Factors predictive for in-hospital mortality following percutaneous coronary intervention

Facteurs prédictifs de mortalité intrahospitalière après angioplastie coronaire

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Summary
Background. — Despite advances in procedures for percutaneous coronary intervention (PCI) and enhancement of materials and adjunctive therapy, postprocedural mortality remains a possible adverse outcome after PCI.
Aims. — To assess factors independently associated with in-hospital mortality in patients referred for PCI.
Methods. — Between January 2004 and December 2005, 4074 PCI were performed in our University Hospital, with 70 deaths registered either during the procedure or during the in-hospital stay. The 70 patients who died were age- and sex-matched with 70 controls in a case-control design study. Clinical and angiographic characteristics at hospital admission were collected from the patients’ medical files.
Results. — The cumulative incidence rate for in-hospital mortality was 1.72%. Variables positively and significantly associated with in-hospital mortality were severe renal failure.

Abbreviations: CI, confidence interval; COPD, chronic obstructive pulmonary disease; GUSTO, global use of strategies to open occluded coronary arteries; MDRD, modification of diet in renal disease; NSTEMI, non-ST-segment elevation myocardial infarction; OR, odds ratio; PAD, peripheral artery disease; PCI, percutaneous coronary intervention; STEMI, ST-segment elevation myocardial infarction.
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Background

Coronary artery disease is one of the most frequent causes of morbidity and mortality in industrialized countries. Since its introduction in 1977, percutaneous coronary intervention (PCI) has developed significantly to become the reference treatment for coronary disease. Improvement in operators’ experience and in technical materials with, in particular, the use of new generation coronary stents, has contributed to the enhancement in the efficacy and safety of the procedures. Advances in PCI have been associated with a reduced risk of adverse outcomes and have broadened the indications of PCI. Multivariable models have been developed previously to assess independent determinants of in-hospital mortality after PCI [1—4]. However, such determinants may vary according to differences in healthcare access, practice patterns and procedural techniques, and may thus differ across countries. The aim of this work was to assess factors independently associated with in-hospital mortality in patients referred for PCI.

Methods

Study population and data collection

Between January 2004 and December 2005, a total of 4074 PCI were performed in the Department of Cardiology of the Toulouse University Hospital (France): 53.5% in patients presenting with non-ST-segment elevation myocardial infarction (NSTEMI), 31.5% in subjects with ST-segment elevation myocardial infarction (STEMI), and 15.0% in patients who had elective PCI (for stable angina or silent ischemia). Seventy (1.72%) patients died either during the procedure or during the in-hospital stay. For each index case of death, an age- and sex-matched control was selected, who corresponded to the first patient with the same sex and age (±4 years) and who underwent a PCI in the Department of Cardiology and survived the procedure. The study population was thus made up of 70 deceased patients (cases) and 70 age- and sex-matched surviving controls. Data on previous medical conditions, cardiovascular risk factors, and clinical and angiographic characteristics were collected from the patients’ medical files. In particular, (55.7% in cases versus 12.9% in controls, \( p<0.0001 \)), cardiac failure (26.1% versus 10.1%, \( p=0.01 \)), ST-segment elevation myocardial infarction (STEMI) (70.6% versus 31.4%, \( p<0.0001 \)), proximal coronary lesion (72.9% versus 40.0%, \( p<0.0001 \)) and angiographically visible thrombus (14.3% versus 4.3%, \( p=0.04 \)). Conversely, history of coronary heart disease, smoking and dyslipidemia were less frequent among cases. In multivariable analysis, the adjusted odds ratios (OR) for in-hospital death were 4.89 (95% confidence interval [CI] 1.96—12.2, \( p<0.0001 \)) in STEMI versus non-STEMI, 4.28 (95% CI 1.73—10.6, \( p=0.01 \)) in those with a proximal coronary lesion, and 9.77 (95% CI 3.42—27.9, \( p<0.0001 \)) in patients with severe renal failure. Conclusion. — STEMI, proximal coronary lesion, and renal failure at admission are identified as particular settings associated with a higher probability of in-hospital mortality after PCI.

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Résumé

Contexte. — En dépit des progrès réalisés dans les procédures, l’amélioration du matériel et des traitements adjuvants, l’angioplastie coronaire évolue encore parfois vers une issue fatale. Objectifs. — Identifier les facteurs indépendamment associés à la probabilité de décès intra-hospitalier, chez les patients adressés pour angioplastie.

Méthodes. — De janvier 2004 à décembre 2005, 4074 angioplasties coronaires ont été réalisées dans notre CHU. Soixante dix décès sont survenus durant la procédure ou le séjour hospitalier. Les 70 patients décédés ont été appariés sur l’âge et le sexe à 70 témoins. Les caractéristiques cliniques et angiographiques des patients à l’admission ont été recueillies à partir du dossier médical.

Résultats. — L’incidence cumulée des décès était de 1,72 %. Les variables associées positive-ment et significativement à la mortalité étaient l’insuffisance rénale (55,7 % parmi les cas versus 12,9 % parmi les témoins, \( p<0.0001 \)), l’insuffisance cardiaque (26,1 % versus 10,1 %, \( p=0.01 \)), le syndrome coronaire aigu avec élévation du segment-ST (SCA-ST+) (70,6 % versus 31,4 %, \( p<0.0001 \)), la présence d’une lésion coronaire proximale (72,9 % versus 40,0 %, \( p<0.0001 \)), d’un thrombus (14,3 % versus 4,3 %, \( p=0.04 \)). À l’inverse, coronaropathie préexistante, tabagisme et dyslipidémie étaient moins fréquents parmi les cas. En analyse multivariée, les odds ratios (OR) ajustés de mortalité étaient : OR = 4,89 (intervalle de confiance à 95 % \([1,96—12,2] \), \( p<0.0001 \)) pour les SCA-ST+ comparativement aux SCA sans élévation du segment-ST, OR = 4,28 (\([1,73—10,6] \), \( p<0.01 \)) en cas de lésion coronaire proximale, OR = 9,77 (\([3,42—27,9] \), \( p<0.0001 \)) en cas d’insuffisance rénale sévère.

Conclusion. — Le SCA-ST+, une lésion coronaire proximale et l’insuffisance rénale sévère sont associés à une probabilité plus élevée de décès postangioplastie.

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Factors predictive for in-hospital mortality following percutaneous coronary intervention

A history of coronary heart disease (previous acute coronary syndrome, PCI or coronary artery bypass surgery), vascular disease (peripheral artery disease [PAD], stroke or transient ischemic attack), cardiac failure, or chronic obstructive pulmonary disease (COPD) were sought, as well as the indication for PCI (STEMI, NSTEMI, stable angina or silent ischemia), the time of the procedure, the clinical presentation of the patient at admission (height, weight, signs of cardiogenic shock) and the angiographic characteristics of the coronary vessels and lesions.

Cardiac failure before PCI (preprocedural cardiac failure) was defined as a combination of symptoms including dyspnoea, ankle edema, pulmonary rales, or need for diuretic, vasodilator or antihypertensive drug treatment. Preprocedural cardiogenic shock was defined as the presence of pulmonary edema with an evidence of hypoperfusion. Kidney function was assessed using the modification of diet in renal disease (MDRD) [5] equation for estimating creatinine clearance. Severe preprocedural renal failure was assessed when creatinine clearance was equal to 40 mL/min or less [6]. Proximal coronary lesions included lesions of the proximal segments of the left anterior descending and the left circumflex arteries.

Statistical analysis

The statistical analysis was performed using the SAS software package, version 9.1 (SAS Institute Inc., Cary, North Carolina, USA), based on a case-control study design. The distribution of qualitative variables was compared between cases and controls using the chi-square test when appropriate and Fisher’s exact test in case of small numbers. Means of quantitative variables were compared using Student’s t-test. Variables associated with the case-control status in bivariate analysis (p-value below 0.20) were introduced in a backward multivariable logistic regression analysis to determine the variables that were significantly and independently associated with the case-control status. Odds ratios (OR) are given with 95% confidence intervals (CI). All p-values are two-sided.

Results

Clinical characteristics

All patients received aspirin (160 mg/day) and a single intravenous injection of heparin (50 UI/kg) as adjunctive therapies. A coronary stent (drug-eluting or bare metal) was implanted in 85% of patients. The population was quite elderly with a mean age of 72.5 and 73.0 years old in controls and cases, respectively, ranging from 33 to 93. The two groups were predominantly male with a sex ratio of 5.4. The median duration of in-hospital stay was four days in both cases (interquartile range <1–8) and controls (interquartile range 3–6). The clinical characteristics of the cases and controls at hospital admission are shown in Table 1. The two groups were not significantly different in terms of age, sex, body mass index, history of vascular (noncoronary) disease, hypertension, diabetes, cardiac failure and COPD. Furthermore, no significant difference was observed regarding the percentage of cases and controls treated during off-hours.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Clinical characteristics.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Controls (n = 70)</td>
</tr>
<tr>
<td>Women, n (%)</td>
<td>11 (15.7)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>72.5 (12.0)</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>26.4 (4.4)</td>
</tr>
<tr>
<td>Previous coronary artery disease, n (%)</td>
<td>26 (37.1)</td>
</tr>
<tr>
<td>Previous vascular disease, n (%)</td>
<td>10 (14.3)</td>
</tr>
<tr>
<td>Previous cardiac failure, n (%)</td>
<td>1 (1.4)</td>
</tr>
<tr>
<td>Previous COPD, n (%)</td>
<td>3 (4.3)</td>
</tr>
<tr>
<td>Preprocedural renal failurea, n (%)</td>
<td>9 (12.9)</td>
</tr>
<tr>
<td>Smoking, n (%)</td>
<td>43 (61.4)</td>
</tr>
<tr>
<td>Hypertension, n (%)</td>
<td>44 (62.9)</td>
</tr>
<tr>
<td>Diabetes, n (%)</td>
<td>14 (20.3)</td>
</tr>
<tr>
<td>Dyslipidemia, n (%)</td>
<td>37 (54.4)</td>
</tr>
<tr>
<td>Indication for PCI, n (%)</td>
<td>22 (31.4)</td>
</tr>
<tr>
<td>STEMI</td>
<td>40 (57.2)</td>
</tr>
<tr>
<td>NSTEMI</td>
<td>8 (11.4)</td>
</tr>
<tr>
<td>Otherb</td>
<td>7 (10.1)</td>
</tr>
<tr>
<td>Preprocedural cardiac failure, n (%)</td>
<td>2 (2.9)</td>
</tr>
<tr>
<td>Time of PCI, n (%)</td>
<td>10.00 pm—6.00 am</td>
</tr>
</tbody>
</table>

Results are given as n (percent) or mean (standard deviation).

COPD: chronic obstructive pulmonary disease; PCI: percutaneous coronary intervention; STEMI: ST-segment elevation myocardial infarction; NSTEMI: non-ST-segment elevation myocardial infarction.

a Creatinine clearance ≤40 mL/min.
b Other: stable angina or silent ischemia.
Conversely, smokers and patients with a history of coronary heart disease or dyslipidemia were significantly more frequent among controls.

Severe preprocedural renal failure was more often observed in cases than in controls (55.7% versus 12.9%, \( p < 0.0001 \)). PCI was performed in a context of an acute coronary syndrome (STEMI or NSTEMI) in 92.8% of the study population. The distribution of patients presenting with STEMI, NSTEMI, silent ischemia or stable angina was significantly different between cases and controls, with the proportion of patients with STEMI greater among the cases \( (p < 0.0001) \). The proportion of patients with preprocedural clinical presentation of cardiac failure or cardiogenic shock was also significantly higher among cases \( (26.1\% \text{ versus } 10.1\%, \ p = 0.01 \text{ for cardiac failure and } 17.1\% \text{ versus } 2.9\%, \ p < 0.01 \text{ for cardiogenic shock}) \).

Hemorrhage after PCI occurred in 12 patients (four in controls and eight in cases), among which seven were considered as severe according to the global use of strategies to open occluded coronary arteries (GUSTO) classification (i.e. intracranial hemorrhage or bleeding that caused hemodynamic compromise and required intervention) [7]. The seven severe hemorrhages all occurred in the group of cases.

**Angiographic data**

The angiographic characteristics of the patients are listed in Table 2. The proportion of patients with lesions of the left main coronary artery as well as the distribution of those with a single-, two- or three-vessel disease tended to be different between cases and controls but did not achieve the significant statistical level. An angiographically visible thrombus was present in 14.3% of the deceased patients, but only in 4.3% of the controls \( (p = 0.04) \). The lesion was considered as proximal in 72.9% of the cases and in 40.0% of the controls \( (p < 0.0001) \).

**Independent predictors of in-hospital mortality**

In multivariable analysis (Table 3), STEMI, proximal coronary lesion and severe preprocedural renal failure were independently associated with a higher probability of in-hospital mortality, whereas patients who smoked remained at a lower risk of death. Further adjustments for age and sex did not significantly change these results.

**Discussion**

Over the past decade, indications for PCI have increased dramatically, with treated patients now including subjects with severe cardiovascular disease, comorbidities and complex lesions. Despite a satisfactory success rate, serious adverse outcomes can still be observed after PCI, including artery dissection, postprocedural chest pain with altered ST-segment or raised biochemical markers of myocardial necrosis, postprocedural need for surgery, or in-hospital death (with an incidence of 1.1 to 1.7%) [1—4,8]. Previous studies aimed at assessing determinants of mortality following PCI were conducted mainly in US registries. As the efficacy of coronary interventions is greatly dependent on healthcare system organization and access to emergency facilities, especially in the particular setting of acute coronary syndromes, national data are now needed to investigate such determinants in the French healthcare system. Our study identifies several adverse conditions associated with a higher probability of in-hospital mortality in patients referred for PCI.

Age, which was used in our study as a matching criterion between cases and controls, has been shown previously to be strongly predictive of a high risk of in-hospital mortality [9]. Associated comorbidities have also been related to an increased risk of death following PCI, in both elderly and young patients. In particular, preprocedural renal failure reduces the success rate of PCI and increases the risk of in-hospital and long-term major acute coronary events. Consistently, decreased preprocedural creatinine clearance was a major independent predictor of death in our study.

Rubenstein et al. [10] suggested that patients with moderate and severe renal failure may actually develop similar short- and long-term outcomes. Furthermore, postprocedural renal failure has also been considered as being predictive of in-hospital mortality [11].

The other comorbidities that have previously been associated with a poor prognosis after PCI are peripheral artery disease and COPD. Indeed, patients presenting with a history of intermittent claudication, angiographic abnormalities of lower limb arteries, stroke or transient ischemic attack, and treated with PCI in the context of an acute coronary syndrome have poor short- and long-term prognoses [12]. This has been related to a worse clinical profile but also to an insufficiently aggressive management. In our study, such a poor relationship between noncoronary artery disease and in-hospital mortality was not observed. COPD has been pin-

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**Table 2** Angiographic characteristics.

<table>
<thead>
<tr>
<th>Coronary status, n (%)</th>
<th>Controls (n = 70)</th>
<th>Cases (n = 70)</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-vessel disease</td>
<td>26 (37.1)</td>
<td>15 (21.4)</td>
<td>0.12</td>
</tr>
<tr>
<td>Two-vessel disease</td>
<td>23 (32.9)</td>
<td>30 (42.9)</td>
<td></td>
</tr>
<tr>
<td>Three-vessel disease</td>
<td>21 (30.0)</td>
<td>25 (35.7)</td>
<td></td>
</tr>
<tr>
<td>Left main coronary artery lesion, n (%)</td>
<td>3 (4.3)</td>
<td>7 (10.0)</td>
<td>0.19</td>
</tr>
<tr>
<td>Proximal lesion, n (%)</td>
<td>28 (40.0)</td>
<td>51 (72.9)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Thrombus, n (%)</td>
<td>3 (4.3)</td>
<td>10 (14.3)</td>
<td>0.04</td>
</tr>
<tr>
<td>Calcifications, n (%)</td>
<td>1 (1.4)</td>
<td>3 (4.3)</td>
<td>0.62</td>
</tr>
<tr>
<td>Intra-aortic balloon pump, n (%)</td>
<td>2 (2.9)</td>
<td>10 (14.3)</td>
<td>0.02</td>
</tr>
</tbody>
</table>
Factors predictive for in-hospital mortality following percutaneous coronary intervention

Table 3  Independent predictors of mortality.

<table>
<thead>
<tr>
<th></th>
<th>OR [95 % CI]</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-procedural renal failure*</td>
<td>9.77 [3.42-27.9]</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Indication for PCI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STEMI</td>
<td>4.89 [1.96-12.2]</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Other†</td>
<td>0.37 [0.05-2.82]</td>
<td>0.34</td>
</tr>
<tr>
<td>Smoking</td>
<td>0.25 [0.10-0.63]</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Proximal coronary lesion</td>
<td>4.28 [1.73-10.6]</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

OR: odds ratio; CI: confidence interval; PCI: percutaneous coronary intervention; STEMI: ST-segment elevation myocardial infarction.

*Creatinine clearance ≤ 40 mL/min.
†Other: stable angina or silent ischemia.

pointed in several series as a predictive factor for in-hospital mortality in patients undergoing surgical revascularization [13]. However, few studies have looked into its relationship with PCI. Selvaraj et al. [14] reported an in-hospital mortality rate of 2.9% in chronic bronchopathic patients versus only 1.2% in those without COPD (p < 0.0001). Patients with COPD are at high-risk because of more frequent comorbidities, generally low left ventricular ejection fraction and contraindications for beta-blockers. In our study, the number of patients with COPD was unfortunately too small to provide sufficient power to conveniently study this parameter.

Patients suffering from a myocardial infarction and presenting with a history of cardiac failure are at very high risk of a poor outcome after PCI, with a fourfold increased risk of mortality [15]. The risk is even higher when cardiac failure develops during the in-hospital phase and is associated with cardiogenic shock. In our study, preprocedural cardiac failure was noted in 26.1% of the deceased patients and in 10.1% of the controls (p = 0.01). However, this significant association disappeared after adjustment for PCI indication (STEMI, NSTEMI, stable angina or silent ischemia). A larger cohort would have allowed a better investigation of the additional risk associated with acute cardiac failure.

Complex lesions are more frequently associated with major artery dissections, distal embolisms, occlusion of smaller vessels and microcirculation alterations (slow flow and no reflow). Wilensky et al. [16] showed that patients treated for complex coronary lesions have a higher mortality rate, tend to develop ventricular rhythm disturbances, and more frequently need surgery despite stent implantation and powerful antplatelet therapy based on glycoprotein IIb/IIIa inhibitors. On the one hand, type C complex lesions, thrombus, calcifications, and bifurcation lesions have been independently associated with an increased risk of myocardial infarction and in-hospital death [17]. On the other hand, the presence of a collateral circulation developed in the left anterior descending artery territory has been shown to reduce infarct areas and consequently to protect against cardiogenic shock and in-hospital mortality [18].

In our study, PCI indication was one of strongest determinant of in-hospital mortality. We found a significantly worse prognosis in patients admitted for STEMI, whereas no significant difference was observed between patients with NSTEMI and those who received elective PCI in a non-emergency context. In the literature, patients with STEMI are consistently at a significantly higher risk of in-hospital mortality, even after extensive adjustment for confounders. This has actually been attributed to infarct size and location rather than type of myocardial infarction [19]. Indeed, stenoses of the proximal segment of the left anterior descending artery are known to be situations at particularly high risk, given that restenosis is more common with these lesions. However, in the current era of drug-eluting stents, the location of the lesion seems to have a smaller impact on prognosis [20].

Surprisingly, in our multivariable analysis, smoking was significantly associated with a lower risk of in-hospital mortality; history of dyslipidemia also tended to be also associated with a lower risk (p = 0.06) (data not shown). This is likely to reflect the fact that patients with cardiovascular risk factors tended to be more numerous among those who underwent PCI elective. Besides, we cannot exclude that patients with cardiovascular risk factors may contact emergency facilities more quickly and thus have access to treatment and PCI more promptly than patients who are not aware of the risk of cardiovascular disease. Our analysis was unable to fully explore this issue as samples were too small to perform stratified analyses, in particular stratifications according to the indication of the procedure (acute or nonacute coronary syndrome). The negative link between smoking and mortality may also be related to the fact...
that active smokers tended to be younger in the group of cases than in controls (mean 65.3 years versus 71.4 years, \( p = 0.05 \)). Since age is a major determinant of mortality, this may have biased the relationship between smoking and mortality, and could be responsible, at least in part, for the observed negative association between smoking and mortality.

**Study limitations**

Because of a retrospective data collection based on patients' medical files, our results are limited by the fact that several potential predictors of mortality could not be taken into account. For instance, left ventricular ejection fraction was lacking in a significant number of the files available and therefore could not be analyzed. Similarly, it would have been interesting to study an indicator of operators’ experience since it has been shown that mortality rate following PCI is inversely proportional to the volume of procedures in the centre and the experience of the practitioners [21].

Another limitation of our study lies in its case-control design, which does not allow us to draw firm conclusions on the causal link between predictors and mortality. Indeed, even after careful multivariable adjustment, certain conditions may have been brought out without any causal impact on mortality.

**Conclusions**

In the era of interventional cardiology, understanding the situations and mechanisms that lead to adverse outcomes after PCI are of major interest. STEMI, proximal lesions and preprocedural renal failure were the main predictors of inhospital mortality in this sample of French patients referred for PCI. Prospective data are still needed to better estimate the risk of adverse outcomes after PCI for a given individual, in the context of the French healthcare system.

**References**


