Comparison Between Angiotensin-Converting Enzyme Inhibitors and Angiotensin Receptor Blockers in Patients with Unstable Angina with Preserved Left Ventricular Systolic Function

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Research Article

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Abstract

Background

We investigated the clinical results of angiotensin-converting enzyme inhibitors (ACEIs) or angiotensin receptor blockers (ARBs) treatment in patients with unstable angina (UA) with preserved left ventricular systolic function who underwent percutaneous coronary intervention (PCI) due to uncertainty regarding the long-term prognosis using ACEIs or ARBs.

Methods

A total of 1627 UA patients with preserved left ventricular systolic function who successfully underwent PCI were enrolled. We classified those patients into two groups: the ACEI group (n=918) and the ARB group (n=709) based on discharge medications. The primary endpoint was the incidence of major adverse cardiovascular and cerebrovascular events (MACCEs), including all-cause death, nonfatal myocardial infarction (MI), stroke and target vessel revascularization (TVR), with a follow-up period of 13 months. The secondary endpoint was the occurrence of separate components of MACCEs. We applied the Kaplan–Meier method to depict survival curves, while intergroup differences were performed using the log-rank test. Multivariable Cox regression analysis was applied to assess the prognostic influence of various factors. To balance potential confounding biases derived from differences in baseline levels, propensity score matching (PSM) was used to adjust for confounders between the ACEI and ARB groups.

Results

After PSM, 660 pairs in each group were created. There were no differences in MACCEs (HR=0.860, 95%CI: 0.465-1.590, $P=0.630$), all-cause death (HR=0.334, 95%CI: 0.090-1.238, $P=0.101$), non-fatal MI (HR=4.929, 95%CI: 0.576-42.195, $P=0.145$), stroke (HR=1.049, 95%CI: 0.208-5.290, $P=0.954$) and TVR (HR=1.276, 95% CI: 0.537-3.031, $P=0.581$) between the ACEI and ARB groups.

Conclusions

Prognoses were comparable between ACEI or ARB treatment in UA patients who had preserved left ventricular systolic function after PCI.

Background

Unstable angina (UA) is a common type of acute coronary syndrome (ACS) with severe conditions and rapid progression^[1]. In recent decades, percutaneous coronary intervention (PCI) has been a main treatment technique for UA^[2]. However, optimal therapeutic drugs remain the cornerstone of treatment in

patients with UA even in the present PCI age group^[3]. Angiotensin-converting enzyme inhibitors (ACEIs) can decrease mortality and the risk of myocardial infarction in patients who have left ventricular systolic dysfunction^[4–6]. The European guidelines recommend that ACEIs are suitable for UA patients with heart failure with left ventricular ejection fraction (LVEF)<40% unless contraindicated, while angiotensin receptor blockers (ARBs) are an alternative for those who are intolerant to ACEIs^[7].

However, there is a paucity of comparisons with regard to long-term use of ACEI or ARB therapy in UA patients. Consequently, we compared 13-month clinical outcomes between ACEI or ARB treatment in UA patients undergoing successful PCI with preserved left ventricular systolic function.

Material And Methods

Study Population and Design

A total of 3812 coronary heart disease (CHD) patients who underwent successful PCI at TEDA International Cardiovascular Hospital from October 2016 to September 2017 were enrolled. We made these exclusion rules:

- (1) Stable CHD (n=338,8.9%);
- (2) Myocardial infarction (n=890, 23.3%);
- (3) Follow-up loss (n=224,5.9%);
- (4) Patients who had not been treated with ACEIs or ARBs at discharge (n=689, 18.1%);
- (5) Patients with LVEF≤40%(n=44, 1.2%).

Ultimately, 1627 UA patients who had preserved left ventricular systolic function after PCI were included. We allocated those patients into two groups, the ACEI group (n=918, 56.4%) and the ARB group (n=709, 43.6%), based on the use of ACEIs or ARBs at discharge (Fig. 1). This research was granted by the ethics committee of TEDA International Cardiovascular Hospital and was conducted according to the Declaration of Helsinki. After discharge, follow-up of the 1627 patients was carried out by clinic visits, readmission, or telephone at 13 months.

PCI Procedure and Medical Treatment

Coronary angiography (CAG) and PCI were performed through standard radial or femoral approaches. All patients were given a loading dose of aspirin 300 mg and clopidogrel 300 mg or ticagrelor 180 mg preprocedurally. After discharge, all patients were advised to continue taking medications following their hospital stay, including dual antiplatelet aggregation treatment, beta-blockers, lipid-lowering medication, and ACEIs or ARBs. In particular, dual antiplatelet aggregation treatment (aspirin 100 mg daily and clopidogrel 75 mg daily or ticagrelor 90 mg twice a day) was recommended for at least 1 year.

Study Definitions and Clinical Outcomes

Unstable angina was defined as myocardial ischaemia in a resting state or on minuscule exertion in the absence of cardiomyocyte damage or necrosis^[7]. The primary endpoint was the incidence of major adverse cardiovascular and cerebrovascular events (MACCEs), including all-cause death, nonfatal myocardial infarction (MI), stroke and target vessel revascularization (TVR), with a follow-up period of 13 months. The secondary endpoint was the occurrence of separate components of MACCEs (all-cause death, nonfatal MI, stroke and TVR).

Statistical Analysis

Continuous variables are presented as the mean values $\pm$ standard deviations, and intergroup differences were compared using independent-samples *t* tests. Categorical variables are presented as numbers (percentages), and intergroup differences were assessed by the chi-square test. We applied the Kaplan–Meier method to depict survival curves, while intergroup differences were performed using the log-rank test. Multivariable Cox regression analysis was applied to assess the prognostic influence of various factors. To balance potential confounding biases derived from differences in baseline levels, propensity score matching (PSM) was used to adjust for confounders between the ACEI and ARB groups. We assessed all covariates regarded as potentially relevant, including demographics, previous medical history, laboratory indicators, discharge medication and coronary angiography characteristics. PSM was conducted by 1:1 nearest-neighbour matching with a calliper of 0.02. After PSM, 660 pairs in each group were created. We applied multivariable Cox regression analysis to calculate the hazard ratio (HR) and 95% confidence interval (CI) in PSM patients. A *P* value < 0.05 (bilateral) was considered statistically significant. All data analysis was performed using SPSS software, version 26 (IBM, New York).

Results

Baseline clinical and coronary angiography characteristics

Among the 1627 UA patients undergoing successful PCI with preserved left ventricular systolic function, 918 patients (56.4%) were treated with ACEIs, and 709 patients (43.6%) were treated with ARBs at the time of discharge. Table 1 displays the demographics, laboratory indicators, discharge medication and coronary angiography characteristics between the two groups.

Table 1
Baseline clinical and coronary angiography characteristics

Variables	All patients			Propensity score matching patients		
	ACEI	ARB	P	ACEI	ARB	P
	(n=918)	(n=709)		(n=660)	(n=660)	
Age (years)	62.5 ± 9.1	63.2 ± 9.3	0.120	63.1 ± 9.0	63.0 ± 9.4	0.940
Men, n (%)	561(61.1)	408(57.5)	0.146	389(58.9)	384(58.2)	0.780
BMI (kg/m ²)	25.8 ± 3.2	26.3 ± 3.3	0.009	26.1 ± 3.2	26.1 ± 3.2	0.990
Hypertension, n (%)	696(75.8)	585(82.5)	0.001	530(80.3)	537(81.4)	0.624
Diabetes mellitus, n (%)	510(55.6)	408(57.5)	0.422	372(56.4)	379(57.4)	0.697
Previous angina, n (%)	844(91.9)	659(92.9)	0.447	615(93.2)	614(93.0)	0.913
Previous MI, n (%)	162(17.6)	85(12.0)	0.002	84(12.7)	85(12.9)	0.934
Previous PCI, n (%)	271(29.5)	196(27.6)	0.407	178(27.0)	182(27.6)	0.805
Previous HF, n (%)	34(3.7)	15(2.1)	0.063	14(2.1)	15(2.3)	0.851
Previous CABG, n (%)	23(2.5)	10(1.4)	0.120	10(1.5)	10(1.5)	1.000
Previous CKD, n (%)	24(2.6)	18(2.5)	0.924	17(2.6)	16(2.4)	0.860
Previous COPD, n (%)	14(1.5)	18(2.5)	0.144	12(1.8)	13(2.0)	0.840
Previous PVD, n (%)	11(1.2)	11(1.6)	0.541	10(1.5)	8(1.2)	0.635
Current smokers, n (%)	366(39.9)	278(39.2)	0.787	270(40.9)	259(39.2)	0.537
LVEF (%)	61.9 ± 5.5	62.4 ± 4.8	0.073	62.4 ± 4.9	62.4 ± 4.9	0.977
SBP (mmHg)	139.1 ± 19.1	138.2 ± 19.2	0.332	138.9 ± 19.2	138.5 ± 19.1	0.707
DBP (mmHg)	80.4 ± 12.0	79.2 ± 11.2	0.054	79.8 ± 11.8	79.6 ± 11.2	0.831
Laboratory indicators						
Serum creatinine (umol/L)	68.7 ± 18.4	68.4 ± 16.8	0.777	68.7 ± 18.3	68.3 ± 16.8	0.641

Abbreviations: ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; BMI, body mass index; MI, myocardial infarction; PCI, percutaneous coronary intervention; HF, heart failure; CABG, coronary artery bypass graft; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; PVD, peripheral vascular disease; LVEF, left ventricular ejection fraction; SBP, systolic blood pressure; DBP, diastolic blood pressure; HDL, high-density lipoprotein; LDL, low-density lipoprotein

Variables	All patients			Propensity score matching patients		
	ACEI	ARB	P	ACEI	ARB	P
	(n=918)	(n=709)		(n=660)	(n=660)	
Blood glucose (mmol/L)	7.9 ± 2.8	7.8 ± 2.9	0.760	7.9 ± 2.8	7.8 ± 2.9	0.736
Total cholesterol (mmol/L)	4.5 ± 1.3	4.5 ± 1.3	0.813	4.5 ± 1.4	4.5 ± 1.3	0.793
Triglyceride (mmol/L)	1.7 ± 1.3	1.8 ± 1.1	0.555	1.8 ± 1.4	1.8 ± 1.2	0.920
HDL cholesterol (mmol/L)	1.1 ± 0.3	1.1 ± 0.3	0.590	1.1 ± 0.3	1.1 ± 0.3	0.945
LDL cholesterol (mmol/L)	2.7 ± 1.0	2.7 ± 0.9	0.952	2.7 ± 1.0	2.7 ± 0.9	0.890
Haemoglobin(g/L)	137.1 ± 15.7	136.6 ± 15.5	0.471	136.8 ± 15.4	136.6 ± 15.5	0.784
Discharge medication						
Aspirin, n (%)	915(99.7)	706(99.6)	1.000	658(99.7)	657(99.5)	1.000
Clopidogrel, n (%)	730(79.5)	610(86.0)	0.001	554(83.9)	564(85.5)	0.445
Ticagrelor, n (%)	188(20.5)	99(14.0)	0.001	106(16.1)	96(14.5)	0.445
Lipid-lowering agents, n (%)	888(96.7)	685(96.6)	0.896	637(96.5)	640(97.0)	0.642
Beta-blockers, n (%)	698(76.0)	472(66.6)	0.000	471(71.4)	456(69.1)	0.367
Coronary angiography characteristics						
Infarct-related artery						
Left main, n (%)	23(2.5)	12(1.7)	0.262	12(1.8)	12(1.8)	1.000
Left anterior descending, n (%)	479(52.2)	367(51.8)	0.868	346(52.4)	344(52.1)	0.912
Left circumflex, n (%)	232(25.3)	199(28.1)	0.205	177(26.8)	182(27.6)	0.757
Right coronary, n (%)	324(35.3)	254(35.8)	0.824	237(35.9)	232(35.2)	0.774
2-vessel, n (%)	114(12.4)	109(15.4)	0.086	96(14.5)	96(14.5)	1.000
3-vessel, n (%)	1(0.1)	1(0.1)	0.855	1(0.2)	1(0.2)	1.000
Abbreviations: ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; BMI, body mass index; MI, myocardial infarction; PCI, percutaneous coronary intervention; HF, heart failure; CABG, coronary artery bypass graft; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; PVD, peripheral vascular disease; LVEF, left ventricular ejection fraction; SBP, systolic blood pressure; DBP, diastolic blood pressure; HDL, high-density lipoprotein; LDL, low-density lipoprotein						

Variables	All patients			Propensity score matching patients		
	ACEI	ARB	P	ACEI	ARB	P
	(n=918)	(n=709)		(n=660)	(n=660)	
Number of stents	1.4 ± 0.6	1.4 ± 0.6	0.912	1.4 ± 0.6	1.4 ± 0.6	0.828
Abbreviations: ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; BMI, body mass index; MI, myocardial infarction; PCI, percutaneous coronary intervention; HF, heart failure; CABG, coronary artery bypass graft; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; PVD, peripheral vascular disease; LVEF, left ventricular ejection fraction; SBP, systolic blood pressure; DBP, diastolic blood pressure; HDL, high-density lipoprotein; LDL, low-density lipoprotein						

In comparison to patients prescribed ACEIs, the average BMI ($26.3 \pm 3.3 \text{ kg/m}^2$ vs. $25.8 \pm 3.2 \text{ kg/m}^2$, $P=0.009$) and the number of patients who had hypertension (82.5% vs. 75.8%, $P=0.001$) were higher in patients prescribed ARBs. In contrast, the ACEI group showed a higher prevalence of a previous history of MI (17.6% vs. 12.0%, $P=0.002$). In addition, we found that prescription rates for ticagrelor (20.5% vs. 14.0%, $P=0.001$) and beta-blockers (76.0% vs. 66.6%, $P=0.000$) were higher in the ACEI group at discharge. In contrast, the use of clopidogrel (86.0% vs. 79.5%, $P=0.001$) was more frequent in the ARB group. Laboratory indicators and coronary angiography characteristics were comparable in both groups.

After matching, potential confounding biases derived from differences in baseline levels were considered in excellent balance between the two groups.

Clinical outcomes

Clinical outcomes by the Kaplan–Meier method and the multivariable Cox regression analysis with a follow-up period of 13 months between both groups are demonstrated in Table 2 and Fig. 2.

Table 2
Clinical outcomes by the Kaplan–Meier method and multivariable Cox regression analysis

Outcomes	Cumulative events at 13 months				
	ACEI	ARB	Log-rank	Hazard ratio (95% CI)	P
All Patients					
MACCEs	33(3.6%)	21(3.0%)	0.473	0.860(0.494-1.495)	0.593
All-cause death	14(1.5%)	4(0.6%)	0.066	0.385(0.124-1.191)	0.097
Non-fatal MI	3(0.3%)	5(0.7%)	0.285	2.540(0.592-10.898)	0.210
Stroke	3(0.3%)	4(0.6%)	0.473	1.718(0.384-7.675)	0.479
TVR	16(1.7%)	12(1.7%)	0.925	0.998(0.471-2.116)	0.997
Propensity score matching patients					
MACCEs	22(3.3%)	19(2.9%)	0.625	0.860(0.465-1.590)	0.630
All-cause death	10(1.5%)	3(0.5%)	0.051	0.334(0.090-1.238)	0.101
Non-fatal MI	1(0.2%)	5(0.8%)	0.104	4.929(0.576-42.195)	0.145
Stroke	3(0.5%)	3(0.5%)	0.996	1.049(0.208-5.290)	0.954
TVR	9(1.4%)	12(1.8%)	0.522	1.276(0.537-3.031)	0.581
Abbreviations: ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; CI, confidence interval; MACCEs, major adverse cardiovascular and cerebrovascular events; Nonfatal MI, nonfatal myocardial infarction; TVR, target vessel revascularization					

The occurrence of MACCEs (3.6% vs. 3.0%, Log-rank $P=0.473$, HR=0.860, 95%CI: 0.494-1.495, $P=0.593$), all-cause death (1.5% vs. 0.6%, Log-rank $P=0.066$, HR=0.385, 95%CI: 0.124-1.191, $P=0.097$), non-fatal MI (0.3% vs. 0.7%, Log-rank $P=0.285$, HR=2.540, 95%CI: 0.592-10.898, $P=0.210$), stroke (0.3% vs. 0.6%, Log-rank $P=0.473$, HR=1.718, 95%CI: 0.384-7.675, $P=0.479$) and TVR (1.7% vs. 1.7%, Log-rank $P=0.925$, HR=0.998, 95%CI: 0.471-2.116, $P=0.997$) did not differ significantly between the two groups.

After PSM, we also found no differences in the incidence of MACCEs (3.3% vs. 2.9%, Log-rank $P=0.625$, HR=0.860, 95%CI: 0.465-1.590, $P=0.630$), all-cause death (1.5% vs. 0.5%, Log-rank $P=0.051$, HR=0.334, 95%CI: 0.090-1.238, $P=0.101$), non-fatal MI (0.2% vs. 0.8%, Log-rank $P=0.104$, HR=4.929, 95%CI: 0.576-42.195, $P=0.145$), stroke (0.5% vs. 0.5%, Log-rank $P=0.996$, HR=1.049, 95%CI: 0.208-5.290, $P=0.954$) and TVR (1.4% vs. 1.8%, Log-rank $P=0.522$, HR=1.276, 95%CI: 0.537-3.031, $P=0.581$) between the ACEI and ARB groups.

Fig. 3 presents subgroup analyses concerning MACCEs in all study populations. There was no obvious difference in prognosis according to the multivariate Cox regression analysis between the two groups.

Discussion

Our present research was the first to indicate that there were no differences in MACCEs, all-cause death, nonfatal MI, stroke or TVR between the ACEI and ARB groups in UA patients undergoing successful PCI with preserved left ventricular systolic function. Similarly, we also found no differences in subgroup analyses based on age, sex, risk factors for coronary disease (hypertension and diabetes mellitus), discharge medication (beta-blockers) and coronary angiography characteristics (left anterior descending artery occlusion).

ACEI can decrease mortality and the risk of myocardial infarction in patients who have left ventricular systolic dysfunction^[4–6]. Therefore, the 2020 European guideline advises that ACEIs should be taken into consideration in UA patients with heart failure (HF) with LVEF<40% unless contraindicated, while ARBs are an alternative treatment for patients with ACEI intolerance^[7]. Nevertheless, presently, the long-term prognosis using ACEIs or ARBs is still controversial. In the VALIANT trial^[8], valsartan and captopril demonstrated similar effectiveness in reducing death from any cause after acute myocardial infarction (AMI). Similar drug effects were in accordance with our findings. However, only AMI patients who had left ventricular systolic dysfunction in the VALIANT trial were enrolled, which made the conclusions less conclusive. In the ONTARGET trial^[9], telmisartan also showed no significant difference in cardiac outcomes compared to ramipril in diabetes mellitus or vascular disease patients, who were not associated with HF. However, the small proportion of UA patients (14.9%) and the lack of LVEF data in the ONTARGET trial made the results not meet our targeted population. In addition, the OPTIMAAL trial^[10] also showed no differences in the incidence of deaths (18% vs. 16%, HR=1.13, 95%CI: 0.99-1.28, $P=0.07$), cardiac death (CD) (9% vs. 7%, HR=1.19, 95%CI: 0.98-1.43, $P=0.07$), non-fatal reinfarction (14% vs. 14%, HR=1.03, 95%CI:0.89-1.18, $P=0.72$) and all-cause hospital admission (66% vs. 65%, HR=1.03, 95%CI:0.97-1.10, $P=0.37$) between losartan and captopril groups at a median follow-up period of 2.7(0.9) years. Even though comparable cardiovascular risk between two groups, the OPTIMAAL trial recommended that ACEI should be considered as preferred therapy in patients who had a high risk AMI.

It was recently pointed out that patients prescribed ACEIs had more improved survival than patients prescribed ARBs in a period of 5 years after AMI (HR=0.53, 95% CI: 0.38-0.74, $P<0.001$)^[11].

ACEIs and ARBs have their respective mechanisms of action that may contribute to differences in long-term prognosis between the two groups^[12–17]. ACEI has been shown to decrease the risk of death and MI in patients with hypertension, diabetes mellitus and HF. Conversely, ARB does not seem to decrease the risk of death or MI. This is because ACEIs have cardiovascular benefits independent of antihypertensive effects, which are absent in ARBs^[12, 13]. ACEI inhibits angiotensin converting enzyme (ACE) and consequently reduces the production of angiotensin II. ACEI also suppresses bradykinin breakdown into inactive peptides, whereas bradykinin has many benefits, such as the improvement of endothelial function and ischaemic preconditioning, delaying the development of atherosclerosis, vasodilation and stimulation of nitric oxide^[14–16]. ARB blocks selectivity for the angiotensin II type 1 (AT1) receptor, which

contributes to a compensatory elevation of angiotensin II levels and the activation of the angiotensin II type 2 (AT2) receptor. Moreover, the AT2 receptor causes detrimental effects, including instability and rupture of plaques, thrombosis, inflammation and myocyte apoptosis^[17].

In short, current European guidelines do not fully encompass the longer-term use of ACEIs or ARBs in UA patients who have preserved left ventricular systolic function. Since the percentage of patients with LVEF $\geq 40\%$ is higher than that of patients with LVEF $< 40\%$ after UA^[18], it is essential to investigate the effects of ACEIs/ARBs on long-term prognosis. For this reason, we compared clinical outcomes between ACEI or ARB treatment in UA patients undergoing successful PCI with preserved left ventricular systolic function.

Several retrospective observational studies have recently described comparable cardiovascular risk between ACEI/ARB treatment in UA patients with preserved left ventricular systolic function after PCI. Raposeiras et al.^[18] reported that patients who had non-ST elevation ACS with LVEF $\geq 40\%$ did not appear to benefit from ACEI/ARB in reducing mortality. However, this study did not evaluate the effects of ACEIs and ARBs separately. Cespon et al.^[19] also focused on a non-ST elevation ACS population with LVEF $\geq 40\%$ to assess whether the selection between ACEIs and ARBs could contribute to differences in long-term prognosis. They found that there were no differences in combined events (all-cause death, AMI and HF) (HR=1.03, 95%CI: 0.85-1.24, $P=0.796$), AMI (HR=1.03, 95%CI: 0.75-1.43, $P=0.839$) and HF (HR=1.04, 95%CI: 0.81-1.34, $P=0.768$) between the ACEI and ARB groups after the follow-up period (median follow-up: 3.6 ± 2.1 years). Their findings on the lack of differences in prognosis were consistent with ours. Ann et al.^[20] divided the study population with CHD into AMI ($n=21747$) and angina ($n=28708$). They allocated those patients into two groups, the ACEI and ARB groups, based on discharge medications. After PSM, they found that the occurrence of all-cause death (HR=1.113, 95% CI: 0.986-1.257, $P=0.084$) was not significantly different in the angina group, with a median follow-up of 2.2 years. Nevertheless, neither of the above study populations^[18-20] were restricted to patients with UA.

Our study is the first to examine the longer-term use of ACEI or ARB treatment in an East Asian population with UA with preserved left ventricular systolic function after PCI, which manifests a real clinical world outlook. Prognoses were comparable between ACEI or ARB treatment according to our final conclusion. Hence, we think that our study may not only increase indications and prescriptions of ARBs but also provide important references for cardiologists about the selection of renin-angiotensin-aldosterone system (RAAS) inhibitors after PCI. However, further prospective, high-quality, large-sample randomized controlled trials are required to evaluate the conclusion.

There were many limitations during our study. First, our study was a single-centre retrospective study with a small sample size, which might cause data loss and selection bias. Second, our study did not collect specific data concerning the species and dose of ACEIs and ARBs. Third, we divided the study population by postdischarge medication, and we do not know how long patients had been taking their medications after discharge. Such confounding factors might significantly influence the reliability of the outcomes. Fourth, the selection of RAAS inhibitors after PCI was at the discretion of the cardiologists. Finally, even

though we performed PSM to adjust for possible confounding baseline factors, a large-sample prospective randomized controlled trial is required to corroborate our findings.

Conclusion

No clear differences in MACCEs, all-cause death, nonfatal MI, stroke or TVR were observed between the ACEI and ARB groups during a 13-month follow-up period. Thus, we consider that prognoses are comparable between ACEI or ARB treatment in UA patients who have preserved left ventricular systolic function after PCI. To further confirm our results, prospective and large-sample randomized controlled trials are needed.

Abbreviations

UA: unstable angina; ACS: acute coronary syndrome; PCI: percutaneous coronary intervention; ACEI: angiotensin-converting enzyme inhibitor; LVEF: left ventricular ejection fraction; ARB: angiotensin receptor blocker; CHD: coronary heart disease; CAG: coronary angiography; MACCEs: major adverse cardiovascular and cerebrovascular events; MI: myocardial infarction; TVR: target vessel revascularization; PSM: propensity score matching; HR: hazard ratio; CI: confidence interval; HF: heart failure; AMI: acute myocardial infarction; CD: cardiac death; ACE: angiotensin-converting enzyme; AT1: angiotensin II type 1; AT2: angiotensin II type 2; RAAS: renin-angiotensin-aldosterone system.

Declarations

Ethics approval and consent to participate

All patients gave their written informed consent. This research was granted approval by the ethics committee of TEDA International Cardiovascular Hospital ([2020]-1021-1) and was conducted according to the Declaration of Helsinki.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used during the current study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

LL conceived the study and conducted the data analysis. JX was involved in the procedure and wrote the manuscript. WL applied for funding, supervised the study and revised the manuscript. All authors read and approved the final manuscript.

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Figures

Figure 1

The study population flowchart. CHD, coronary heart disease; PCI, percutaneous coronary intervention; ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; LVEF, left ventricular ejection fraction; UA, unstable angina

Figure 2

Survival curves for the all study population (a,c,e,g,i) and PSM patients (b,d,f,h,j). PSM, propensity score matching; MACCEs, major adverse cardiovascular and cerebrovascular events; nonfatal MI, nonfatal myocardial infarction; TVR, target vessel revascularization; ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker

Figure 3

Subgroup analyses concerning MACCEs in all study populations. MACCEs, major adverse cardiovascular and cerebrovascular events; CI, confidence interval; LAD, left anterior descending; ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker