernicus University, Toruń, Collegium Medicum in Bydgoszcz, Poland

Abstract

Background: The purpose of this study was to compare risk predicted using available risk scores and actual outcomes in patients with left main coronary artery disease undergoing percutaneous coronary intervention with stent implantation (PCI LM).

Methods: We studied 204 patients treated with elective or emergent coronary angioplasty. We estimated in-hospital mortality using the EuroSCORE, Parsonnet and GRACE risk scores and compared this data with actual in-hospital mortality.

Results: There were no deaths among 62 patients undergoing elective PCI LM regardless of the estimated risk. Acute coronary syndrome (ACS) was diagnosed in all 142 patients undergoing emergent PCI LM. Mortality in this group was 24% (34/142). Area under receiver operating characteristic curve (AUC) values for the EuroSCORE, Parsonnet and GRACE risk scores in patients with ACS were 0.812 (p = 0.0001), 0.857 (p = 0.0001), and 0.870 (p = 0.0001), respectively. No statistically significant differences were found when these AUC values for different evaluated risk scores were compared. Overall, the EuroSCORE and Parsonnet risk scores had no discriminative value, as all deaths occurred in the highest risk group. Only the GRACE risk score discriminated risk among intermediate- and high-risk patients with ACS.

Conclusions: The EuroSCORE and Parsonnet scoring systems are of no value in predicting periprocedural mortality risk in patients undergoing elective PCI LM. Overall, discriminative ability of the EuroSCORE, Parsonnet, and GRACE risk scores in unselected patients with ACS undergoing emergent PCI LM was good. In this group of patients, the EuroSCORE and Parsonnet scoring systems had no discriminative value in low and moderate risk patients. Only the GRACE risk score discriminated risk among intermediate and high risk patients.

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Key words: left main coronary artery disease, percutaneous coronary angioplasty, EuroSCORE, Parsonnet risk score, GRACE risk score
Adam Sukiennik et al., Predicted and observed in-hospital mortality after LMCA stenting

Introduction

Left main coronary artery disease (LM CAD), present in 5–9% of patients with angina pectoris, is associated with particularly unfavorable prognosis when treated medically, because 1- and 3-year mortality of 19% and 50%, respectively, has been reported in such patients [1, 2]. Coronary Artery Study (CASS) showed large advantage of coronary artery bypass grafting (CABG) over medical treatment in patients with LM CAD, as 5-year survival following CABG was 84% compared to 58% among patients treated medically [3]. Thus, revascularization is the method of choice when significant LM CAD is detected. In American College of Cardiology/American Heart Association guidelines, CABG is the treatment of choice for unprotected left main coronary artery stenosis (Class I recommendation, level of evidence A) [4].

The first percutaneous coronary intervention (PCI) in a patient with unprotected left main coronary artery stenosis was performed by Andreas Gruentzig in 1978 [5]. However, despite good immediate results this treatment was soon abandoned in favor of CABG due to unfavorable long-term outcomes [6]. During later years, hemodynamically significant left main coronary artery stenosis, particularly when unprotected by at least one patent coronary bypass graft, was considered an absolute contraindication for percutaneous revascularization [2, 3].

However, dynamic growth of invasive cardiology, widespread use of stents, including antimitotic drug-eluting stents, and introduction of new antiplatelet agents created new therapeutic possibilities also in the treatment of LM CAD. Despite these advances, current guidelines state that PCI of left main coronary artery stenosis should only be performed (Class IIa recommendation, level of evidence B) if surgical revascularization is not possible or the operative risk is prohibitively high (e.g. > 10 points using the EuroSCORE scoring system) [7, 8].

Risk prediction in cardiac surgery is based on several commonly used risk scores, such as the Parsonnet risk score [9, 10] and the EuroSCORE scoring system [11–14]. Risk prediction in patients with acute coronary syndromes is currently based on the Global Registry of Acute Coronary Events (GRACE) risk score [15,16]. These risk scores were validated in large patient populations. However, LM CAD is a unique clinical condition and the predictive value of these risk scores in such patients is not necessarily as good as in more general population of cardiac patients. Currently, only few data are available regarding the use of these risk scores in LM CAD, as their predictive value was not comprehensively evaluated in such patients and existing studies were performed in relatively small groups.

Purpose of the study

The purpose of this study was to compare periprocedural mortality risk predicted using available risk scores and actual outcomes in our patients with LM CAD undergoing PCI with stent implantation.

Methods

From August 2001 do January 2006, coronary angioplasty with stenting of the left main coronary artery was performed in 204 patients treated in the Department of Cardiology and Internal Medicine at the University Hospital in Bydgoszcz, Poland. These procedures amounted to 2.8% of all PCI procedures performed during the study period. All interventions were performed according to standard PCI procedures. Prior to PCI, patients were given 1 mg/kg of heparin (or 0.7 mg/kg if abciximab was concurrently used), acetylsalicylic acid and ticlopidine or clopidogrel. Following the procedure, all patients were treated with acetylsalicylic acid and ticlopidine or clopidogrel. PCI was preceded by coronary angiography. Bare metal stents or, in 15 patients, drug-eluting stents (DES) were implanted into the left main coronary artery at the discretion of the physician performing the procedure. In addition, 72 patients were treated with abciximab infusion.

All patients gave informed consent for coronary angioplasty. The study protocol was revised and approved by a local Ethics Committee. The study group characteristics is presented in Table 1.

Table 1. Clinical characteristics of the study population.

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Diabetes</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>(37.7%)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>140</td>
</tr>
<tr>
<td></td>
<td>(68.6%)</td>
</tr>
<tr>
<td>Hypercholesterolemia</td>
<td>153</td>
</tr>
<tr>
<td></td>
<td>(75%)</td>
</tr>
<tr>
<td>Cigarette smoking</td>
<td>113</td>
</tr>
<tr>
<td></td>
<td>(55.4%)</td>
</tr>
<tr>
<td>Creatinine level ≥ 2 mg/dL</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>(5.4%)</td>
</tr>
<tr>
<td>Previous stroke</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>(14.2%)</td>
</tr>
<tr>
<td>UA/NSTEMI as the indication for PCI</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td>(28.4%)</td>
</tr>
<tr>
<td>STEMI as the indication for PCI</td>
<td>84</td>
</tr>
<tr>
<td></td>
<td>(41.2%)</td>
</tr>
<tr>
<td>Resuscitated cardiac arrest</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>(10.8%)</td>
</tr>
<tr>
<td>Cardiogenic shock on admission</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>(31.9%)</td>
</tr>
<tr>
<td>Intra-aortic balloon pump necessary during treatment</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>(10.8%)</td>
</tr>
</tbody>
</table>

PCI — percutaneous coronary intervention; NSTEMI — non-ST segment elevation myocardial infarction; STEMI — ST segment elevation myocardial infarction; UA — unstable angina
We studied 204 patients (mean age 65.5 years, range 26–85 years), including 55 women (mean age 70 years, range 44–85 years) and 149 men (mean age 63 years, range 26–83 years). The study group was divided into two subgroups of 62 patients (30%) undergoing elective treatment and 142 patients (70%) undergoing emergent treatment.

Among patients undergoing elective coronary angioplasty, left main coronary artery was protected by at least one patent coronary bypass graft in 8 patients, 6 patients were deemed not suitable for CABG, and 46 patients did not give consent for CABG.

Acute coronary syndrome (ACS) was diagnosed in patients undergoing emergent coronary angioplasty, including 58 patients (41%) with non-ST segment elevation ACS and 84 patients (59%) with ST segment elevation ACS. On admission, 65 patients (46%) were in cardiogenic shock, and 20 patients (14.1%) have been resuscitated following a cardiac arrest. Left main coronary artery was protected by at least one patent coronary bypass graft in 16 patients. Intra-aortic balloon pump was used in 22 patients (15.5%). In five cases, the immediate cause of stent implantation was iatrogenic dissection of the left main coronary artery during catheterization and angiography.

The most obvious alternative treatment in such patients is cardiac surgery. Therefore, we evaluated cardiac surgery risk using a European scoring system known as the EuroSCORE. According to this system, patients assigned 0–2 points are considered a low surgical risk group with estimated perioperative mortality of 0.8%, patients assigned 3–5 points are considered an intermediate surgical risk group with estimated perioperative mortality of 3%, and patients assigned 6 or more points are considered a high surgical risk group with estimated perioperative mortality exceeding 11.2%. Another risk score allowing rapid, bedside estimation of the perioperative risk is the Parsonnet score. In this scoring system, 0–4, 5–9, 10–15, 15–19, and 20+ points correspond to the estimated mortality of 1%, 5%, 9%, 17%, and 31%, respectively. In all patients with ACS, we also evaluated in-hospital mortality risk using the GRACE risk score.

**Statistical analysis**

All calculations and analyses were performed using Statistica package, version 7.1 PL (StatSoft, Tulsa, USA), and MedCalc for Windows, version 9.2.0.0 (MedCalc Software, Mariakerke, Belgium). P<0.05 was considered statistically significant. Normal distribution of variables was tested using Kolmogorov-Smirnov and Shapiro-Wilk tests. For variables with skewed distribution, data were presented as median values and ranges. Receiver operating characteristic (ROC) curves were used for statistical analysis [17, 18]. Area under ROC curve (AUC) was calculated to determine discriminatory value of a given score. AUC values were compared using Hanley and McNeil method [19].

**Results**

Among 62 patients undergoing elective PCI with stent implantation, the EuroSCORE scoring system indicated low operative risk in 23 (37.1%) patients, intermediate risk in 23 (37.1%) patients, and high risk in 16 (25.8%) patients. According to the Parsonnet score, perioperative mortality risk was 1% in 4 (6.5%) patients, 5% in 14 (22.6%) patients, 9% in 16 (25.8%) patients, 17% in 13 (21%) patients, and 31% in 15 (24.2%) patients. However, there were no deaths in this patient group regardless of the estimated risk.

Among 142 patients with ACS undergoing emergent PCI with stent implantation, 34 deaths (24%) occurred, including 7 deaths (12.1%) among 58 patients with unstable angina/non-ST segment elevation myocardial infarction (UA/NSTEMI), and 27 deaths (32.1%) among 84 patients with ST segment elevation myocardial infarction (STEMI). Among patients with UA/NSTEMI, 14 patients were in cardiogenic shock and half of them died. Among patients with STEMI, 51 patients were in cardiogenic shock and 25 of them (49%) died. Overall, death ensued in 32 (49.2%) of 65 patients (45.8% of all patients with ACS) who were in cardiogenic shock prior to PCI.

Evaluation using the EuroSCORE scoring system indicated low operative risk in 4 (2.8%) patients with ACS, intermediate risk in 14 (9.9%) patients, and high risk in 124 (87.3%) patients. All 34 patients who died (24%) belonged to the latter group (Fig. 1). According to the Parsonnet score, perioperative mortality risk was 1% in 4 patients, 5% in 2 patients, 9% in 13 patients, 17% in 18 patients, and 31% in 105 (73.9%) patients. Again, all 34 patients who died (32.4%) belonged to the highest risk group (Fig. 2).

Among 142 patients with ACS, in-hospital mortality risk estimates based on the GRACE risk score were as follows: estimated risk was less than 1% in 7 (4.9%) patients and 1–4% in 30 (21.1%) patients, with no deaths in these two groups; while one patient (4%) died out of 25 (17.6%) patients with the estimated mortality risk of 5–8%, 4 patients (21.1%) died out of 19 (13.4%) patients with the estimated mortality risk of 9–19%, and 29 patients
(47.5%) died out of 61 (43%) patients with the estimated mortality risk of \( \geq 20\% \) (Fig. 3).

Overall, AUC was 0.876 (\( p = 0.0001 \)) for the EuroSCORE scoring system and 0.870 (\( p = 0.0001 \)) for the Parsonnet risk score. No statistically significant difference was found when these AUC values were compared (\( p = 0.860 \)) (Fig. 4, Table 2).

In patients with ACS, AUC values for the EuroSCORE, Parsonnet and GRACE risk scores were 0.812 (\( p = 0.0001 \)), 0.805 (\( p = 0.0001 \)), and 0.857 (\( p = 0.0001 \)), respectively. No statistically significant differences were found when these AUC values were compared pair-wise (Fig. 5, Table 3).

**Discussion**

In the current era of widespread use of coronary stents, including antiproliferative DES, and antiplatelet drugs such as clopidogrel and ticlopidine, it is debatable whether left main coronary artery stenosis should still be considered an absolute contraindication to PCI [20]. This debate regarding the optimal treatment of the left main coronary artery stenosis has been fueled by the results of multicenter French Left Main study (FLM) and the recent results of the LE MANS study, showing lower one-year mortality in patients treated with coronary angioplasty and stenting compared to CABG [21, 22].

Previous studies suggest that the early and long-term results of PCI in patients with LM CAD depend on the baseline clinical status [23]. Risk factors for mortality among patients undergoing angioplasty of the left main coronary artery stenosis include low left ventricular ejection fraction (LVEF), significant mitral regurgitation, cardiogenic shock, acute myocardial infarction, renal failure, multivessel coronary artery disease and postprocedural stent lumen diameter [1, 24–26]. Recently, an increased preprocedural high-sensitivity C-reactive protein (hsCRP) level has also been shown to be a risk factor for adverse outcomes [27].

Our data show no major complications and deaths during in-hospital follow-up of patients...
undergoing elective PCI of LM CAD. Notably, some of these patients were previously refused CABG due to perceived high surgical risk, and some patients did not give consent for CABG. In the study by Brener et al. [28] in 97 patients with LM CAD treated with stent implantation, risk factors for adverse outcomes were the number of points by the EuroSCORE scoring system and diabetes. In the

<table>
<thead>
<tr>
<th>Risk estimation model</th>
<th>AUC</th>
<th>Standard error</th>
<th>95% confidence interval</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>EuroSCORE</td>
<td>0.876</td>
<td>0.0396</td>
<td>0.823 to 0.918</td>
<td>0.0001</td>
</tr>
<tr>
<td>Parsonnet</td>
<td>0.870</td>
<td>0.0404</td>
<td>0.816 to 0.913</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Comparison of models</th>
<th>ΔAUC</th>
<th>Standard error</th>
<th>95% confidence interval</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>EuroSCORE vs. Parsonnet</td>
<td>0.00588</td>
<td>0.0333</td>
<td>−0.0594 to 0.0712</td>
<td>0.860</td>
</tr>
</tbody>
</table>

ΔAUC — difference between AUC values for the two risk scores.

Table 2. Area under ROC curve (AUC) values for the EuroSCORE and Parsonnet risk scores and their comparison in the overall study population.

<table>
<thead>
<tr>
<th>Risk estimation model</th>
<th>AUC</th>
<th>Standard error</th>
<th>95% confidence interval</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>EuroSCORE</td>
<td>0.812</td>
<td>0.0475</td>
<td>0.738 to 0.872</td>
<td>0.0001</td>
</tr>
<tr>
<td>GRACE</td>
<td>0.857</td>
<td>0.0427</td>
<td>0.788 to 0.910</td>
<td>0.0001</td>
</tr>
<tr>
<td>Parsonnet</td>
<td>0.805</td>
<td>0.0481</td>
<td>0.730 to 0.867</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Comparison of models</th>
<th>ΔAUC</th>
<th>Standard error</th>
<th>95% confidence interval</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>EuroSCORE vs. GRACE</td>
<td>0.0451</td>
<td>0.0349</td>
<td>−0.234 to 0.114</td>
<td>0.197</td>
</tr>
<tr>
<td>EuroSCORE vs. Parsonnet</td>
<td>0.00681</td>
<td>0.0388</td>
<td>−0.0692 to 0.0828</td>
<td>0.861</td>
</tr>
<tr>
<td>GRACE vs. Parsonnet</td>
<td>0.0519</td>
<td>0.0366</td>
<td>−0.0199 to 0.124</td>
<td>0.157</td>
</tr>
</tbody>
</table>

ΔAUC — difference between AUC values for risk scores compared pairwise.

Table 3. Area under ROC curve (AUC) values for the EuroSCORE, GRACE and Parsonnet risk scores and their comparison in patients with acute coronary syndromes.

**Figure 4.** ROC curves for the EuroSCORE and Parsonnet risk scores in the overall study population.

**Figure 5.** ROC curves for the EuroSCORE, GRACE and Parsonnet risk scores in patients with acute coronary syndromes.
study by Silvestri et al. [29] who evaluated 140 patients
who underwent elective PCI of the left main coro-
nary artery stenosis (excluding patients with acute
myocardial infarction and/or cardiogenic shock),
30-day mortality was 0% in the low operative risk
group and 9% in the high operative risk group. The
latter included patients with contraindications to
CABG and patients with at least one of the follo-
wing risk factors: advanced age (> 75 years), pre-
vious cardiac surgery, LVEF < 35%, renal failure,
severe respiratory failure, and poor distal coronary
outflow [29]. In our study, no in-hospital deaths
were noted among patients who underwent electi-
ve angioplasty of the left main coronary artery even
in high surgical risk groups by the EuroSCORE and
Parsonnet risk score criteria. These results are
comparable to those reported by Kim et al. [30],
with no periprocedural deaths in a group of 324 pa-
tients who underwent elective angioplasty of the
left main coronary artery. Patients with acute STEMI
and patients undergoing urgent angioplasty within
24 hours from the onset of symptoms were exclu-
ded from that study. In contrast to studies by Silvestri et al. [29] and by Kim et al. [30], we anal-
yzed all patients undergoing angioplasty of the left
main coronary artery, including patients with acu-
et STEMI (41.2% of all patients) and patients with
cardiogenic shock (31.9% of patients). In a study in-
volving 104 patients, Christiansen et al. [31] sho-
ed that 30-day mortality in low and high operati-
ve risk groups and in patients with acute myocardial
infarction was 0%, 16% and 37%, respectively, and
predicted mortality using the EuroSCORE scor-
ing system was 2%, 8% and 18%, respectively.
Among our patients undergoing emergent PCI of
the left main coronary artery, mortality in low, in-
termediate and high operative risk groups was 0%,
0% and 24%, respectively, while predicted mortali-
ity using the EuroSCORE scoring system was
0.8%, 3% and 11.2%, respectively. Multicenter
ULTIMA registry, involving the largest patient pop-
ulation so far (n = 279), showed that the out-
comes following angioplasty of an unprotected left
main coronary artery stenosis in patients with low
operative risk were better (no periprocedural de-
aths, one-year mortality of 3.4%) than the results
of CABG in similar patients. One-year mortality
among patients with intermediate operative risk
was 24.4%, and it exceeded 56% among patients
with high operative risk [1]. Among patients with
acute myocardial infarction treated with angiopla-
sty and stenting of the left main coronary artery,
periprocedural mortality was 35%, and one-year
mortality was 55% [32]. Outcomes of stenting were
worse in patients with impaired left ventricular
function (LVEF < 30%), significant mitral regurgi-
tations, renal disease, and advanced age (> 75
years) [25, 33, 34]. However, these were high ope-
rate risk patients who were often denied surgical
treatment. In contrast to the above results, inh-
ospital mortality was only 1.7% and one-year morta-
lity was 5.1% among 297 patients treated with PCI
of the left main coronary artery, reported by Han
et al. [35] in a single-center Chinese study. This
group included 23.9% patients undergoing emer-
gent PCI, 45.1% patients with unstable angina, 7.1%
patients with acute myocardial infarction and 4%
patients in cardiogenic shock.

LM CAD is a rare cause of an acute myocardial
infarction (0.37–0.6%) [36, 37]. However, pro-
gnosis is very poor in patients with a left main coro-
nary artery stenosis that led to an acute myocardial
infarction complicated by a cardiogenic shock
(so called left main shock syndrome), with peripro-
cedural mortality of 32–94% [25, 32, 33, 38–41].
Few studies have been published that reported re-
sults of surgical revascularization in such patients.
Nakanishi et al. reported mortality of 46% among
patients undergoing CABG due to an acute myocar-
dial infarction (n = 13), including 53% patients in
 cardiogenic shock [42]. Despite indications for
CABG, significant logistic problems (time required
for preparation to operation, patient transport to the
operating room) commonly make the performance
of the surgical procedure impossible. Thus, it se-
ems that immediate PCI with stenting might often
be the only practical effective treatment. Despite
lack of large studies, mounting evidence from smal-
ler groups of patients show effectiveness of such
strategy, with mortality reduced to 32–44% [32, 39–
41, 43].

Risk prediction models, such as the EuroSCORE
and Parsonnet risk scores, are commonly used in
 cardiac surgery to predict operative risk [9–14].
Usefulness of the EuroSCORE scoring system was
also shown for predicting PCI-related risk for high
risk procedures [44–46]. Despite independent rela-
tion between the number of points and the risk of
death, these scores have limited usefulness in pre-
dicting PCI-related risk. As these models were de-

erived from data on the outcomes of surgical treat-
ment, some parameters might bear no relation to
PCI-related risk. This limitation may explain lack
of relation between the number of points by these
scoring systems and PCI outcomes in patients under-
going elective treatment that was observed in our
study. In this population, no deaths were noted du-
ring short-term follow-up among patients undergoing
elective PCI, although about 25% of patients could be categorized as highest risk. This might be explained by a low number of patients in our study, but it might also result from limited usefulness of such scoring systems in patients undergoing PCI due to associated low mortality.

We found good discriminative ability of the EuroSCORE and Parsonnet risk scores in patients undergoing emergent PCI, as evaluated using AUC values for respective ROC curves (0.812 and 0.805, respectively). However, mortality risk analysis using these scoring systems showed poor discriminative value among low and moderate risk patients, as all deaths occurred in the highest risk group (Fig. 1, 2). These discrepant findings may be explained by a large number of patients in cardiogenic shock (45.8%), mostly related to STEMI. This population is characterized by high mortality exceeding 50% [25, 32, 47, 48].

Discriminative value of the GRACE risk score in the same group of patients tended to be highest (AUC = 0.857), although we found no significant difference compared to the other risk scores. This model also had no discriminative value among low risk patients (estimated mortality risk 1–4%) but tended to have better discriminative value among moderate risk patients (estimated mortality risk 5–19%) and high risk patients (estimated mortality risk ≥ 20%) (Fig. 3). These findings suggest an advantage of the GRACE risk score over the other evaluated risk prediction models in regard to the estimation of PCI-related risk in patients with ACS undergoing PCI of the left main coronary artery.

Study limitations

We studied unselected patients with LM CAD, including 24 (11.8%) patients with protected left main coronary artery stenosis. Most patients underwent emergent angioplasty and stenting of the left main coronary artery, including 46% patients in cardiogenic shock and 14.1% patients who had been resuscitated following a cardiac arrest. Due to all these factors, precise determination of the baseline clinical status as related to risk estimation using the EuroSCORE and Parsonnet scoring systems (no baseline echocardiographic evaluation, incomplete history regarding risk factors) was difficult and resulted in underestimation of predicted risk in critically ill patients. The EuroSCORE scoring system may underestimate risk in higher risk patients. Due to relatively low number of patients, multivariate analysis of the differences between predicted and actual risk could not be reliably performed.

Conclusions

The EuroSCORE and Parsonnet scoring systems are of no value in predicting periprocedural mortality risk in patients undergoing elective left main coronary artery stenting. Overall, discriminative ability of the EuroSCORE, Parsonnet, and GRACE risk scores in unselected patients with ACS undergoing emergent PCI of LM CAD was good. In this group of patients, the EuroSCORE and Parsonnet scoring systems had no discriminative value in low and moderate risk patients, as all deaths occurred in the highest risk group. Only the GRACE risk score discriminated risk among intermediate and high-risk patients with acute coronary syndrome.

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