International Journal of Cardiology 292 (2019) 43–49

Contents lists available at ScienceDirect

International Journal of Cardiology

journal homepage: www.elsevier.com/locate/ijcard

Effect of renal insufficiency and diabetes mellitus on in-hospital mortality after acute coronary syndromes treated with primary PCI. Results from the ALKK PCI Registry

Spyridon Liosis [a,*], Matthias Hochadel [b], Harald Darius [c], Steffen Behrens [d], Harald Mudra [e], Bernward Lauer [f,h], Albrecht Elsässer [g], Anselm K. Gitt [a], Ralf Zahn [a], Uwe Zeymer [a], for the ALKK study group

[a] Herzzentrum Ludwigshafen, Department of Cardiology, Ludwigshafen am Rhein, Germany
[b] Institut für Herzinfarktforschung, Ludwigshafen am Rhein, Germany
[c] Vivantes Hospital Neukölln, Department of Internal Medicine-Cardiology, Berlin, Germany
[d] Vivantes Humboldt Hospital, Department of Cardiology, Berlin, Germany
[e] Neuperlach Hospital, Department of Cardiology, Pulmonology & Internal Intensive Care, Munich, Germany
[f] University Hospital Jena, Department of Cardiology, Jena, Germany
[g] Klinikum Oldenburg, Department of Cardiology, Oldenburg, Germany
[h] Central Hospital Bad Berka, Department of Cardiology, Bad Berka, Germany

ARTICLE INFO

Article history:
Received 5 July 2018
Received in revised form 9 April 2019
Accepted 23 April 2019
Available online 25 April 2019

Keywords:
Percutaneous coronary intervention
Acute coronary syndromes
Diabetes mellitus
Renal insufficiency

ABSTRACT

Background: It is known that patients with acute coronary syndromes (ACS) and diabetes mellitus (DM) are at higher risk for in-hospital adverse events. However, we hypothesized that the higher event rate is due to the patients' subgroup with renal failure (RF), a common sequel of DM.

Methods and results: We used data of the prospective ALKK-PCI registry including all consecutive percutaneous coronary interventions (PCI) for ACS of 48 hospitals between 2008 and 2013. We divided 69,651 patients in four groups according to their history of DM and RF (GFR < 60 ml/min). All-cause, in-hospital mortality of the following four groups: noDM/noRF, DM/noRF, DM/RF, RF/noDM, was: 3.5%, 6.6%, 21.9%, and 14.1% for STEMI and 1.5%, 2.1%, 7.2%, and 5.4% for NSTE-ACS. In a multivariate analysis we looked for independent mortality-predictors. Odds ratios with confidence intervals for the following variables: DM without RF, DM with RF, RF without DM were: 1.62 (1.37–1.90), 3.02 (2.43–3.76), and 2.13 (1.80–2.52) for STEMI and 1.20 (0.99–1.45), 2.72 (2.18–3.88), and 2.08 (1.69–2.56) for NSTE-ACS. We also calculated mortality in four groups (60–90, 45–60, 45–30, <30 ml/min) according to the estimated glomerular filtration rate (eGFR). Mortality rates were: 5.0%, 12.8%, 17.7%, and 31.5% for STEMI and 2.1%, 3.8%, 7.1%, and 12.0% for NSTE-ACS (p for trend <0.0001 for both).

Conclusions: In-hospital death after PCI in patients with ACS and DM is mainly observed in the subgroup with co-existing RF. In a multivariate analysis, DM without RF was a significant mortality-predictor in STEMI, but not in NSTE-ACS. RF, irrespective of co-existent DM, was a stronger predictor than DM alone for both ACS-types (OR > 3) and mortality increased with decreasing eGFR.

1. Introduction

Diabetes mellitus (DM) is associated with a high risk for mortality and major adverse cardiac and cerebrovascular events (MACCE) after acute coronary syndromes (ACS) and/or percutaneous coronary intervention (PCI), despite contemporary antithrombin and antiplatelet therapy and despite the wide use of drug eluting stents [1–6]. Potential reasons include higher platelet reactivity [7,8], lower responsiveness to antiplatelet therapy [9,10], elevated inflammatory parameters [6] and more diffuse coronary artery disease [1,11]. However, previous analyses reporting about increased mortality rates of diabetics were influenced by low rates of invasive strategies and revascularization procedures in diabetic patients [3,12,13]. Renal failure (RF), a common sequel of DM, affecting over 40% of diagnosed diabetics [14], is also independently associated with death and MACCE following PCI for ACS in numerous studies [15–20], some of them suggesting an even stronger correlation than DM per se. In our analysis we hypothesized that the higher in-hospital event rate among diabetics receiving PCI for ACS is mainly due to the patient subgroup with renal failure (RF). Therefore, we sought to investigate the impact of RF and DM on in-hospital outcome after PCI for ACS.

* Corresponding author at: Herzzentrum Ludwigshafen, Medizinische Klinik B, Bremserstrasse 79, D-67063 Ludwigshafen, Germany.
E-mail address: spymed86@yahoo.gr (S. Liosis).

https://doi.org/10.1016/j.ijcard.2019.04.071
0167-5273/

2. Methods

The ALKK PCI registry is a prospective German registry that was initiated in 1992 to monitor quality control and contains all consecutive procedures of the participating hospitals on an intention-to-treat basis [23]. Data acquisition is legally binding and patient consent is not a prerequisite. Data were obtained anonymously by standardized questionnaires in 48 participating hospitals, including information about medical history, coronary risk factors, hemodynamic status, procedure indication, antithrombotic therapy, procedural data and complications until hospital discharge. All data were analyzed centrally at the Karl Ludwig Neuhaus Datenzentrum, Ludwigshafen, Germany.

All patients receiving PCI for ACS with and without ST-segment elevation within the period 2008 to 2013 were included on an intention-to-treat basis. We separately analyzed data of consecutive patients with ST-elevation myocardial infarction (STEMI) and non-ST-elevation acute coronary syndrome (NSTE-ACS).

STEMI was diagnosed in the presence of the two following criteria: persistent unstable angina pectoris for ≥20 min and ST-segment elevation of ≥1 mm in ≥2 limb leads or ≥2 mm in ≥2 contiguous precordial leads, or the presence of presumed new left bundle branch block. It was later confirmed by the elevation of enzymes (creatinine kinase and its MB isoenzyme, aspartate aminotransferase, and lactic dehydrogenase) to at least twice the normal value. NSTE-ACS included NSTEMI and unstable angina pectoris. NSTEMI was defined by persistent angina pectoris for ≥20 min and elevation of Troponin T or I, without ST-segment elevation in ECG. Raised levels were considered those exceeding the upper normal level at the local laboratory at each participating site. Unstable angina pectoris was defined according to the following criteria: a. persistent angina pectoris for ≥20 min; or new onset (de novo) angina Class II or III of the Classification of the Canadian Cardiovascular Society (CCS); or recent destabilization of previously stable angina with at least CCS Class III angina characteristics (crescendo angina); or post-myocardial infarction angina and b. absence of Troponin elevation or ST-segment elevation in ECG. Stroke was defined as the occurrence of persistent specific neurological deficits. Renal failure was defined as baseline estimated glomerular filtration rate (eGFR) ≤ 60 ml/min or dialysis. In this analysis, eGFR was calculated from serum creatinine concentration according to the abbreviated MDRD-formula [20a], and cut-points of 90, 60, and 30 ml/min defined stages of renal function in line with current guidelines [20b]. Postprocedural reinfarction was diagnosed if patients had signs of recurrent ischemia and an additional relevant increase of cardiac biomarkers. The presence or absence of DM was a self-reported event, based on patients' history and medication.

All analyses were performed using the SAS© system release 9.1 on a personal computer (SAS Institute, Inc., Cary, NC, USA). Categorical data are presented as absolute numbers or percentages, metrical data as medians with first and third quartiles. Whenever possible, percentages were used to describe patient populations. The frequencies of categorical variables in four groups according to renal function and diabetic status were compared by Pearson χ^2 test and by calculating odds ratios (OR) and 95% confidence intervals (CI). Continuous variables were compared by Kruskal-Wallis test. These values were calculated from the available cases; the number of available cases is shown as denominator of proportions. p-Values < 0.05 were considered significant.

Unadjusted and adjusted effects of DM and RF were analyzed in logistic regression models, separately for patients with STEMI and NSTE-ACS. Realizing that diabetes and renal failure are often not independent diseases but that renal failure is frequently a sequel of diabetes, the possible combinations were evaluated as a factor with four categories. To avoid adjustment for other intermediate factors and poor interpretability of the resulting effect estimates, confounders were selected by clinical reasoning, that were judged not to be consequences of diabetes. The resulting regression models included in addition to the 4 group levels: age (linearly), sex, acute presentation with cardiogenic shock or congestive heart failure, arterial hypertension and hypercholesterolemia. Means were imputed for missing values of explanatory variables. In order to take clustering within the participating centers into account, marginal regression models were fitted using generalized estimating equations with a compound symmetry working correlation matrix. To assess the relative risk levels of these four categories, all pairwise comparisons were performed adjusting p-values for multiple testing by the Tukey-Kramer method.

3. Results

Between 2008 and 2013 a total of 69,651 patients with STEMI (n = 23,383) and NSTE-ACS (n = 46,268) undergoing PCI were subdivided into 4 groups according to their history of diabetes and impaired renal function (GFR < 60 ml/min): patients without DM or RF, patients with DM but without RF, patients with co-existing DM and RF, and patients with RF but no DM. From overall 51,529 patients without DM, 45,260 patients (87.8%) had normal and 6269 (12.2%) impaired renal function. Among 18,122 patients with DM, 12,247 patients (67.6%) had normal and 5875 (32.4%) impaired renal function.

We separately analyzed patients with NSTE-ACS and STEMI. The baseline characteristics are demonstrated in Table 1. Patients with the combination of DM and RF were more likely to be older, to have history of arterial hypertension and hypercholesterolemia, to have had a

Table 1
Baseline characteristics.

	STEMI (n = 23,383)					NSTE-ACS (n = 46,268)				
	No DM or RF 71.3% (n = 16,675)	DM without RF 15.4% (n = 3605)	RF without DM 7.5% (n = 1762)	DM with RF 5.7% (n = 1341)	p-Value	No DM or RF 61.8% (n = 28,585)	DM without RF 18.7% (n = 8642)	RF without DM 9.7% (n = 4507)	DM with RF 9.8% (n = 4534)	p-Value
Demographics										
Age (years)	60.9 (51.8; 71.6)	66.7 (57.3; 75.1)	73.7 (64.6; 81.4)	74.2 (67.7; 80.8)	<0.001	68.0 (56.8; 75.9)	71.0 (62.3; 77.1)	76.6 (69.6; 82.3)	75.3 (69.7; 80.6)	<0.001
Male gender	74.9% (12,494/16675)	67.5% (2432/3605)	72.5% (1278/1762)	62.4% (837/1341)	<0.001	72.0% (20,584/28585)	65.3% (5640/8642)	73.6% (3319/4507)	65.4% (2963/4534)	<0.001
Cardiac history										
Prior MI*	20.4% (2886/14164)	22.7% (689/3032)	27.4% (390/1425)	33.0% (335/1015)	<0.001	25.8% (6527/25272)	29.4% (2236/7599)	35.0% (1328/3798)	41.6% (1603/3858)	<0.001
Prior stroke/TIA*	2.4% (298/12243)	5.2% (136/2628)	8.8% (108/1232)	14.5% (127/877)	<0.001	3.7% (819/22349)	6.6% (444/6759)	9.6% (318/3299)	14.9% (503/3371)	<0.001
History of PCI	13.1% (2141/16324)	19.7% (688/3490)	22.6% (386/1711)	27.1% (348/1286)	<0.001	27.8% (7755/27940)	35.6% (3003/8447)	40.6% (1798/4434)	47.4% (2105/4445)	<0.001
History of CABG	2.4% (396/16585)	4.2% (150/3575)	7.9% (138/1741)	9.7% (129/1326)	<0.001	9.3% (2638/28518)	13.8% (1187/8609)	19.2% (861/4490)	23.3% (1052/4519)	<0.001
Risk factors										
Arterial hypertension*	67.1% (9172/13663)	86.2% (2608/3027)	83.2% (1162/1396)	94.1% (991/1053)	<0.001	76.0% (19,410/25533)	89.7% (7014/7819)	91.1% (3504/3848)	95.1% (3745/3937)	<0.001
Hypercholesterinemia*	54.8% (6595/12039)	68.6% (1863/2714)	62.6% (790/1262)	76.9% (737/959)	<0.001	57.4% (12,978/22604)	71.1% (5025/7063)	68.2% (2416/3544)	77.2% (2865/3709)	<0.001
Clinical and angiographic findings										
3-Vessel CAD*	26.4% (3518/13332)	37.0% (1068/2887)	41.3% (570/1381)	53.1% (544/1024)	<0.001	36.0% (8375/23249)	46.0% (8375/23249)	52.4% (1916/3654)	59.7% (2226/3730)	<0.001
Congestive heart failure	9.5% (1586/16675)	13.1% (472/3603)	26.3% (463/1762)	36.0% (483/1341)	<0.001	4.6% (1322/28585)	8.1% (699/8642)	15.2% (686/4507)	20.5% (931/4534)	<0.001
Cardiogenic shock	4.5% (745/16675)	5.3% (191/3603)	13.9% (245/1762)	20.7% (277/1341)	<0.001	1.2% (357/28585)	1.5% (132/8642)	3.5% (159/4507)	4.4% (199/4534)	<0.001

* Information was not documented by all centers in every year.

Table 2
Periprocedural antithrombotic therapy.

	STEMI (n = 23383)					NSTE-ACS (n = 46268)				
	No DM or RF 71.3% (n = 16675)	DM without RF 15.4% (n = 3605)	RF without DM 7.5% (n = 1762)	DM with RF 5.7% (n = 1341)	*p*-Value	No DM or RF 61.8% (n = 28585)	DM without RF 18.7% (n = 8642)	RF without DM 9.7% (n = 4507)	DM with RF 9.8% (n = 4534)	*p*-Value
Unfraction. heparin	93.2% (13077/14028)	94.3% (2958/3138)	95.6% (1412/1477)	95.3% (1064/1116)	<0.001	91.5% (21038/22987)	93.3% (6752/7237)	95.1% (3545/3729)	95.4% (3702/3882)	<0.001
LMW heparin	1.9% (255/13721)	2.5% (77/3085)	2.2% (32/1466)	2.5% (28/1111)	0.074	3.1% (675/21585)	3.6% (247/6900)	3.3% (120/3601)	4.1% (154/3782)	0.014
Bivalirudin	7.5% (940/12524)	7.2% (199/2760)	5.1% (69/1352)	5.8% (59/1012)	0.004	3.0% (609/20082)	2.7% (171/6340)	1.5% (51/3391)	1.3% (45/3491)	<0.001
Fondaparinux	0.5% (73/13677)	0.5% (14/3082)	0.7% (10/1443)	0.7% (8/1109)	0.632	2.6% (552/21565)	3.2% (218/6898)	3.1% (111/3589)	2.7% (103/3778)	0.031
GP IIb/IIIa antagonists	50.3% (7487/14887)	48.6% (1594/3281)	45.5% (694/1524)	46.7% (534/1144)	<0.001	20.0% (5313/26556)	16.6% (1334/8042)	14.3% (577/4037)	14.8% (607/4111)	<0.001
ASS	93.8% (12290/13104)	94.8% (2777/2929)	95.8% (1362/1421)	94.9% (1031/1086)	0.003	93.0% (18876/20289)	94.9% (6229/6562)	95.0% (3314/3490)	95.7% (3508/3665)	<0.001
Clopidogrel	66.8% (8913/13334)	69.2% (2094/3026)	73.7% (1071/1454)	73.6% (818/1112)	<0.001	76.0% (15157/19951)	77.5% (5046/6507)	81.5% (2888/3544)	80.6% (3011/3735)	<0.001
Prasugrel	23.0% (3164/13759)	20.9% (649/3102)	13.9% (206/1482)	9.5% (110/1160)	<0.001	8.9% (1874/21022)	9.1% (615/6735)	4.9% (178/3663)	5.1% (196/3850)	<0.001
Ticagrelor	9.6% (1382/14459)	9.5% (306/3218)	10.6% (166/1563)	12.0% (145/1213)	0.032	11.5% (2613/22683)	11.7% (836/7120)	10.4% (405/3892)	11.0% (440/4013)	0.127

previous stroke or AMI, to have received prior PCI or CABG and to present more often with symptoms of congestive heart failure and cardiogenic shock.

The antithrombotic therapy used during and after PCI for STEMI and NSTE-ACS is given in Table 2. Patients with DM and/or RF were treated more often with heparin and clopidogrel, but received less frequently bivalirudin, prasugrel and GP IIb/IIIa inhibitors. There was no difference in the rate of use of ticagrelor in the group of STEMI, although there was a higher rate for patients with DM and RF in the group of NSTEMI.

TIMI-3 flow for all vessels after PCI for all four patient groups is shown in Fig. 1, which reveals a lower rate of TIMI 3 flow for patients with renal failure.

A comparison of the univariate all-cause in-hospital mortality between diabetics and non-diabetics, as well as between patients with and without renal failure is given in Fig. 2, whereas a comparison of all 4 groups is shown separately for STEMI and NSTE-ACS in Fig. 3. The highest event rates were observed in patients with impaired renal function regardless of their diabetic state.

In addition, patients were divided into four groups (separately for STEMI and NSTE-ACS), according to their eGFR. All-cause death rates for each group were calculated. The results are presented in Fig. 4. We observed a significant increase in mortality along with the decrease of eGFR in both STEMI and NSTE-ACS.

Finally, unadjusted and adjusted effects of the 4 group levels on in-hospital all-cause mortality after PCI separately for STEMI and NSTE-ACS are shown in Figs. 5 and 6. Adjustment was done for age (linear increase), sex, cardiogenic shock, congestive heart failure, arterial hypertension and hypercholesterolemia. RF with or without co-existing DM was associated with an increased mortality in both categories of ACS (OR 2.13, 95%-CI 1.80–2.52 without co-existing DM, OR 3.02, 95%-CI 2.43–3.76 with co-existing DM for STEMI, OR 2.08, 95%-CI 1.69–2.56 without co-existing DM, OR 2.72, 95%-CI 2.18–3.88 with co-existing DM for NSTE-ACS). In the pairwise comparisons, no significant difference in mortality risk could be detected in the comparisons of DM with no RF vs. reference (no DM, no RF) ($p = 0.22$) in NSTE-ACS patients. Diabetes alone did not significantly increase mortality risk in the group of NSTE-ACS after adjustment. All other comparisons between the levels of DM and RF exhibited significant differences ($p < 0.05$).

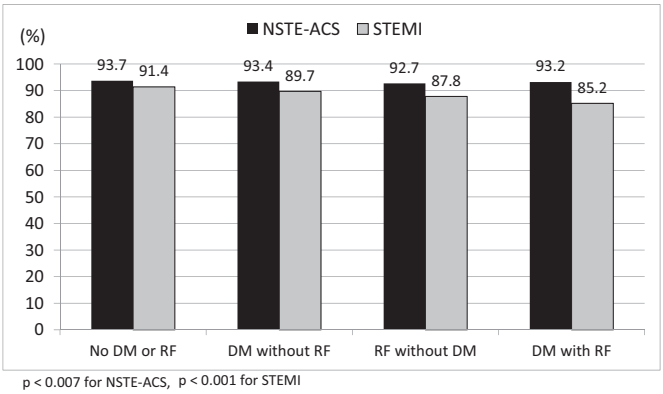

Fig. 1. TIMI-3 flow (all vessels) after PCI. $p < 0.007$ for NSTE-ACS, $p < 0.001$ for STEMI.

4. Discussion

The main finding of our analysis is that the majority of in-hospital deaths in diabetics after PCI for ACS are observed in diabetics with RF (GFR < 60 ml/min) and that DM without RF failed to be a significant mortality predictor in NSTE-ACS. On the other hand, RF, even in the absence of DM, was a stronger predictor of death than DM alone, for both STEMI and NSTE-ACS, while crude mortality significantly increased with decreasing eGFR.

DM has been characterized as an independent predictor of mortality and adverse events after ACS [1,3–6,24,25]. Studies from Norhammar et al. [5] and Antoniucci et al. [24] showed worse outcomes among diabetics after ACS compared with non-diabetics. Similar results were presented in a substudy of the PLATelet inhibition and patient Outcomes (PLATO) trial comparing ticagrelor and clopidogrel in the setting of AMI [3]. It showed an 80% higher mortality in patients with DM, regardless of the antiplatelet therapy administered. A substudy of the Acute Catheterization and Urgent Intervention Triage Strategy (ACUITY) trial [4] reported that diabetics have an increased rate of 30-day mortality and ischemic complications after PCI for ACS, despite guideline adherent therapy and extended use of bivalirudin and glycoprotein IIb/IIIa inhibitors (GPI). Studies investigating the macroscopic characteristics of CAD in DM have demonstrated a more severe and diffuse disease [1,11] with more frequent plaque ulceration and intracoronary thrombus [26]. Moreover, high platelet reactivity, low responsiveness to antiplatelet therapy, as well as elevated inflammatory agents are involved in the pathophysiology of DM [6–10,27]. These characteristics are probably the underlying cause of worse outcomes and increased mortality of diabetics in the setting of ACS.

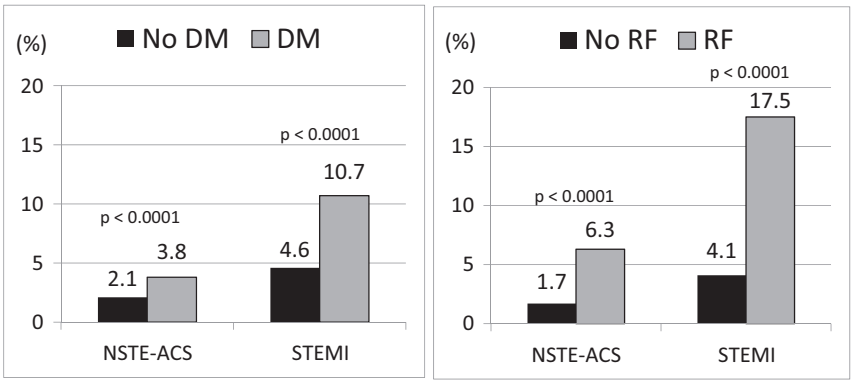

Fig. 2. In-hospital unadjusted mortality in diabetics (DM) vs. non-diabetics and in renal failure (RF) vs. no renal failure.

Another factor that could possibly influence outcomes after ACS among diabetics is the lower rate of revascularization procedures in this group of patients [3,12,13]. In the previously cited PLATO substudy, patients with DM were intended for coronary angiography and PCI less often. Diabetic patients with NSTE-ACS also received less in-hospital revascularization according to the data presented by Hasin et al. [13]. To exclude this selection bias we included only patients treated with PCI in our analysis.

Whereas studies predicting long-term outcomes after PCI for ACS indicate DM consistently as an independent predictor of mortality, trials

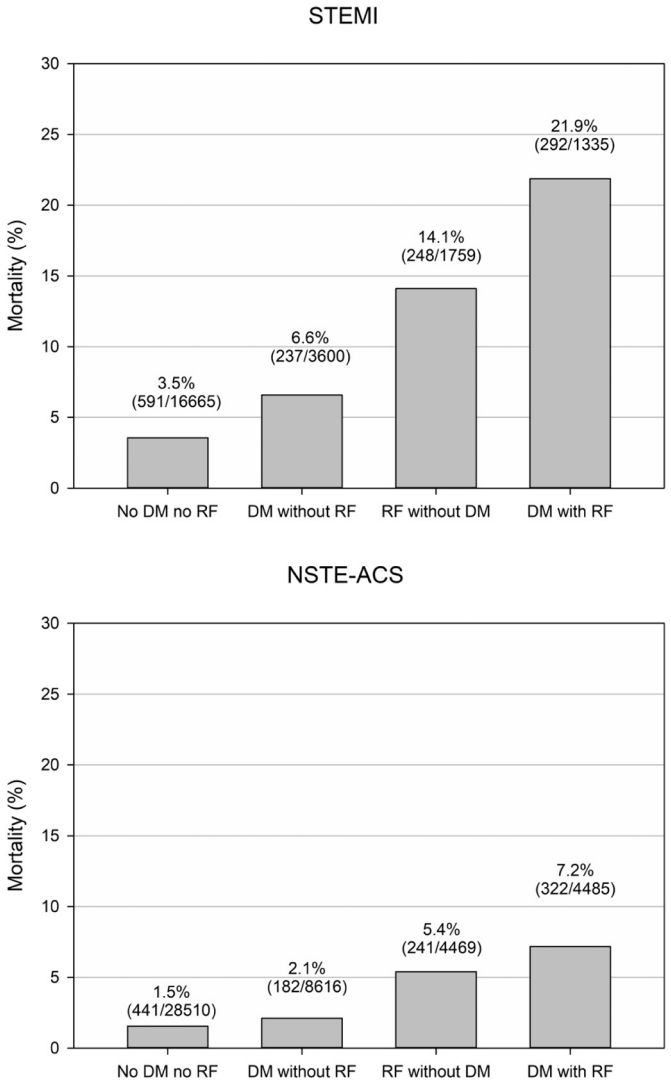

Fig. 3. In-hospital mortality in the 4 groups according to diabetic state (DM) and renal failure (RF).

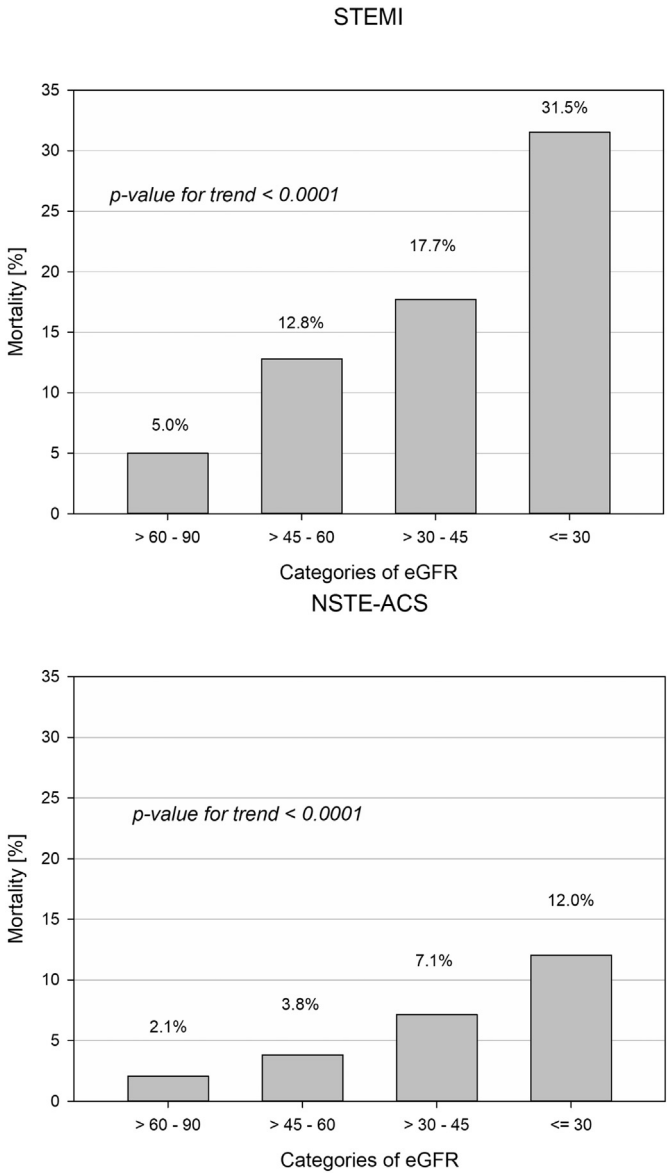

Fig. 4. In-hospital mortality according to current eGFR.

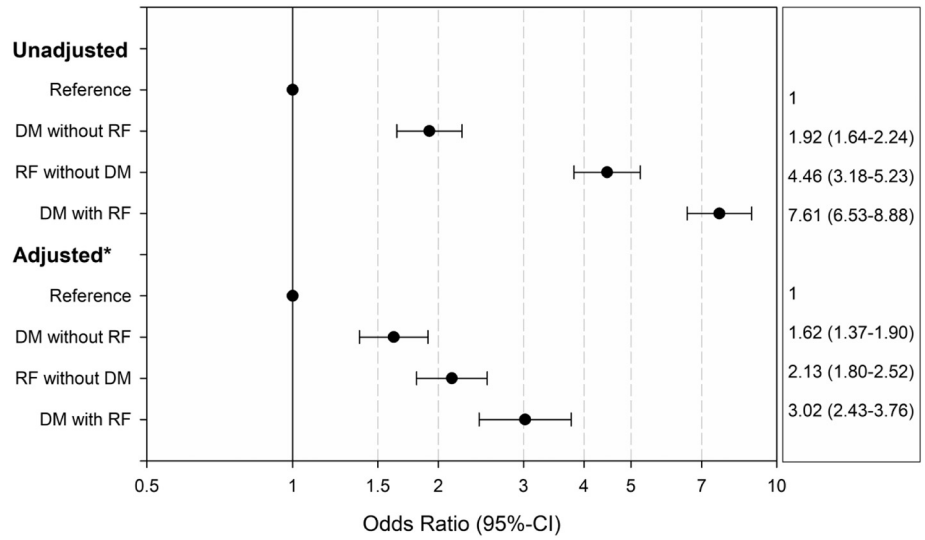

Fig. 5. Unadjusted and adjusted effects on in-hospital mortality in patients with STEMI. *Adjusted for age (linear), sex, acute presentation with congestive heart failure, or cardiogenic shock, arterial hypertension, hypercholesterolemia, and within-center correlation. All pairwise comparisons between the levels were significant ($p \leq 0.02$).

investigating periprocedural and short-term mortality are controversial, with some of them showing no difference between outcomes in diabetics and non-diabetics in the early phase. Hasin et al. could find a higher 1-year but similar in-hospital mortality after ACS in the diabetic population after multivariate analysis. In the model of Sadeghi et al. [19] predicting outcomes after PCI for AMI, DM was not independently associated with reduced survival at 30 days. Mathew et al. [28] and Laskey et al. [29] presented similar findings with increased long-term but not short-term mortality in DM after PCI for ACS and stable CAD. On the contrary other studies support that DM is an independent predictor of mortality in the early phase as well [1,3,4].

The importance of chronic RF, a common sequel of DM, in predicting MACCE and mortality after ACS and/or PCI has been well characterized [15–19,30]. Best et al. [15] concluded that impaired renal function and especially a GFR < 50 ml/min is a strong predictor of short- and long-term death and cardiovascular events after PCI for AMI in a dose dependent fashion, even after multivariate analysis is performed. Our analysis supports these findings, showing an increasing mortality in patients with lower eGFR values. In the same study DM was a less powerful predictor than chronic RF (OR 2.25–8.91 for RF depending on severity vs. 1.66 for DM). Other studies conducted by Sadeghi et al. [19] including patients receiving PCI for AMI and later by Blackmann et al. [18] and Osten et al. [16] for PCI after ACS or stable CAD, presented similar results, pointing out that moderate to severe RF (GFR < 60 ml/min) is a strong independent predictor of mortality (4- to 13-fold increase) and MACCE especially in the early phase regardless of the patient's diabetic status. In both analyses DM failed to reach statistical significance for in-hospital mortality after multivariate adjustment. In addition Singh et al. [20] created in 2002 a simple risk score for predicting procedural complications after PCI for AMI or stable CAD, in which RF but not DM could be associated with worse outcomes. These results encourage the hypothesis that renal insufficiency, which in many cases co-exists with DM can play a more important role in predicting the adverse events after ACS than DM per se. Possible mechanisms that could

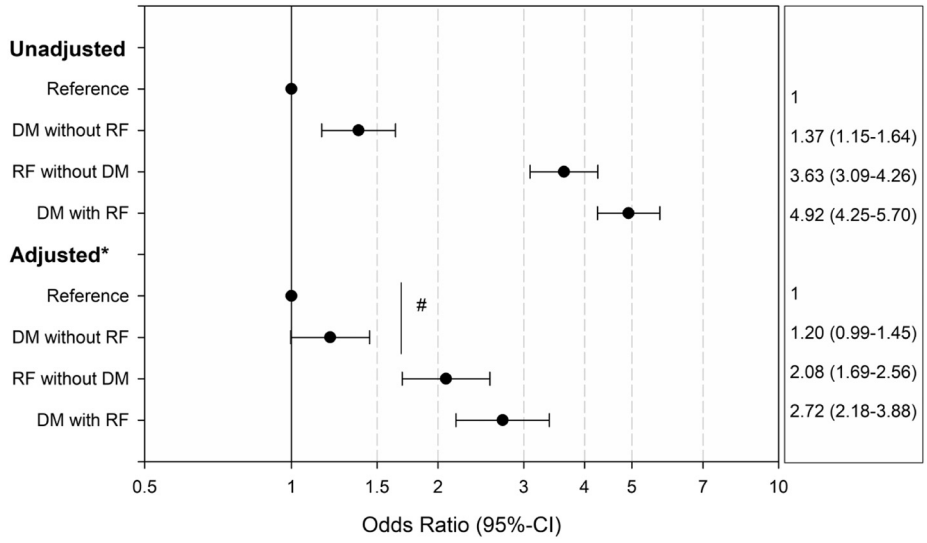

Fig. 6. Unadjusted and adjusted effects on in-hospital mortality in patients with NSTE-ACS. *Adjusted for age (linear), sex, acute presentation with congestive heart failure, or cardiogenic shock, arterial hypertension, hypercholesterolemia, and within-center correlation. #In the pairwise comparisons of DM without RF vs. reference (no DM, no RF) no significant difference was detected; all other comparisons between the levels were significant ($p < 0.01$).

explain the impact of RF have been already described in previous studies. Data from Russo et al. [31] and Goodman et al. [32] demonstrated more complex and heavily calcified coronary anatomy in patients with CRF, while other studies could detect metabolic abnormalities in advanced renal disease such as dyslipidemia, homocystinemia and increased atherosclerotic, thrombotic and oxidative stress [33–36]. An increased platelet activation and suboptimal response to antiplatelet therapy have also been described for these patients [37].

In our initial univariate analysis diabetics were characterized by increased in-hospital mortality. After dividing diabetic patients according to the presence or absence of RF though, the influence of DM on mortality declines, whereas the impact of RF becomes more apparent. The majority of in-hospital deaths among diabetics occurred in the subgroup of coexisting RF. These diabetic patients may have a more advanced microvascular disease with renal and probably multi-organ involvement, which might lead to higher postprocedural mortality. In the multivariate analysis DM without co-existing RF remained a weak, but significant predictor of mortality in STEMI, but failed to predict death in NSTE-ACS. On the other hand, renal insufficiency (GFR < 60 ml/min) even without the presence of DM was both for STEMI and NSTE-ACS independently related with an approximately 2-fold increase in hospital mortality. Death rates increased along with decreasing eGFR, suggesting a dose-dependent relation. These findings support the results of previous studies presented above [13,15–19,28,30]. Patients with non-diabetic RF appeared to be at high risk for in-hospital death. A further analysis and comparison with diabetic RF patients may be difficult, regarding the fact that in our registry the cause of renal failure is not reported. It may be a heterogeneous group of patients including hypertensive nephropathy, rheumatic disease, drug associated nephrotoxicity, cardiorenal syndrome etc. In the same way we cannot be absolutely sure about the presence of diabetic nephropathy in all our diabetic patients with RF.

Some previous analyses suggest a stronger influence of DM on mortality and MACCE compared to our study. These discrepancies may be due to a low rate of revascularization procedures especially in the group of diabetic patients in these trials [3,13], as it has been already cited above. Additionally, some studies did not include RF in the multivariate regression analysis [1,24], probably overestimating in this way the impact of DM.

The fact that RF (especially in combination with DM, but also in its absence) is strongly associated with worse in-hospital outcomes after PCI for ACS is of great importance for the postprocedural patient management and risk stratification. The high-risk nature of those patients must be appreciated and a close surveillance after PCI is needed. A guideline-adherent medication with statins, beta-blockers and angiotensin converting enzyme (ACE) inhibitors should not be underused in renal insufficiency patients [38,39]. The use of stents should be routine and additional antiplatelet or antithrombin therapy such as GPI and bivalirudin may be considered, taking into account possible bleeding complications as well. Prehydration, minimization of contrast dose and consideration of *N*-acetylcysteine is important in order to reduce the risk of contrast nephropathy [40–42]. In addition aggressive management of hyperlipidemia, diabetes and other risk factors must be early initiated.

4.1. Limitations

As always in registries a selection bias cannot be fully ruled out. Therefore, even after the adjustment for confounding for baseline variables, we cannot be sure that we were able to adjust for every factor, which might have influenced the results. Moreover, data about left ventricular function, an important predictor of outcome after AMI [43,44], were partly missing and these factors could not be included in the multivariate analysis. The use of bivalirudin and GPIs especially in the group of NSTE-ACS was in our study population low. Those agents could potentially lead to improved outcomes after PCI for patients with high-risk characteristics such as DM and RF. Finally, data about the mode of death (e.g. cardiac and non-cardiac mortality), as well as data about the cause of RF, as already mentioned in the discussion section, were not available.

5. Conclusions

In-hospital death after PCI in patients with ACS and DM is mainly observed in the subgroup with co-existing RF. In a multivariate analysis, DM without RF remained a weak, but significant predictor of all-cause mortality in STEMI, but failed to predict death in NSTE-ACS. On the other hand, RF, irrespective of the co-existence of DM, was a stronger predictor than DM alone, for both ACS groups. The mortality of patients with RF increased with decreasing eGFR. Consequently, the high-risk nature of patients with RF must be early recognized and a close surveillance after PCI with optimal use of guideline adherent therapy should be initiated.

Conflict of interest

The authors report no relationships that could be construed as a conflict of interest.

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