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Effects of Angiotensin-Converting Enzyme Inhibitor Therapy on Clinical Outcome in Patients Undergoing Coronary Artery Bypass Grafting

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Objectives This study evaluates the effect of pre-operative angiotensin-converting enzyme inhibitor (ACEI) therapy on early clinical outcomes after coronary artery bypass grafting (CABG).

Background Therapy with ACEIs has been shown to reduce the rate of mortality and prevent cardiovascular events in patients with coronary artery disease. However, their pre-operative use in patients undergoing CABG is still controversial.

Methods A retrospective, observational, cohort study was undertaken of prospectively collected data on 10,023 consecutive patients undergoing isolated CABG between April 1996 and May 2008. Of these, 3,052 patients receiving pre-operative ACEI were matched to a control group by propensity score analysis.

Results Overall rate of mortality was 1%. Pre-operative ACEI therapy was associated with a doubling in the risk of death (1.3% vs. 0.7%; odds ratio [OR]: 2.00, 95% confidence interval [CI]: 1.17 to 3.42; $p = 0.013$). There was also a significant difference between the ACEI and control group in the risk of post-operative renal dysfunction (PRD) (7.1% vs. 5.4%; OR: 1.36, 95% CI: 1.1 to 1.67; $p = 0.006$), atrial fibrillation (AF) (25% vs. 20%; OR: 1.34, 95% CI: 1.18 to 1.51; $p < 0.0001$), and increased use of inotropic support (45.9% vs. 41.1%; OR: 1.22, 95% CI: 1.1 to 1.36; $p < 0.0001$). In a multivariate analysis, pre-operative ACEI treatment was an independent predictor of mortality ($p = 0.04$), PRD ($p = 0.0002$), use of inotropic drugs ($p < 0.0001$), and AF ($p < 0.0001$).

Conclusions Pre-operative therapy with ACEI is associated with an increased risk of mortality, use of inotropic support, PRD, and new onset of post-operative AF. (J Am Coll Cardiol 2009;54:1778–84) © 2009 by the American College of Cardiology Foundation

Angiotensin-converting enzyme inhibitors (ACEIs) have been shown to reduce the rate of mortality and to prevent cardiovascular events in patients with coronary artery disease (1–4), especially after acute myocardial infarction (MI) (5–7). The authors of the EUROPA (European Trial on Reduction of Cardiac Events With Perindopril in Stable Coronary Artery Disease) study (4) showed a 14% reduction in total rate of mortality, nonfatal MI, unstable angina, and cardiac arrest. Moreover, in a meta-analysis of 4 trials that included 98,496 patients with early MI, treatment with ACEI was associated with an average 7% proportional reduction in mortality within 30 days (5). ACEIs, through the reduction of angiotensin II and increased bradykinin availability, explicate their cardioprotective proprieties on left ventricular afterload and remodeling, improving cardiac hemodynamics, and reducing ventricular mass (3,8,9).

In addition to lowering blood pressure, ACEIs possess a vasculoprotective and anti-ischemic action through their antiatherosclerotic, antithrombotic, anti-inflammatory effects (10–12). Consequently, most patients with coronary artery disease receive these drugs. Nevertheless, there are still significant controversies regarding the pre-operative use of ACEIs in patients undergoing coronary artery bypass grafting (CABG). It has been hypothesized by several authors (13–16) that the pre-operative administration of ACEI in these patients contributes to lowering of systemic vascular resistance and vasoplegia in the early post-operative phase, resulting in hypotension and renal dysfunction.

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Authors of the IMAGINE (Ischemia Management With Accupril Post Bypass Graft via Inhibition of Angiotensin Converting Enzyme) study (17) reported that, in CABG patients at low risk of cardiovascular events, routine early

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initiation of ACEI therapy does not improve clinical outcome up to 3 years after surgery and may increase adverse events during the first 3 months. Others authors (18–20) concluded that pre-operative treatment with ACEIs does not cause hypotension and can safely be used in patients undergoing cardiac surgery. A national survey in the United Kingdom revealed that the majority of cardiac surgeons believe that the use of pre-operative ACEIs increases use of fluids, inotropes, and vasoconstrictors. However, only 39% of respondents practiced discontinuing the drug before operation (21). The aim of the present study was, therefore to review our institutional database to evaluate the effects of pre-operative ACEI treatment on early clinical outcomes after CABG.

Abbreviations and Acronyms

ACEI = angiotensin-converting enzyme inhibitor
AF = atrial fibrillation
CABG = coronary artery bypass grafting
CI = confidence interval
MI = myocardial infarction
NYHA = New York Heart Association
OR = odds ratio
PRD = post-operative renal dysfunction

Methods

Patient selection. This was a retrospective, observational, cohort study of prospectively collected data from consecutive patients who underwent isolated CABG at the Bristol Heart Institute between April 1996 and May 2008. The study was approved by the clinical audit committee of the University Hospital Bristol NHS Foundation Trust, and individual consent was waived. The data collection form is entered in a database (Patient Analysis & Tracking System, Dendrite Clinical Systems, London, United Kingdom) and includes 5 sections that are filled in consecutively by anesthetists, surgeons, the intensive care unit, the high-dependency unit, and ward nurses. The base sample contained detailed clinical information on approximately 10,023 patients. Exclusion criteria were patients who had unknown ACEI treatment before surgery and those with pre-operative cardiogenic shock. The final sample size was 9,274 patients, of which 4,730 (51%) received pre-operative ACEI. To reduce the effect of treatment selection bias and potential confounding in this observational study, we used a propensity score-matching analysis to evaluate the effect of pre-operative treatment of ACEI on our end points (22). Finally, 3,052 patients on ACEI treatment were matched to a control group (Fig. 1).

End points and definitions. The primary end point was in-hospital mortality, defined as any death occurring within

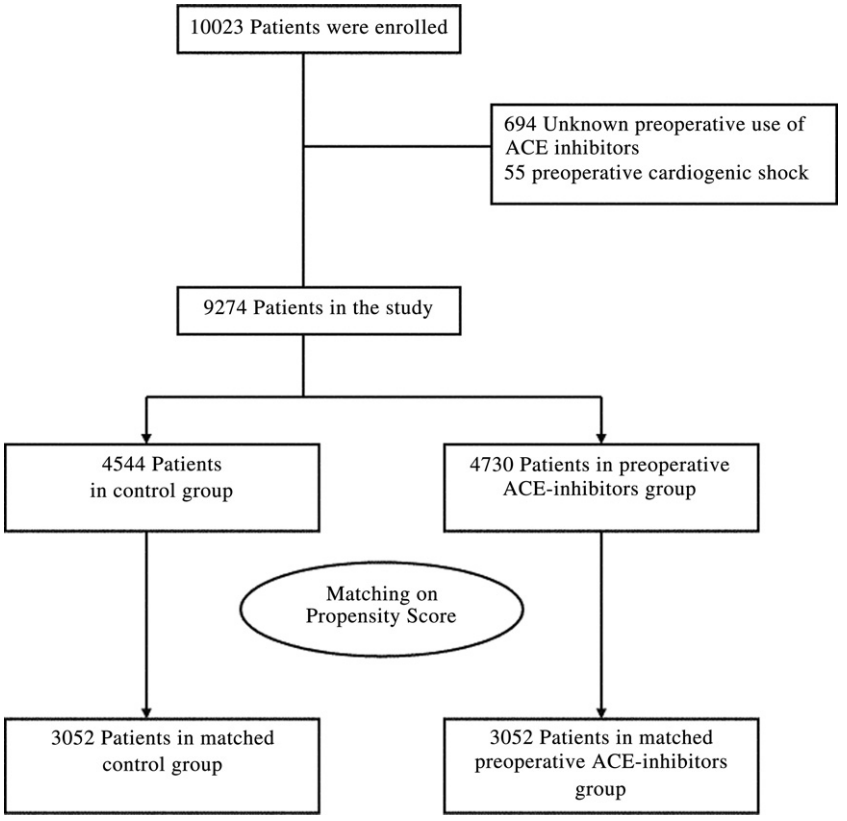

Figure 1 Study Profile

ACE = angiotensin-converting enzyme.

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30 days of operation. Secondary end points were as follows: post-operative renal dysfunction (PRD), atrial fibrillation (AF), MI, stroke, and post-operative inotropic drug use. Pre-operative use of an ACEI, including angiotensin receptor blockers, was defined as administration within 24 h before surgery. Priority of surgery was defined as follows: emergency (the surgery should be performed within hours to prevent morbidity or death), urgent (medical factors requiring the patient to stay in hospital waiting for an operation), or elective (the clinical status of the patient allows discharge from hospital with readmission for surgery at a later date). The decision to perform an off-pump or on-pump CABG technique was based on individual surgeon preference.

A diagnosis of post-operative MI was based on the presence of Q waves >0.04 ms and/or a reduction in R waves >25% in at least 2 contiguous leads on electrocardiogram (ECG). The PRD was defined as a serum creatinine level >200 μmol/l plus an increase of at least 1.5 times pre-operative baseline concentrations. New onset of post-operative AF was defined as any duration at any time in the post-operative period on the basis of a rhythm strip or 12-lead ECG. A diagnosis of stroke was made if there was evidence of new neurological deficit with morphological substrate confirmed by computed tomography or nuclear magnetic resonance imaging.

Anesthetic, surgical technique, and post-operative management. Anesthetic and surgical techniques were standardized for all patients and have been reported previously (23,24). In brief, for patients undergoing on-pump CABG, cardiopulmonary bypass was instituted with the use of ascending aortic cannulation and 2-stage venous cannulation of the right atrium. The membrane oxygenator was primed with 1,000 ml of Hartman's crystalloid, 500 ml of Gelofusine (B. Braun, Melsungin, Germany), 0.5 g/kg mannitol, 7 ml of 10% calcium gluconate, and 6,000 IU heparin. Alpha-stat pH management was used, and the systemic temperature was kept between 34°C and 36°C. Myocardial protection was achieved with intermittent hyperkalaemic warm blood cardioplegia. For off-pump CABG surgery, the Bristol technique was used to expose the coronaries and provide stabilization to undertake the anastomosis (24). At the end of surgery, patients were transferred to the intensive care unit and managed according to the unit protocol (23,24).

Statistical analysis. Continuous data were expressed as mean ± SD, and categorical data as percentages. The Kolmogorov-Smirnov test was used to check for normality of data in the 2 groups before further analysis. Differences between ACEI user and nonuser were compared with the use of a chi-square test for categorical variables and *t* or Wilcoxon rank sum tests, as appropriate, for continuous variables.

To reduce the effect of selection bias and potential confounding in this observational study, we developed a propensity score analysis. The propensity for ACEI use was determined without regard outcomes by the use of a nonparsimonious multiple logistic-regression analysis. All the variables listed in Table 1 were included in the analysis. A propensity score, indicating the predicted probability of receiving ACEI treatment, was then calculated from the logistic equation for each patient.

Finally, we used the propensity score to match ACEI users to nonusers (1:1 match). Specifically, we matched each patient with ACEI use to one with non-ACEI use who had a propensity score that was identical to 5 digits. If this could not be done, we then proceeded to the next highest digit match (4-, 3-, 2-, and 1-digit) to make the best matches, in a hierarchical sequence until no more matches could be made. After the propensity score match was performed, we assessed differences between the 2 groups with the paired *t* test or Wilcoxon signed rank test for continuous variables, and McNemars's test or marginal homogeneity test for categorical variables. Conditional logistic regression was performed to identify risk factors for rate of mortality, PRD, post-operative AF, and post-operative use of inotropic support. Results are reported as percentages and odds ratios

Table 1 Baseline Characteristics of the Patients

Variable	ACEI (n = 4,730)	No ACEI (n = 4,544)	p Value
Demographics			
Age, mean (SD), yrs	65.2 (9.1)	64.2 (9.2)	<0.0001
Female	844 (17.8)	871 (19.2)	0.106
BSA	1.9 (0.2)	2 (0.2)	<0.0001
Cardiovascular risk factors			
Hypertension	3,522 (74.5)	2,669 (58.7)	<0.0001
Smoker	2,013 (42.6)	2,684 (59.1)	<0.0001
Diabetes mellitus	969 (20.5)	507 (11.2)	<0.0001
CCS class 3 to 4	2,466 (52)	2,467 (54.3)	0.039
NYHA functional class III to IV	1,150 (32.8)	1,377 (30.3)	0.011
Previous MI	2,771 (58.6)	1,593 (35.1)	<0.0001
EF, %			<0.0001
Good (>50)	3,177 (67.2)	3,627 (79.8)	
Fair (30–50)	1,241 (26.2)	822 (18.1)	
Poor (<30)	312 (6.6)	95 (2.1)	
History of AF	179 (3.8)	125(2.8)	0.006
COPD	449 (9.5)	404 (8.9)	0.334
Vascular disease	482 (10.2)	393 (8.6)	0.012
Creatinine, mean (SD), mol/l	109.6 (30.7)	110.4 (36.3)	0.2
Redo surgery	116 (2.5)	115 (2.5)	0.861
CAD, mean (SD)	2.63 (0.59)	2.57 (0.63)	<0.0001
LMS disease	1,032 (21.8)	839 (18.5)	<0.0001
Priority			<0.0001
Elective	2,354 (49.8)	2,788 (61.4)	
Urgent	2,317 (49)	1,691 (37.2)	
Emergent	59 (1.2)	65 (1.4)	
No. of grafts, mean (SD)	2.72 (0.78)	2.69 (0.84)	0.094
OPCAB	2,628 (55.6)	1,928 (42.2)	<0.0001

Values are expressed as n (%) unless specified otherwise.

ACEI = angiotensin-converting enzyme inhibitor; AF = atrial fibrillation; BSA = body surface area; CAD = coronary artery disease; CCS = Canadian Cardiovascular Society; COPD = chronic obstructive pulmonary disease; EF = ejection fraction; LMS = left main stem; MI = myocardial infarction; NYHA = New York Heart Association; OPCAB = off-pump coronary artery bypass grafting.

(ORs) with 95% confidence interval (CI). All reported p values are 2-sided, and p values of <0.05 were considered to indicate statistical significance. All statistical analysis was performed with SPSS version 15.0 (SPSS Inc., Chicago, Illinois) and StatsDirect version 2.7.2 (StatsDirect Ltd., Chesire, United Kingdom).

Results

Patients characteristics and clinical outcomes. Among 9,274 patients in the study, 4,730 (51%) were on ACEI treatment, and 4,544 (49%) were not. Baseline characteristics of the study population are shown in Table 1. ACEI users were older and had a greater body surface area; they were more likely to have a lower angina functional class, greater prevalence of hypertension, diabetes, to be nonsmokers, to have vascular and coronary artery disease, as well as previous history of MI and AF. Patients taking ACEI were also more likely to have a lower ejection fraction, greater New York Heart Association (NYHA) functional class, and greater prevalence of urgent operations. Finally, the prevalence of off-pump procedures was greater in the ACEI users than in nonusers. After performing propensity score analysis for the entire population, 3,052 patients receiving pre-operative ACEI were matched to a control group. In the matched cohorts, pre-operative characteristics and the use of off pump procedures were similar in both groups (Table 2).

Overall rate of mortality was 1%. Pre-operative ACEI therapy was associated with a doubling in the risk of death (1.3%, n = 40 vs. 0.7%, n = 20, OR: 2.00, 95% CI: 1.17 to 3.42; p = 0.013). There were a significant difference between the ACEI and control group in the risk of PDR (7.1%, n = 217 vs. 5.4%, n = 167, OR: 1.36, 95% CI: 1.1 to 1.67; p = 0.006), AF (25%, 763 patients vs. 20%, 610 patients, OR: 1.34, 95% CI: 1.18 to 1.51; p < 0.0001), and use of inotropic support (45.9%, n = 1,401 vs. 41.1%, n = 1,254, OR: 1.22, 95% CI: 1.1 to 1.36; p < 0.0001). There were no significant difference in post-operative MI (p = 0.27) or cerebral events (p = 0.26) between the 2 groups (Fig. 2). A conditional logistic regression was performed to identify risk factors for rate of mortality, PRD, post-operative AF, and post-operative inotropic drug support.

Mortality. Pre-operative ACEI treatment was an independent predictor of mortality (OR: 2.83, 95% CI: 1.03 to 7.8; p = 0.04). Other independent risk factors were age and NYHA functional class III to IV (Table 3).

Post-operative use of inotropic support. Multivariate analysis showed that ACEI treatment was associated with an increased use of inotropic support post-operatively (OR: 1.17, 95% CI: 1.07 to 1.29; p < 0.0001). Additional risk factors were age, female sex, pre-operative renal function, redo surgery, numbers of coronaries diseased, left main stem disease, pre-operative ejection fraction, and nonelective operations (Table 4).

Table 2 Baseline Characteristics of the Propensity-Matched Patients

Variable	ACEI (n = 3,052)	No ACEI (n = 3,052)	p Value
Demographics			
Age, mean (SD), yrs	64.9 (9.1)	64.8 (9)	0.5
Female	596 (19.5)	589 (19.3)	0.85
BSA	1.94 (0.25)	1.95 (0.28)	0.28
Cardiovascular risk factors			
Hypertension	2,070 (67.8)	2,096 (68.7)	0.46
Smoker	1,561 (51.1)	1,533 (50.2)	0.46
Diabetes mellitus	440 (14.4)	430 (14.1)	0.73
CCS class 3 to 4	1,642 (53.8)	1,601 (52.5)	0.3
NYHA functional class III to IV	996 (32.6)	942 (30.9)	0.14
Previous MI	1,417 (46.4)	1,403 (46)	0.7
EF, %			0.2
Good (>50)	2,254 (73.9)	2,270 (74.4)	
Fair (30–50)	673 (22.1)	691 (22.6)	
Poor (<30)	125 (4.1)	91 (3)	
History of AF	93 (3)	100 (3.3)	0.65
COPD	241 (7.9)	242 (7.9)	0.96
Vascular disease	289 (9.5)	292 (9.6)	0.93
Creatinine, mean (SD), mol/l	110.2 (32.9)	109 (31.4)	0.78
Redo surgery	81 (2.7)	84 (2.8)	0.86
CAD, mean (SD)	2.61 (0.61)	2.6 (0.62)	0.45
LMS disease	630 (20.6)	608 (19.9)	0.5
Priority			0.81
Elective	1,715 (56.2)	1,743 (57.1)	
Urgent	1,306 (42.8)	1,259 (41.3)	
Emergent	31 (1)	50 (1.6)	
No. of grafts, mean (SD)	2.7 (0.8)	2.7 (0.82)	0.82
OPCAB	1,496 (49)	1,500 (49.1)	0.94

Values are expressed as n (%) unless specified. By the use of greedy matching, 245 patients were matched on all 5 digits, 1,114 were matched on 4 digits, 1,151 on 3 digits, 484 on 2 digits, and 58 were matched on 1 digit. The mean absolute difference in propensity score (SD) between matched pair was 0.00076 (0.0036).

Abbreviations as in Table 1.

Risk of PRD. The ACEI users had a significant increased risk of PRD (OR: 1.7, 95% CI: 1.22 to 2.38; p = 0.0002). Additional risk factors for PRD were age, pre-operative renal function and NHYA functional class III to IV (Table 5).

Post-operative AF. We found that ACEI therapy was an independent risk factor for post-operative AF (OR: 1.33, 95% CI: 1.17 to 1.51; p < 0.0001). Other risk factors were age, chronic obstructive pulmonary disease, and history of AF (Table 6).

Discussion

This study demonstrates that pre-operative administration of ACEI in patients undergoing CABG is associated with a significant increased in perioperative mortality, PRD, AF, and use of inotropic support. The effect of ACEI therapy on early clinical outcomes in patients undergoing CABG is still controversial. Lazar (25) proposed that the use of ACEI can benefit patients undergoing cardiac surgery by minimizing perioperative ischemia and reducing long-term cardiovascular events, not only for their antihypertensive effects but also because of their vasculoprotective and antiatherogenic prop-

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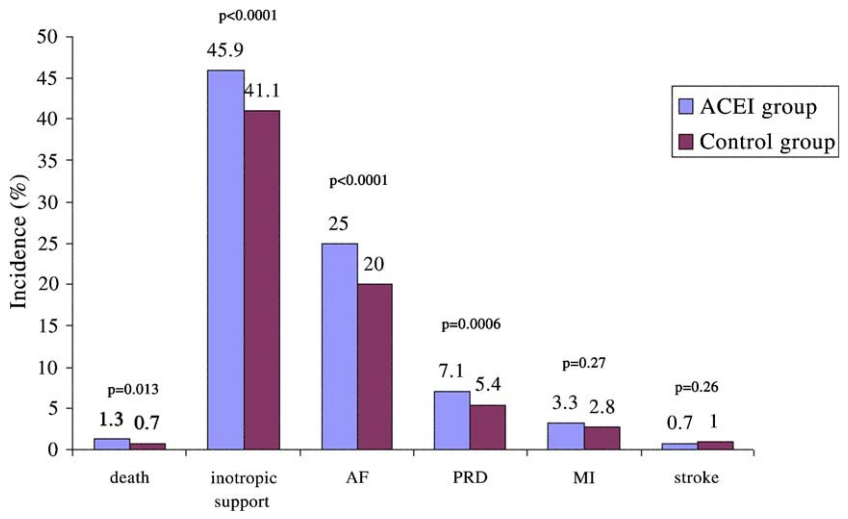

Figure 2 Clinical Outcomes in Propensity-Matched Cohort

ACEI = angiotensin-converting enzyme inhibitors; AF = atrial fibrillation; MI = myocardial infarction; PRD = post-operative renal dysfunction.

erties. He concluded that all patients undergoing CABG should receive ACEI pre-operatively with a sensible dosing regimen that minimizes hypotension. Devbhandari et al. (21) published the result of a United Kingdom national survey to address the issue whether it is beneficial or not to discontinue ACEI before cardiac surgery. They found that 35% of respondents believed that ACEI should be withheld before surgery, and most (63%) believed that their use leads to vasodilation, resulting in increased use of fluids, inotropes, and vasoconstrictors. However, 65% of surgeons did not think that ACEI should be withheld before surgery.

Clinical outcomes. Our findings that the pre-operative use of ACEI was an independent predictor of post-operative inotropic support are in line with most published data (13–15,26–29). Bertrand et al. (27) in a small randomized trial showed that more severe hypotensive episodes requiring vasoconstrictor treatment occur after induction of general anesthesia in patients chronically treated with ACEI and receiving the drug on the morning before operation, in comparison with those in whom ACEI were discontinued on the day before operation. Similar results were reported by Carrel et al. (14), Boeken et al. (28), and Deakin et al. (29), whereas the authors of other studies (18,19) did not find such an association between ACEI treatment and vasoplegia after cardiac surgery.

Table 3 Multivariate Analysis of In-Hospital Mortality in the Propensity-Matched Cohort

Variable	Odds Ratio	95% Confidence Interval	p Value
Age	1.14	1.03–1.26	0.007
ACEI	2.83	1.03–7.8	0.04
NYHA functional class III to IV	4.9	1.14–19.9	0.03

Abbreviations as in Table 1.

Perioperative hypotension is a well-known risk factor for the development of PDR in patients undergoing cardiac surgery; however, the association between ACEI therapy and PRD after cardiac surgery is also controversial (30). Colson et al. (31) and Licker et al. (32) showed that creatinine clearance was maintained among patients who received an acute administration of ACEI before surgery compared with those receiving placebo. However, the effect of ACEI on kidney function may be different in patients who have been exposed to long-term ACEI treatment. Rady and Ryan (20) did not find a significant association between ACEI therapy and post-operative renal failure in patient undergoing cardiac surgery and chronically treated with ACEI. This study used quite a severe form of renal impairment as an end point but did not analyze the association with less severe renal dysfunction. Arora et al. (16) in a large observational studied demonstrated a significant association between pre-operative use of ACEI and acute renal impairment after cardiac surgery, and similar results also were

Table 4 Multivariate Analysis of Post-Operative Inotropic Support in the Propensity-Matched Cohort

Variable	Odds Ratio	95% Confidence Interval	p Value
Age	1.02	1.01–1.03	<0.0001
Female	1.32	1.14–1.53	0.0002
ACEI	1.17	1.07–1.29	<0.0001
Creatinine, mol/l	1.007	1.004–1.01	<0.0001
CAD	1.39	1.21–1.59	<0.0001
Left main disease	1.28	1.04–1.58	0.017
EF <50%	1.74	1.41–2.14	<0.0001
Redo surgery	1.75	1.07–2.87	0.027
Emergent operations	7.45	3.1–17.8	<0.0001
Urgent operations	1.21	1.01–1.45	<0.0001

Abbreviations as in Table 1.

shown after abdominal aortic surgery (33). Our study clearly showed that ACEI treatment is an independent risk factor for PRD defined as a serum creatinine level >200 μmol/l plus an increase of at least 1.5 times pre-operative baseline concentrations. It is most likely that this PRD occurs when renal perfusion pressure cannot be sustained because of substantial decreases in mean arterial pressure with an increased use of vasoconstrictor and inotropic drugs.

It has been shown that even a small increase in serum creatinine after cardiac surgery is associated with increased risk for deaths in these patients (16,34). Indeed, our data showed that pre-operative ACEI therapy increased the risk of death by 2-fold in patients undergoing CABG. The fact that other studies have failed to demonstrated similar results (20,35) is very likely because of inadequate sample size with insufficient power to detect differences in mortality, a very infrequent event after CABG. In addition, it seems that ACEI therapy may increase adverse events during the first 3 months and does not improve clinical outcome up to 3 years after surgery (17). Conversely, authors of the APRES (Angiotensin-Converting Enzyme Inhibition Post Revascularization Study) (36) showed long-term treatment with ramipril after invasive revascularization significantly reduced the incidence of the composite end point of cardiac death, acute MI, or clinical heart failure.

There seems to be increasing evidence to suggest that ACEI have the potential to prevent post-operative AF, possibly because of its ability to decrease left atrial stretching secondary to afterload reduction and atrial remodeling (37,38). However, it is important to understand that the publication of 2 meta-analyses (38,39) did not include any cardiac surgical patients and, therefore, the evidence for this potential benefit in cardiac surgery is weak. A study by White et al. (40) in patients undergoing CABG and valve surgery failed to show statistically significant association between the pre-operative ACEI use and reduction in post-operative AF events. Our data show that ACEI therapy before CABG increases the risk of post-operative AF in a very large cohort of patients. Contrary to the study by White et al. (40), our study examined only patients undergoing CABG and had a much larger sample size.

Pre-operative administration of ACEI in patients undergoing CABG contributes to the lowering of systemic vascular resistance and vasoplegia in the early post-operative phase, resulting in hypotension and requiring the administration of more fluids and inotropic and/or vasoconstrictor drugs (13–15,26–29). It is known that hypotension and volume overload are risk factors for new onset of post-operative AF (41). In addition, perioperative use of inotropics and/or vasoconstrictor drugs may increase the risk of this arrhythmia after cardiac surgery (42,43). All these elements, combined with the other predisposing and intraoperative risk factors, in presence of triggers (atrial premature contractions, imbalance of autonomic nervous system electrolyte imbalance) might induce the new onset of post-operative AF.

Table 5 Multivariate Analysis of Post-Operative Renal Dysfunction in the Propensity-Matched Cohort

Variable	Odds Ratio	95% Confidence Interval	p Value
Age	1.06	1.02–1.09	0.0004
ACEI	1.7	1.22–2.38	0.0002
Creatinine, mol/l	1.04	1.03–1.06	<0.0001
NYHA functional class III to IV	1.9	1.1–3.28	0.021

Abbreviations as in Table 1.

Table 6 Multivariate Analysis of Post-Operative Atrial Fibrillation in the Propensity-Matched Cohort

Variable	Odds Ratio	95% Confidence Interval	p Value
Age	1.03	1.02–1.04	<0.0001
COPD	1.38	1.10–1.76	0.005
History of AF	2.33	1.37–3.96	0.0011
ACEI	1.33	1.17–1.51	<0.0001

Abbreviations as in Table 1.

Study limitations. This study is based on the retrospective analysis of our large, institutional, observational, prospectively collected database. Propensity score analysis is simply a method for reducing bias in observational studies when randomization to treatment groups is not possible and the matching was limited by available variables. Our database did not allow distinction between the use of ACEIs or angiotensin receptor blockers, and no information was recorded about the timing and specific drug used or dose. We did not consider the years of surgery as a further potential confounder. However, during our study period there were no changes regarding surgical or anaesthetic technique or comorbidities of our patients. The overall rate of mortality remained approximately 1% during the study period. Finally, although the magnitude of risk associated with ACEIs was less than other variables, their contribution is still significantly relevant to adverse clinical outcome.

Conclusions

Pre-operative ACEI use is associated with worse early clinical outcomes in patients undergoing CABG. Omitting ACEIs before surgery and restarting them post-operatively might be a reasonable approach to improve early outcomes while retaining the benefits of their cardioprotective effects after CABG.

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