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ORIGINAL RESEARCH

Five-year follow-up of OCT-guided percutaneous coronary intervention in patients with ST-segment elevation myocardial infarction

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ABSTRACT

BACKGROUND: Compared with intravascular ultrasound guidance, there is limited evidence for optical coherence tomography (OCT) guidance during primary percutaneous coronary intervention (pPCI) in ST-segment elevation myocardial infarction (STEMI) patients.

AIMS: We investigated the role of OCT in guiding a reperfusion strategy and improving the long-term prognosis of STEMI patients.

METHODS: All patients who were diagnosed with STEMI and who underwent pPCI between January 2017 and December 2020 were enrolled and divided into OCT-guided versus angiography-guided cohorts. They had routine follow-up for up to 5 years or until the time of the last known contact. All-cause death and cardiovascular death were designated as the primary and secondary endpoints, respectively.

RESULTS: A total of 3,897 patients were enrolled: 2,696 (69.2%) with OCT guidance and 1,201 (30.8%) with angiographic guidance. Patients in the OCT-guided cohort were less often treated with stenting during pPCI (62.6% vs 80.2%; p<0.001). The 5-year cumulative rates of all-cause mortality and cardiovascular mortality in the OCT-guided cohort were 10.4% and 8.0%, respectively, significantly lower than in the angiography-guided cohort (19.0% and 14.1%; both log-rank p<0.001). All 4 multivariate models showed that OCT guidance could significantly reduce 5-year all-cause mortality (hazard ratio [HR] in model 4: 0.689, 95% confidence interval [CI]: 0.551-0.862) and cardiovascular mortality (HR in model 4: 0.692, 95% CI: 0.536-0.895). After propensity score matching, the benefits of OCT guidance were consistent in terms of all-cause mortality (HR: 0.707, 95% CI: 0.548-0.913) and cardiovascular mortality (HR: 0.709, 95% CI: 0.526-0.955).

CONCLUSIONS: Compared with angiography alone, OCT guidance may change reperfusion strategies and lead to better long-term survival in STEMI patients undergoing pPCI. Findings in the current observational study should be further corroborated in randomised trials.

KEYWORDS: clinical research; optical coherence tomography; STEMI

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Previous studies have shown that compared with angiographic guidance alone, the application of optical coherence tomography (OCT) could impact decision-making, optimise percutaneous coronary intervention (PCI), and improve outcomes[1-5]. However, most studies have focused on patients with stable angina or non-ST-segment elevation acute coronary syndrome (ACS) and mainly on the process of stent implantation. Different from stable angina or non-ST-segment elevation ACS, ST-segment elevation myocardial infarction (STEMI) is a result of transmural ischaemia and is mostly caused by ruptures or erosions and occlusive thrombosis, rather than a gradual narrowing of the coronary arteries[6]. Restoring myocardial perfusion as soon as possible by primary PCI (pPCI) is key in patients presenting with STEMI and, in current guidelines, has the highest level of recommendations in the management of these patients[7]. In the current study, we aimed to investigate whether OCT guidance could reduce long-term mortality compared with angiographic guidance alone in a large cohort of STEMI patients treated with pPCI.

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Methods

STUDY POPULATION

All consecutive patients diagnosed with STEMI between January 2017 and December 2020 in the 2nd Affiliated Hospital of Harbin Medical University (Harbin, China) were retrospectively selected. The diagnosis of STEMI was based on clinical symptoms of continuous chest pain, ST-segment elevation >0.1 mV in at least 2 contiguous leads or new left bundle branch block on the electrocardiogram, and elevated cardiac markers, as described previously[8]. The main exclusion criteria were the following: (1) patients who did not undergo PCI but were treated with medical therapy; (2) patients with cardiogenic shock; (3) the presence of preinterventional thrombolysis; (4) elective PCI several days after admission; (5) use of intravascular ultrasound (IVUS) or functional lesion assessment during pPCI; (6) culprit lesion located in the left main artery; (7) patients who refused further interventional treatments after index angiographic or OCT examinations; (8) patients recommended for coronary artery bypass grafting after index angiography; and (9) patients who were transferred to our hospital after pPCI in local hospitals.

Patients were divided into OCT-guided versus angiography-guided cohorts according to whether OCT or angiography was used to guide the pPCI procedure. Clinical and angiographic features, reperfusion strategies, and survival data were compared between cohorts.

This study was approved by the ethics board of our hospital, and all enrolled patients provided written informed consent. Reporting of this study complied with the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) statement for cohort studies.

Impact on daily practice

The current large-scale cohort study proved for the first time that, for ST-segment elevation myocardial infarction (STEMI) patients who undergo primary percutaneous coronary intervention (pPCI), optical coherence tomography (OCT) guidance is associated with a shift in the decision-making process and a significant reduction in long-term mortality compared with angiographic guidance alone. These findings provide strong evidence for the application of OCT as an optimising tool in the pPCI process for STEMI patients and should be considered as a paradigm for future studies and clinical practice.

PERCUTANEOUS CORONARY INTERVENTION PROCEDURES

Due to the retrospective design, detailed PCI strategies and specific devices/medications were not prespecified and were at each operator's discretion. For OCT guidance, there was a general, but not mandatory protocol in our centre according to contemporary expert documents and local clinical practice[9,10]. After index angiography, intracoronary nitroglycerine was administered before further intervention. Thrombus aspiration and/or gentle predilation with small balloons was commonly applied for lesions with total occlusion or severe stenosis to restore antegrade blood flow before the OCT examination. Further reperfusion strategies and the selection of devices were mainly based on a real-time comprehensive evaluation of the OCT and angiographic findings. Lesions without severe residual stenosis and diagnosed as plaque erosions, ruptures without dissection and/or haematoma, and those caused by spontaneous coronary artery dissections, spasm, or showing no obvious abnormalities in OCT images were potential candidates to avoid stent implantation[8,11]. For patients with a pre-PCI OCT examination and who required stent implantation, it was recommended to conduct lesion preparation, and choose an appropriate landing zone and stent size based on the OCT findings. Whenever possible, post-PCI OCT was routinely performed to optimise stent implantation. For patients who did not undergo pre-PCI OCT but had suboptimal post-PCI angiographic results (mainly including stent underexpansion, edge dissection, stent thrombosis, and other unexplained angiographic abnormalities), OCT was recommended to identify the underlying causes and guide further optimisations[9].

DATA COLLECTION

Patient characteristics, procedural details, and follow-up data were collected from the electronic medical record system and dedicated electronic follow-up system. Detailed definitions of cardiovascular risk factors are summarised in **Supplementary Appendix 1**[5,12]. Angiographic diameter stenosis data were collected from the intervention report and visually graded by the operators during PCI in at least 2 different angiographic

Abbreviations

AMI	acute myocardial infarction	**OCT**	optical coherence tomography	**PSM**	propensity score matching
IVUS	intravascular ultrasound	**PCI**	percutaneous coronary intervention	**STEMI**	ST-segment elevation myocardial infarction

projections. After discharge, all patients were routinely followed up at 1, 3, 6, and 12 months, and annually thereafter, through a combination of inpatient, outpatient, and telephone follow-ups. Unplanned follow-up visits in our hospital due to emergencies or other reasons were also recorded. Follow-up was censored at 5 years (1,825 days) or the last known contact time in this study. The primary endpoint was all-cause death, which is considered the most unbiased outcome in observational studies[13]. Cardiovascular death was reported as the secondary endpoint, which encompassed deaths due to cardiac reasons, vascular reasons, and undetermined reasons, according to the Academic Research Consortium-2 consensus document[13]. Detailed definitions are available in **Supplementary Appendix 2**.

STATISTICAL ANALYSIS

SPSS Statistics, version 26.0 (IBM) was used for statistical analysis. A 2-sided p<0.05 was considered statistically significant. Continuous variables are reported as mean±standard deviation (SD) or median (quartiles) and were compared using the Student's t-test or Mann-Whitney U test. Categorical variables are shown as absolute frequencies (relative percentages) and were compared using the chi-square test or Fisher's exact test. Kaplan-Meier analysis and the log-rank test were performed for time-to-event endpoints. The reverse Kaplan-Meier method was used to calculate the median follow-up time. Cox proportional hazards regression models were used to estimate treatment effects expressed as a hazard ratio (HR) with 95% confidence interval (CI). Baseline clinical and angiographic characteristics, the year of admission, thrombus aspiration, and stent implantation at the culprit vessel were adjusted gradually in 4 multivariable models. Missing baseline data (4.4% of serum lipid-level data and 5.5% of left ventricular ejection fraction values) in the multivariate regression analysis were estimated by multiple imputation (5 times).

Propensity score matching (PSM) analysis was conducted without replacement using maximum execution performance to eliminate the effects of potential confounders on clinical outcomes. We adjusted all the clinical and angiographic characteristics in **Table 1** as well as the year of admission between cohorts using propensity scores to match the patients 1:1, with a match tolerance of 0.02, yielding 1,050 patients in each matched cohort.

Results

A total of 3,897 STEMI patients with pPCI were included in the final analysis: 1,201 (30.8%) cases in the angiography-guided cohort and 2,696 cases (69.2%) in the OCT-guided cohort. A detailed flowchart is shown in **Figure 1**. The proportion of OCT guidance varied significantly across the different years of admission **(Supplementary Figure 1)**.

CLINICAL CHARACTERISTICS

Baseline clinical and angiographic characteristics are shown in **Table 1**. The age of the overall population was 60.2±11.8 years, and 2,794 (71.7%) were male. Patients in the OCT-guided cohort were younger (59.1±11.6 years vs 62.5±11.7 years; p<0.001) and more likely to be male (1,986 [73.7%] vs 808 [67.3%]; p<0.001). Compared with the angiography-guided

Table 1. Baseline clinical and angiographic characteristics.

	Overall (n=3,897)	Angiographic guidance (n=1,201)	OCT guidance (n=2,696)	*p*-value
Age, years	60.2±11.8	62.5±11.7	59.1±11.6	<0.001
Male	2,794 (71.7)	808 (67.3)	1,986 (73.7)	<0.001
Previous MI	313 (8.0)	116 (9.7)	196 (7.3)	0.013
Previous PCI	207 (5.3)	61 (5.1)	146 (5.4)	0.666
Dyslipidaemia[a]	2,505 (67.2)	761 (66.8)	1,744 (67.4)	0.707
Diabetes mellitus	1,242 (31.9)	431 (35.9)	811 (30.1)	<0.001
Hypertension	2,066 (53.0)	698 (58.1)	1,368 (50.7)	<0.001
Smoking history	2,604 (66.8)	776 (64.6)	1,828 (67.8)	0.051
CKD	107 (2.7)	64 (5.3)	43 (1.6)	<0.001
LVEF[a], %	56.5±7.7	54.7±8.9	57.3±7.0	<0.001
Culprit vessel				0.001
LAD	1,822 (46.8)	511 (42.5)	1,311 (48.6)	
LCx	441 (11.3)	157 (13.1)	284 (10.5)	
RCA	1,634 (41.9)	533 (44.4)	1,101 (40.8)	
Preintervention of the culprit vessel				
DS, %	97.3±7.5	97.8±6.1	97.0±8.0	0.001
Total occlusion	2,620 (67.2)	815 (67.9)	1,805 (67.0)	0.577
TIMI flow 0/1	2,986 (76.6)	925 (77.0)	2,061 (76.4)	0.697
Multivessel disease	2,581 (66.2)	900 (74.9)	1,681 (62.4)	<0.001

Values are mean±SD or n (%). [a]Data for dyslipidaemia and LVEF were missing in 172 and 216 individuals, respectively. CKD: chronic kidney disease; DS: diameter stenosis; LAD: left anterior descending artery; LCx: left circumflex artery; LVEF: left ventricular ejection fraction; MI: myocardial infarction; OCT: optical coherence tomography; PCI: percutaneous coronary intervention; RCA: right coronary artery; SD: standard deviation; TIMI: Thrombolysis in Myocardial Infarction

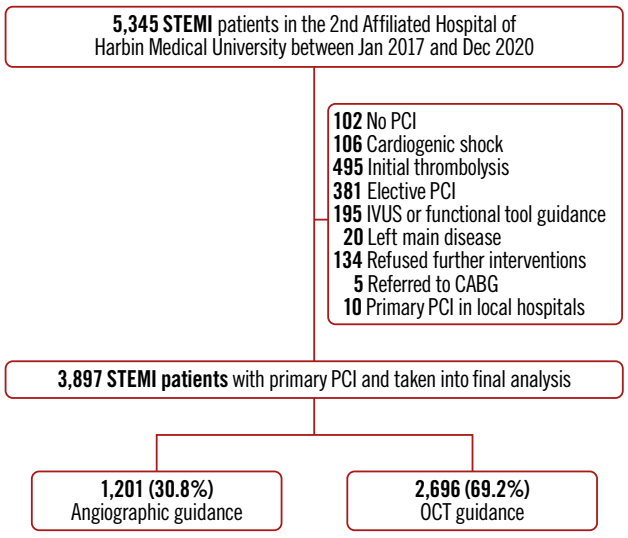


Figure 1. *Study flowchart. CABG: coronary artery bypass grafting; IVUS: intravascular ultrasound; OCT: optical coherence tomography; PCI: percutaneous coronary intervention; STEMI: ST-segment elevation myocardial infarction*

cohort, there was a lower prevalence of previous myocardial infarction, diabetes mellitus, hypertension, and chronic kidney disease in the OCT-guided cohort.

ANGIOGRAPHIC AND PROCEDURAL FEATURES

As shown in **Table 1**, the distribution of culprit vessels was different between the 2 cohorts. OCT was more commonly used in patients with the left anterior descending artery as the culprit vessel. Preintervention angiographic diameter stenosis was more severe in the angiography-guided cohort than in the OCT-guided cohort, but there were a comparable proportion of totally occluded lesions and lesions with Thrombolysis in Myocardial Infarction (TIMI) flow 0/1.

Procedural characteristics during pPCI are shown in **Table 2**. In the OCT-guided cohort, the proportion of pre-PCI OCT evaluation was 97.0%. For those with OCT-guided stent implantation, the proportions of patients with both pre- and post-PCI, only pre-PCI and only post-PCI OCT evaluation were 87.9%, 7.3% and 4.8%, respectively. During pPCI, thrombus aspiration was used more commonly in patients treated with OCT guidance (2,317 [85.9%] vs 687 [57.2%]; p<0.001). Compared with the angiography-guided cohort, the rate of stent implantation at the culprit vessel was significantly lower in the OCT-guided cohort (1,688 [62.6%] vs 963 [80.2%]; p<0.001). All the stents implanted were drug-eluting stents. In patients treated with stent implantation at the culprit vessel, the total number of stents was smaller, the maximum stent diameter was larger (3.19±0.42 mm vs 3.10±0.42 mm; p<0.001), and there was a higher rate of post-dilation in the OCT-guided cohort than the angiography-guided cohort. The angiography-guided cohort had a higher rate of multivessel intervention during pPCI. Procedural details of the non-culprit vessels are shown in **Supplementary Table 1**.

Almost all patients received antiplatelet agent(s) and a statin at discharge. As for the choice of $P2Y_{12}$ receptor inhibitor, ticagrelor was administered more frequently in the OCT-guided cohort when compared with the angiography-guided cohort (1,617 [60.3%] vs 621 [52.8%]; p<0.001). Usage of other medications at discharge appeared to be similar between the 2 cohorts **(Supplementary Table 2)**.

LONG-TERM MORTALITY

The median follow-up duration of the overall population was 3.5 years; it was 4.0 years in the OCT-guided cohort and 3.1 years in the angiography-guided cohort. The overall cumulative rates of all-cause mortality were 5.2% at 1 year, 8.9% at 3 years, and 12.9% at 5 years. Kaplan-Meier survival curves showed a lower cumulative rate of all-cause mortality in the OCT-guided cohort at 5-year follow-up (10.4% vs 19.0% in the angiography-guided cohort; log-rank p<0.001). Compared with angiographic guidance, patients treated with OCT guidance experienced a 52.9% risk reduction in all-cause mortality in the unadjusted Cox regression analysis (HR: 0.471, 95% CI: 0.386-0.573; p<0.001) **(Figure 2)**.

Four models were constructed: model 1 adjusted for all the baseline clinical and angiographic risk factors in **Table 1** (including age, male sex, previous myocardial infarction, previous PCI, dyslipidaemia, diabetes mellitus, hypertension, smoking history, chronic kidney disease, left ventricular ejection fraction, culprit vessel locations, preintervention diameter stenosis, preintervention TIMI 0/1, and multivessel

Table 2. Procedural characteristics during primary PCI.

	Overall (n=3,897)	Angiographic guidance (n=1,201)	OCT guidance (n=2,696)	*p*-value
Thrombus aspiration	3,004 (77.1)	687 (57.2)	2,317 (85.9)	<0.001
Stent implantation at the culprit vessel	2,651 (68.0)	963 (80.2)	1,688 (62.6)	<0.001
Total number of stents[a]	1.3±0.5	1.4±0.6	1.2±0.4	<0.001
Maximum stent diameter[a], mm	3.16±0.42	3.10±0.42	3.19±0.42	<0.001
Post-dilation[a]	2,070 (78.1)	716 (74.4)	1,354 (80.2)	<0.001
Multivessel intervention	151 (3.9)	75 (6.2)	76 (2.8)	<0.001
Contrast-induced nephropathy	311 (8.0)	104 (8.7)	207 (7.7)	0.297

Values are mean±SD or n (%). [a]For patients with stent implantation at the culprit vessel. OCT: optical coherence tomography; PCI: percutaneous coronary intervention; SD: standard deviation

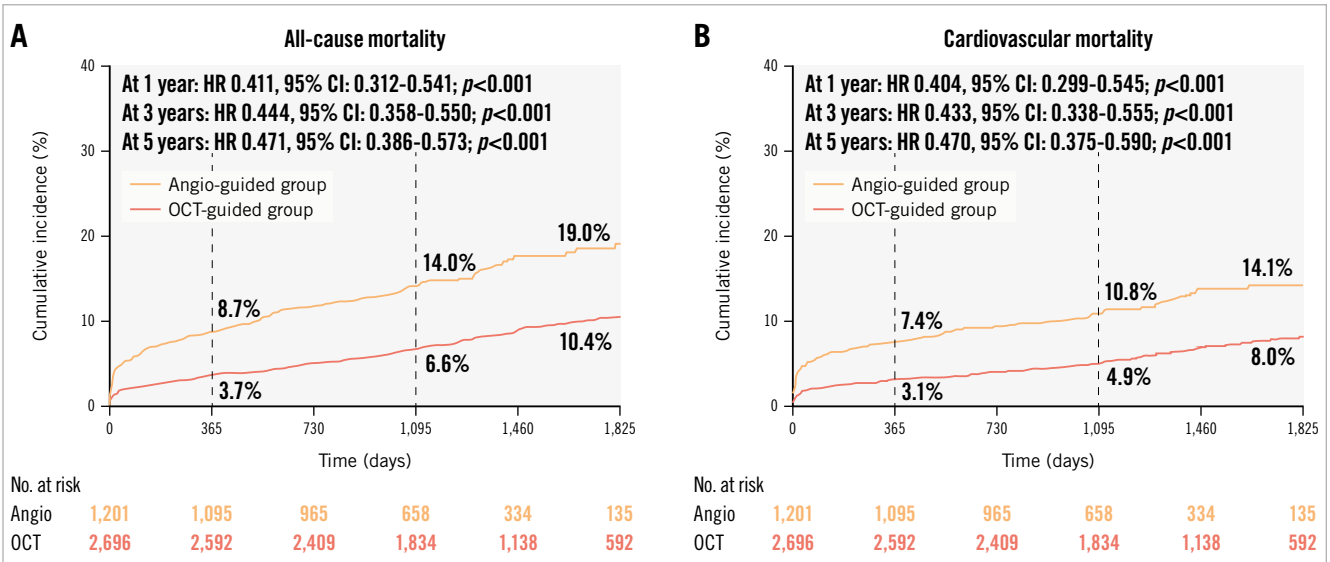


Figure 2. *Cumulative incidence curves of long-term mortality in the overall population. Kaplan-Meier curves show the cumulative incidences of all-cause mortality (A) and cardiovascular mortality (B) in the 2 cohorts. There was significantly lower all-cause mortality in the OCT-guided cohort than the angiography-guided cohort at 1-year, 3-year, and 5-year follow-ups (all p-values<0.001). Similar results were shown in terms of cardiovascular mortality. CI: confidence interval; HR: hazard ratio; OCT: optical coherence tomography*

disease); model 2 adjusted for the factors in model 1 plus the year of admission; model 3 adjusted for the factors in model 2 plus thrombus aspiration; and model 4 adjusted for the factors in model 3 plus stent implantation at the culprit vessel. Multivariate analysis in model 4 showed a 31.1% risk reduction in all-cause mortality in the OCT-guided cohort (adjusted HR: 0.689, 95% CI: 0.551-0.862; p=0.001) after adjustment for all clinical characteristics, angiographic risk features, thrombus aspiration, and culprit vessel stenting during pPCI. Similar results were shown in the other adjusted models **(Figure 3)**. The detailed results of each model are shown in **Table 3** and **Supplementary Figure 2**-**Supplementary Figure 4**. Thrombus aspiration and culprit vessel stent implantation during pPCI were not independently associated with long-term death in model 4.

When it came to cardiovascular mortality, the overall cumulative rates were 4.4%, 6.7%, and 9.9% at 1, 3 and 5 years, respectively. OCT guidance was protective as well (unadjusted HR: 0.470, 95% CI: 0.375-0.590; p<0.001), achieving a lower 5-year rate of cardiovascular mortality than angiographic guidance (8.0% vs 14.1%; log-rank p<0.001) **(Figure 2)**. Multivariate analysis also showed a significant benefit in the OCT-guided cohort compared with the angiography-guided cohort in model 4 (adjusted HR: 0.692, 95% CI: 0.536-0.895; p=0.005) as well as in the other multivariate models **(Figure 3, Table 3 and Supplementary Figure 2-Supplementary Figure 4)**.

PROPENSITY SCORE MATCHING ANALYSIS

Baseline clinical and angiographic demographics and the year of admission showed satisfactory score matching comparability with a minimum p-value of 0.221, details of which are shown in **Supplementary Table 3**. In the PSM cohorts, there was still a higher rate of thrombus aspiration and a lower rate of stent implantation at the culprit vessel during pPCI. Detailed results of the procedural characteristics in the matched cohorts are shown in **Supplementary Table 4** and **Supplementary Table 5**.

The Kaplan-Meier curves for all-cause mortality and cardiovascular mortality for the PSM cohorts are shown in **Figure 4**. Compared with angiographic guidance, OCT guidance was associated with a significantly lower rate of all-cause mortality (13.4% vs 17.0%; log-rank p=0.008) and cardiovascular mortality (10.0% vs 12.2%; log-rank p=0.023) over the 5-year follow-up period. The application of OCT during pPCI was a protective factor for all-cause mortality (PSM HR: 0.707, 95% CI: 0.548-0.913; p=0.008) and cardiovascular mortality (PSM HR: 0.709, 95% CI: 0.526-0.955; p=0.023) in the PSM cohorts.

Discussion

To our knowledge, this is the largest published study focusing on reperfusion strategies and long-term survival rates for OCT guidance versus angiographic guidance in STEMI patients undergoing pPCI. The main findings of this study are as follows: 1) Compared with angiography alone, OCT guidance during pPCI led to a reduction in culprit vessel stent implantation; 2) OCT guidance during pPCI in STEMI patients was associated with a significant risk reduction in all-cause mortality and cardiovascular mortality during a maximum follow-up of 5 years **(Central illustration)**.

IMPACT OF OCT ON PRIMARY PERCUTANEOUS CORONARY INTERVENTION STRATEGIES

In the current study, OCT examination was usually performed after implementing thrombus aspiration or gentle predilation with a small balloon to achieve TIMI flow 2/3. Intravascular imaging such as IVUS and OCT can compensate for the

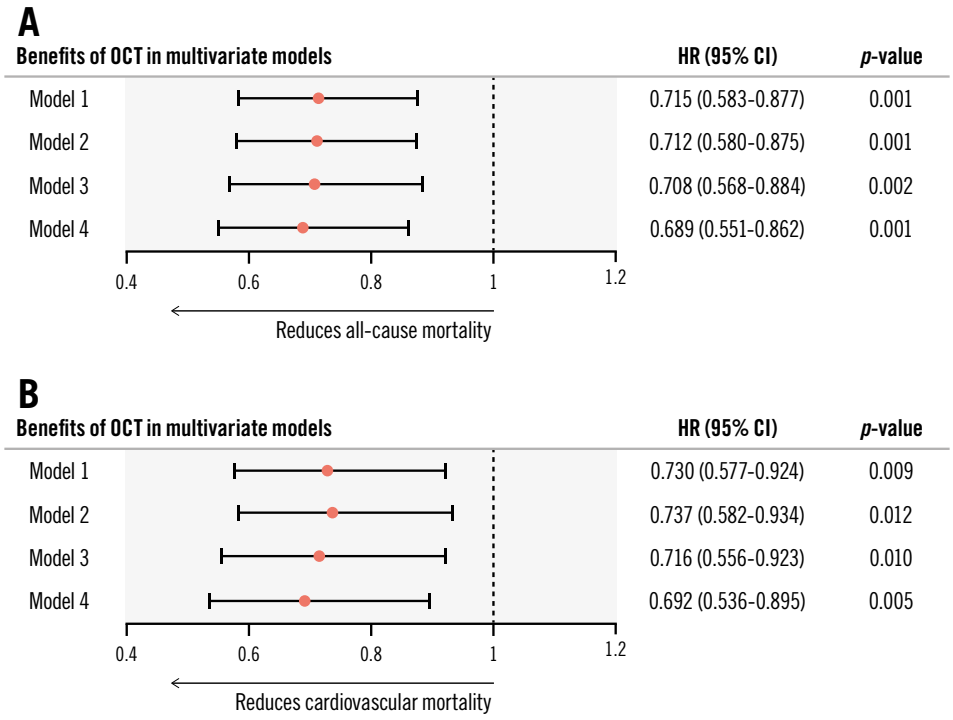


Figure 3. *Benefits of OCT in reducing long-term mortality in multivariate models. For STEMI patients undergoing primary PCI, OCT guidance was able to consistently reduce 5-year all-cause mortality (A) and cardiovascular mortality (B) in multiple Cox regression models. Model 1 adjusted for baseline clinical and angiographic characteristics (including age, male sex, previous myocardial infarction, previous PCI, dyslipidaemia, diabetes mellitus, hypertension, smoking history, chronic kidney disease, left ventricular ejection fraction, culprit vessel locations, preintervention diameter stenosis, preintervention Thrombolysis in Myocardial Infarction flow 0/1, and multivessel disease). Model 2 adjusted for all factors in model 1 plus the year of admission. Model 3 adjusted for all factors in model 2 plus thrombus aspiration. Model 4 adjusted for all factors in model 3 plus stent implantation at the culprit vessel. CI: confidence interval; HR: hazard ratio; OCT: optical coherence tomography; PCI: percutaneous coronary intervention; STEMI: ST-segment elevation myocardial infarction*

limitations of coronary angiography while simultaneously providing valuable cross-sectional insights into luminal stenosis, plaque morphology, and vulnerability. The EROSION series of studies proved that, for STEMI patients with a residual angiographic diameter stenosis ≤70%, OCT guidance enabled the majority of erosions, certain ruptures without dissection and/or haematoma, and calcified nodules without obstructive stenosis to avoid stent implantation, with no excess in long-term clinical outcomes[14,15]. Besides, OCT was also able to help identify uncommon causes of STEMI such as spontaneous coronary artery dissection, spasm, and non-atherosclerotic thromboembolism, some of which had no obstructive luminal stenosis, and stent implantation was therefore also avoided[11,16]. In the EROSION III study, 56.2% of STEMI patients (86.2% with culprit erosions and 40.5% with culprit ruptures) were treated without stenting after OCT assessment, resulting in a 15% reduction in stent implantation compared with the angiography-guided group[11]. In the present study, we extended the study population to 3,897 STEMI patients who were treated with pPCI and followed for up to 5 years, finding a 17.6% reduction of stenting in the OCT-guided cohort compared with the angiography-guided cohort. Our results confirmed the role of OCT in altering reperfusion strategies and improving long-term survival outcomes. This benefit might be attributed to the superiority of OCT in simultaneously assessing morphological severity and underlying STEMI mechanisms in order to choose appropriate reperfusion strategies for each lesion and to achieve optimal post-PCI results[11,15].

During pPCI of STEMI patients, approaches for restoring blood flow mainly include balloon predilation, thrombus aspiration, and/or direct stent implantation. The negative results of TOTAL, TASTE, and other studies in improving clinical outcomes reduced the recommendation level of routine thrombus aspiration in STEMI in the contemporary guidelines[7]. However, several studies have also indicated that STEMI patients with a high thrombus burden might benefit from thrombus aspiration[17]. In the current study, although thrombus aspiration was more commonly used in the OCT-guided cohort, it was not independently related with all-cause or cardiovascular mortality in multivariate analysis. Thrombus aspiration made it possible to evaluate residual thrombus burden and assess culprit lesion morphology using OCT, after which precise interventional treatment (stenting or not and also the size of devices) was conducted according to the OCT findings. This might have contributed to the improved survival in the OCT-guided cohort. Besides, several studies have focused on STEMI patients with a large

Table 3. Predictors of 5-year mortality in multivariate model 4.

	All-cause mortality			Cardiovascular mortality		
	HR	95% CI	*p*-value	HR	95% CI	*p*-value
OCT guidance	0.689	0.551-0.862	0.001	0.692	0.536-0.895	0.005
Age	1.063	1.052-1.074	<0.001	1.057	1.045-1.069	<0.001
Male	0.831	0.666-1.037	0.101	0.792	0.614-1.022	0.073
Previous MI	1.315	0.891-1.941	0.168	0.986	0.607-1.601	0.953
Previous PCI	0.827	0.506-1.352	0.448	1.014	0.568-1.813	0.961
Dyslipidaemia	0.938	0.755-1.165	0.562	1.015	0.788-1.308	0.907
Diabetes mellitus	0.977	0.785-1.216	0.838	0.993	0.774-1.273	0.953
Hypertension	1.101	0.895-1.355	0.361	1.135	0.892-1.443	0.302
Smoking history	1.060	0.850-1.322	0.602	0.941	0.731-1.211	0.638
CKD	4.467	3.275-6.092	<0.001	4.511	3.193-6.372	<0.001
LVEF	0.951	0.941-0.961	<0.001	0.944	0.932-0.955	<0.001
Culprit lesion in LAD		1 (reference)			1 (reference)	
Culprit lesion in LCx	1.011	0.720-1.418	0.952	1.065	0.729-1.555	0.744
Culprit lesion in RCA	0.866	0.694-1.080	0.201	0.813	0.629-1.050	0.113
Preintervention DS	0.994	0.971-1.017	0.613	0.997	0.970-1.025	0.829
Preintervention TIMI 0/1	1.528	1.062-2.197	0.022	1.399	0.919-2.129	0.117
Multivessel disease	1.123	0.884-1.426	0.342	1.219	0.922-1.611	0.164
Admitted in 2017		1 (reference)			1 (reference)	
Admitted in 2018	0.896	0.681-1.179	0.434	0.983	0.712-1.358	0.917
Admitted in 2019	0.818	0.618-1.083	0.160	0.880	0.631-1.227	0.450
Admitted in 2020	1.016	0.732-1.412	0.923	1.253	0.863-1.818	0.236
Thrombus aspiration	0.992	0.760-1.296	0.956	1.071	0.784-1.462	0.667
Stent implantation at the culprit vessel	0.800	0.635-1.008	0.059	0.770	0.591-1.002	0.052

CI: confidence interval; CKD: chronic kidney disease; DS: diameter stenosis; HR: hazard ratio; LAD: left anterior descending artery; LCx: left circumflex artery; LVEF: left ventricular ejection fraction; MI: myocardial infarction; OCT: optical coherence tomography; PCI: percutaneous coronary intervention; RCA: right coronary artery; TIMI: Thrombolysis in Myocardial Infarction

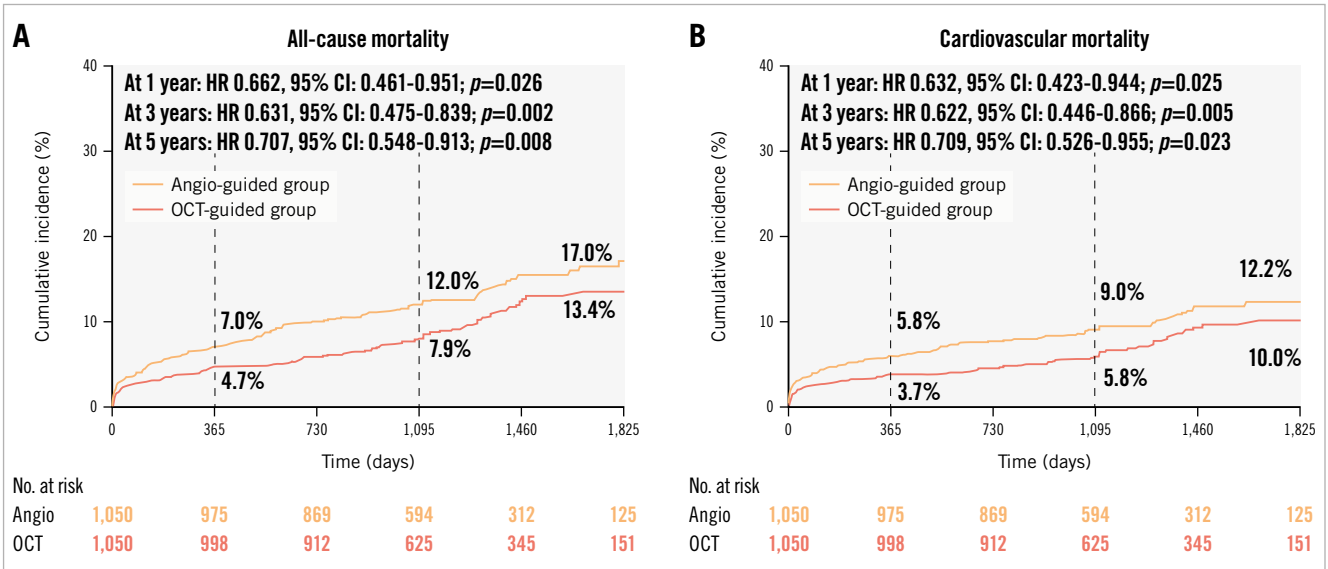
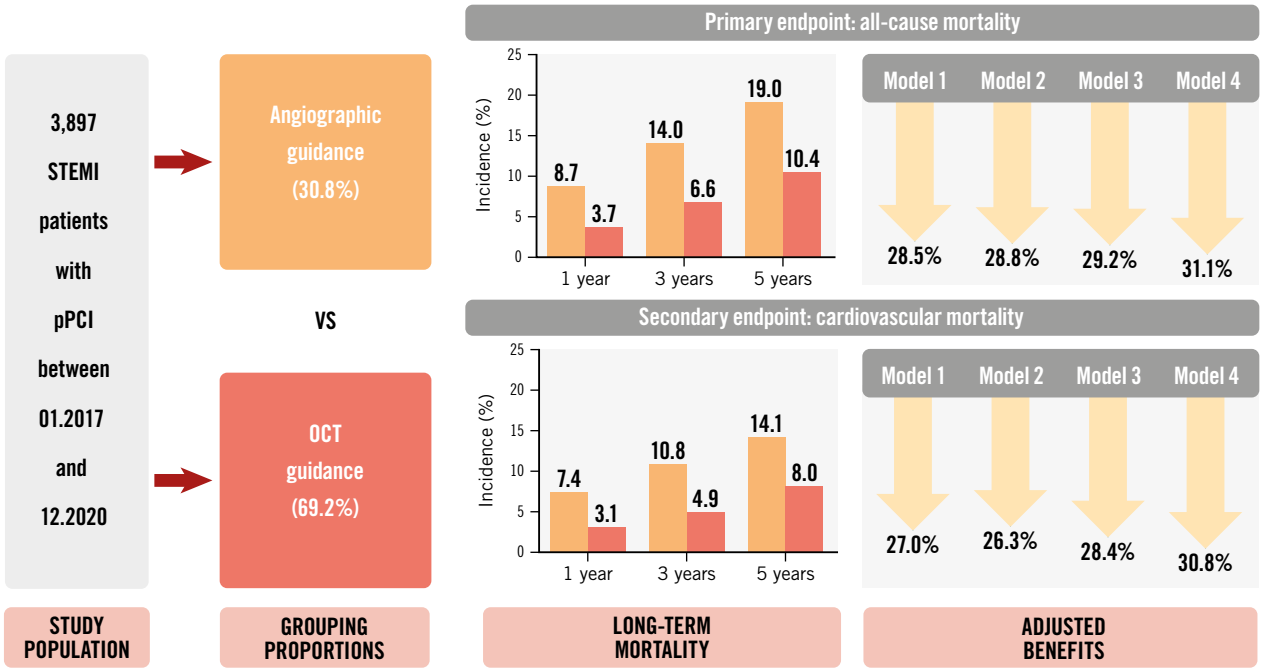


Figure 4. *Cumulative incidence curves of long-term mortality in the matched cohorts. After propensity score matching, there remained significantly lower incidences of all-cause mortality (A) and cardiovascular mortality (B) in the OCT-guided cohort than the angiography-guided cohort at 1-year, 3-year and 5-year follow-ups. CI: confidence interval; HR: hazard ratio; OCT: optical coherence tomography*

OCT guidance reduces long-term mortality in STEMI patients treated with pPCI.



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This cohort study included 3,897 ST-segment elevation myocardial infarction (STEMI) patients who underwent primary percutaneous coronary intervention (pPCI) and were followed for 5 years. Optical coherence tomography (OCT) guidance versus angiographic guidance robustly contributed to better long-term survival in multivariate series models.

thrombus burden and on identifying the effective methods to remove thrombus[18,19]. The COCTAIL II trial revealed that intralesional abciximab enabled better myocardial reperfusion than intracoronary abciximab[18]. Another prospective non-randomised study found that for selected ACS with a large thrombus burden, these might be treated safely with aspiration thrombectomy and no stent or deferred stents under the facilitation of OCT[19].

Compared with the angiography-guided cohort, OCT-guided patients more often received ticagrelor at discharge, which has stronger antithrombotic functions than clopidogrel and has been proven to be safe and effective in the novel OCT-guided non-stenting strategy for ACS caused by plaque erosion in the EROSION study[8].

LONG-TERM MORTALITY OF ST-SEGMENT ELEVATION MYOCARDIAL INFARCTION

Recently, an analysis of the NORIN-STEMI registry in India reported 11% mortality at 1-year follow-up, slightly higher than the angiography-guided cohort in our study[20]. Another study conducted by Jamal et al reported 11.1% 3-year mortality for STEMI patients who received pPCI, slightly lower compared to the angiography-guided cohort (14.0%) and significantly higher than the OCT-guided cohort (6.6%) in our study[21]. Two large-scale registries in France and Denmark reported the 5-year rate of all-cause death for STEMI with pPCI to be 16% and 23.3%, respectively, which were comparable with the angiography-guided cohort and higher than the OCT-guided cohort in our study[22,23]. These discrepancies were reasonable and may be attributed to variations in study design, patient characteristics and the high rate of OCT utilisation (69.2%) in our centre.

BENEFITS OF OCT IN ST-SEGMENT ELEVATION MYOCARDIAL INFARCTION

As the earliest and most widely used intravascular imaging modality, the benefits of IVUS in improving clinical outcomes of patients with acute myocardial infarction (AMI) have been widely proven[24-28]. Two large-scale registries in Korea (the COREA-AMI registry and the KAMIR-NIH registry) demonstrated that the utilisation of IVUS during PCI was associated with improved long-term cardiovascular prognosis when compared with angiographic guidance[24,25]. Two nationwide studies in the USA enrolling hundreds of thousands of patients found that the utilisation of IVUS during PCI was able to reduce the rates of in-hospital death and readmission for patients with AMI and STEMI[26,27]. Results from the J-MINUET registry in Japan showed better in-hospital survival in AMI patients with IVUS/OCT guidance during urgent PCI compared with standard angiographic guidance[28].

Advantages of IVUS include the detection of plaque burden and vascular remodelling. However, the diagnosis of thrombus by IVUS is presumptive. OCT is the best way to detect thrombus and the only technique to positively diagnose plaque erosion *in vivo*, although it cannot see through red blood cell-rich thrombus. These advantages maintain OCT as a promising tool in the management of STEMI. The recent published OCTIVUS trial demonstrated a non-inferior clinical outcome in OCT-guided PCI versus IVUS-guided PCI, yet patients diagnosed as STEMI were excluded in the trial design[29]. No significant difference in 2-year mortality was observed in ILUMIEN IV, which compared the clinical outcomes of OCT-guided PCI with angiography-guided PCI in high-risk patients or lesions, 57% of which were ACS. There are many potential reasons for the inconsistent findings between ILUMIEN IV and the current study (such as different populations, study designs and interventional approaches), among which the most important points might be the exclusion of STEMI ≤24 hours from the onset of ischaemic symptoms and the requirement of stent implantation for all patients in ILUMIEN IV[4].

So far, few large-scale studies have focused on the role of OCT in improving the long-term prognosis of STEMI patients. A retrospective study with 270 ACS patients in each matched cohort showed a reduced number of stents and a numerically, but not statistically, lower incidence of 2-year major adverse cardiovascular events in the OCT-guided cohort than in the angiography-guided cohort[30]. Another meta-analysis with 2,612 cases revealed that OCT-guided PCI was associated with better prognosis compared to angiography-guided PCI in ACS patients[31]. Kim et al reported a risk reduction in 1-year patient- and device-oriented endpoints in 209 OCT-guided patients compared with 5,679 angiography-guided cases in a PSM subset analysis of the KAMIR-NIH registry and found these benefits were mainly driven by reduced all-cause mortality and cardiac mortality, respectively[32]. The protective value of OCT in reducing in-hospital death was not observed in the J-MINUET registry, which might be attributed to the limited number of patients in the OCT-guided cohort (only 152 patients, 5.5% of the overall population)[28].

Compared with IVUS, the use of OCT in AMI patients was low: only 2.4% in the Republic of Korea, 5.5% in Japan, and less than 1% in the USA[27,28,32]. The main reasons include high cost, insufficient clinical training, and a lack of high-quality evidence. In the current study, approximately two-thirds of STEMI patients treated with pPCI received OCT guidance, which significantly changed reperfusion choices and resulted in robust benefits in long-term survival. Instead of employing a one-size-fits-all approach for stent implantation in STEMI, it might be a better paradigm to perform OCT after restoring antegrade blood flow, then making further reperfusion decisions, optimisations, and tailored medications according to the comprehensive findings from angiography and OCT.

Limitations

First of all, this was a retrospective and non-randomised cohort study, which introduced unknown biases that cannot be controlled for. The lower clinical and angiographic complexities in the OCT-guided group than the angiography-guided group was an important selection bias. Multivariate regression analysis and PSM analysis were conducted to reduce the impact of potential confounders. Besides, all patients between 2017 and 2020 were enrolled to minimise subjective selection bias, and follow-up was collected routinely in a real-time manner, which ensured the quality of data. Second, this study specifically focused on all-cause death and cardiovascular death, without analysing other events such as revascularisation. The Academic Research Consortium-2 consensus document highlighted death as the most convincing and accurate clinical endpoint, as it was least affected by the methods of follow-up and other uncertainties[13]. Third, the type of available devices varied according to the year of enrolment. Fourth, due to the effect of COVID-19, characteristics and interventional strategies for patients in 2020 might have been different from the previous years. The year of admission was included in the multivariate analysis and PSM cohorts to mitigate potential effects. Fifth, the current study concentrated on the utilisation of OCT or not during pPCI, thus detailed results of angiographic and OCT data measured by the core lab were not reported.

Conclusions

In this large-scale observational study, the utilisation of OCT guidance during pPCI in STEMI patients was associated with a reduction in long-term mortality when compared with angiographic guidance alone. Further studies with prospective randomised designs are warranted to confirm these findings.

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Conflict of interest statement

The authors have no conflicts of interest to declare.

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Supplementary data

Supplementary Appendix 1. Definitions of cardiovascular risk factors.

Supplementary Appendix 2. Definitions and classifications of mortality.

Supplementary Table 1. Detailed procedural characteristics of non-culprit vessels for patients undergoing multivessel interventions.

Supplementary Table 2. Medications at discharge.

Supplementary Table 3. Baseline clinical and angiographic characteristics and the year of admission in the matched cohorts.

Supplementary Table 4. Procedural characteristics during primary PCI in the matched cohorts.

Supplementary Table 5. Detailed procedural characteristics of non-culprit vessels for patients undergoing multivessel interventions in the matched cohorts.

Supplementary Figure 1. Distributions of the study population in each year.

Supplementary Figure 2. Predictors of 5-year mortality in multivariate model 1.

Supplementary Figure 3. Predictors of 5-year mortality in multivariate model 2.

Supplementary Figure 4. Predictors of 5-year mortality in multivariate model 3.

The supplementary data are published online at: https://eurointervention.pcronline.com/doi/10.4244/EIJ-D-24-00249

Supplementary data

Supplementary Appendix 1. Definitions of cardiovascular risk factors.

Smoking history included current smokers and former smokers. Diabetes mellitus was diagnosed as documented history of diabetes mellitus or casual plasma glucose level ≥ 200mg/dL, or fasting glucose ≥ 126mg/dL, or 2-h plasma glucose level ≥ 200mg/dL in the oral glucose tolerance test, or hemoglobin A1c ≥ 6.5%. Hypertension was defined as systolic blood pressure ≥ 140mmHg or diastolic blood pressure ≥ 90mmHg or documented history of hypertension. Dyslipidaemia was defined as total cholesterol level ≥ 220mg/dL, or triglycerides ≥ 150mg/dL, or low-density lipoprotein cholesterol ≥ 140mg/dL, or high-density lipoprotein cholesterol ≤ 40mg/dL, or documented history of dyslipidaemia. Chronic kidney disease was defined as creatinine > 200umol/L.

Supplementary Appendix 2. Definitions and classifications of mortality.

All-cause mortality was defined as documented death for any reason. Cardiovascular mortality was defined as the occurrence of death caused by cardiovascular factors, which mainly include the following categories: (1) death resulting from acute myocardial infarction, heart failure, cardiovascular procedures or cardiovascular hemorrhage; (2) death resulting from stroke; (3) death resulting from cardiac shock or unwitnessed sudden death; (4) death resulting from other cardiovascular reasons; (5) death resulting from undetermined reasons.

Supplementary Table 1. Detailed procedural characteristics of non-culprit vessels for patients undergoing multivessel interventions.

	Overall (n=151)	**Angiographic Guidance (n=75)**	**OCT Guidance (n=76)**	***p*-value**
Balloon angioplasty only	17 (11.3)	9 (12.0)	8 (10.5)	0.775
Stent implantation	132 (87.4)	66 (88.0)	66 (86.8)	0.830
Total number of stents[a]	1.4±0.7	1.6±0.8	1.2±0.5	0.002
Maximum stent diameter, mm[a]	3.01±0.39	3.03±0.39	2.98±0.40	0.543

Values are mean±SD or n (%).

[a]For patients with stent implantation at the non-culprit vessel. OCT: optical coherence tomography.

Supplementary Table 2. Medications at discharge.

	Overall[a] (n=3857)	Angiographic Guidance (n=1177)	OCT Guidance (n=2680)	*p*-value
Antiplatelet agent(s)	3856 (100.0)	1176 (99.9)	2680 (100.0)	0.305
Aspirin	3828 (99.2)	1161 (98.6)	2667 (99.5)	0.004
Clopidogrel	1604 (41.6)	552 (46.9)	1052 (39.3)	＜0.001
Ticagrelor	2238 (58.0)	621 (52.8)	1617 (60.3)	＜0.001
DAPT	3828 (99.2)	1166 (99.1)	2662 (99.3)	0.384
Statin	3818 (99.0)	1166 (99.1)	2652 (99.0)	0.753
Beta-blocker	2437 (63.2)	726 (61.7)	1711 (63.8)	0.200
ACEI/ARB	1988 (51.5)	596 (50.6)	1392 (51.9)	0.456

Values are n (%).

[a]40 patients died during hospitalization, resulting an overall population of 3857 at discharge.

ACEI: angiotensin-converting enzyme inhibitor; ARB: angiotensin II receptor blocker; DAPT: dual anti-platelet therapy; OCT: optical coherence tomography.

Supplementary Table 3. Baseline clinical and angiographic characteristics and the year of admission in the matched cohorts.

	Angiographic Guidance (n=1050)	OCT Guidance (n=1050)	*p*-value
Year of admission			0.343
2017	149 (14.2)	176 (16.8)	
2018	274 (26.1)	251 (23.9)	
2019	364 (34.7)	357 (34.0)	
2020	263 (25.0)	266 (25.3)	
Age, years	62.1±11.7	61.5±11.4	0.221
Male	716 (68.2)	731 (69.6)	0.479
Previous MI	90 (8.6)	91 (8.7)	0.938
Previous PCI	52 (5.0)	54 (5.1)	0.842
Dyslipidaemia	680 (64.8)	699 (66.6)	0.383
Diabetes mellitus	369 (35.1)	353 (33.6)	0.462
Hypertension	599 (57.0)	580 (55.2)	0.403
Smoking history	689 (65.6)	702 (66.9)	0.549
CKD	28 (2.7)	32 (3.0)	0.600
LVEF, %	55.1±8.8	55.5±8.2	0.242
Culprit vessel			0.459
LAD	453 (43.1)	454 (43.2)	
LCX	139 (13.2)	121 (11.5)	

RCA	458 (43.6)	475 (45.2)	
Preintervention of the culprit vessel			
DS, %	97.8±6.3	97.5±6.1	0.272
Total occlusion	724 (69.0)	699 (66.6)	0.243
TIMI flow 0/1	819 (78.0)	803 (76.5)	0.405
Multivessel disease	773 (73.6)	748 (71.2)	0.222

Values are mean±SD or n (%).

CKD: chronic kidney disease; DS: diameter stenosis; LAD: left anterior descending artery; LCX: left circumflex artery; LVEF: left ventricular ejection function; MI: myocardial infarction; OCT: optical coherence tomography; PCI: percutaneous coronary intervention; RCA: right coronary artery; TIMI: Thrombolysis In Myocardial Infarction.

Supplementary Table 4. Procedural characteristics during primary PCI in the matched cohorts.

	Angiographic Guidance (n=1050)	OCT Guidance (n=1050)	*p*-value
Thrombus aspiration	609 (58.0)	895 (85.2)	＜0.001
Stent implantation at the culprit vessel	833 (79.3)	690 (65.7)	＜0.001
Total number of stents[a]	1.4±0.6	1.2±0.5	＜0.001
Maximum stent diameter, mm[a]	3.10±0.42	3.19±0.42	＜0.001
Post-dilation[a]	623 (74.8)	573 (83.0)	＜0.001
Contrast-induced nephropathy	90 (8.6)	87 (8.3)	0.814
Multivessel intervention	63 (6.0)	37 (3.5)	0.008

Values are mean±SD or n (%).

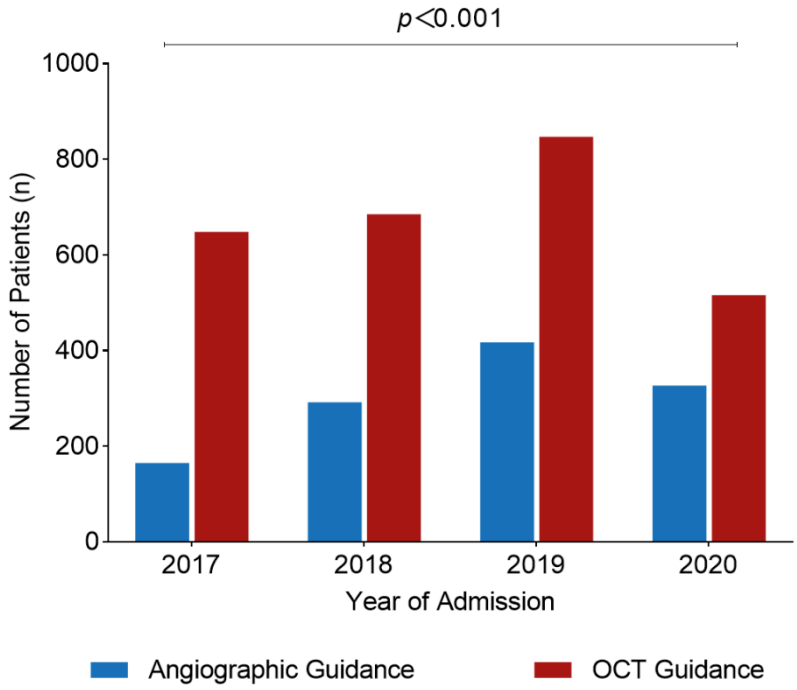
[a]For patients with stent implantation at the culprit vessel. Abbreviations as in Supplementary Table 3.

Supplementary Table 5. Detailed procedural characteristics of non-culprit vessels for patients undergoing multivessel interventions in the matched cohorts.

	Angiographic Guidance (n=63)	OCT Guidance (n=37)	*p*-value
Balloon angioplasty only	9 (14.3)	4 (10.8)	0.849
Stent implantation	54 (85.7)	33 (89.2)	0.849
Total number of stents[a]	1.6±0.8	1.1±0.3	0.001
Maximum stent diameter, mm[a]	3.02±0.39	2.90±0.35	0.164

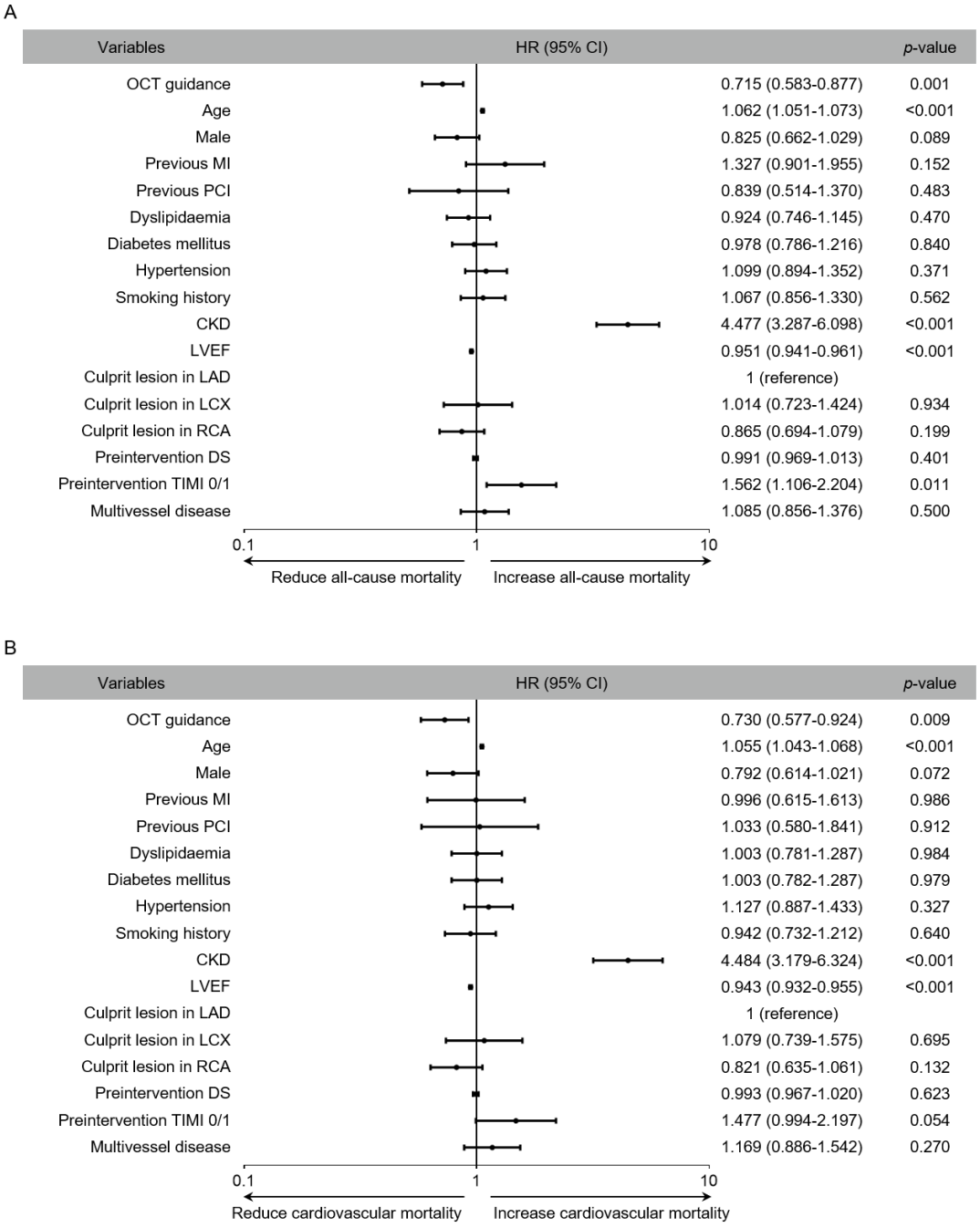
Values are mean±SD or n (%).

[a]For patients with stent implantation at the non-culprit vessel. Abbreviations as in Supplementary Table 1.



Supplementary Figure 1. Distributions of the study population in each year.

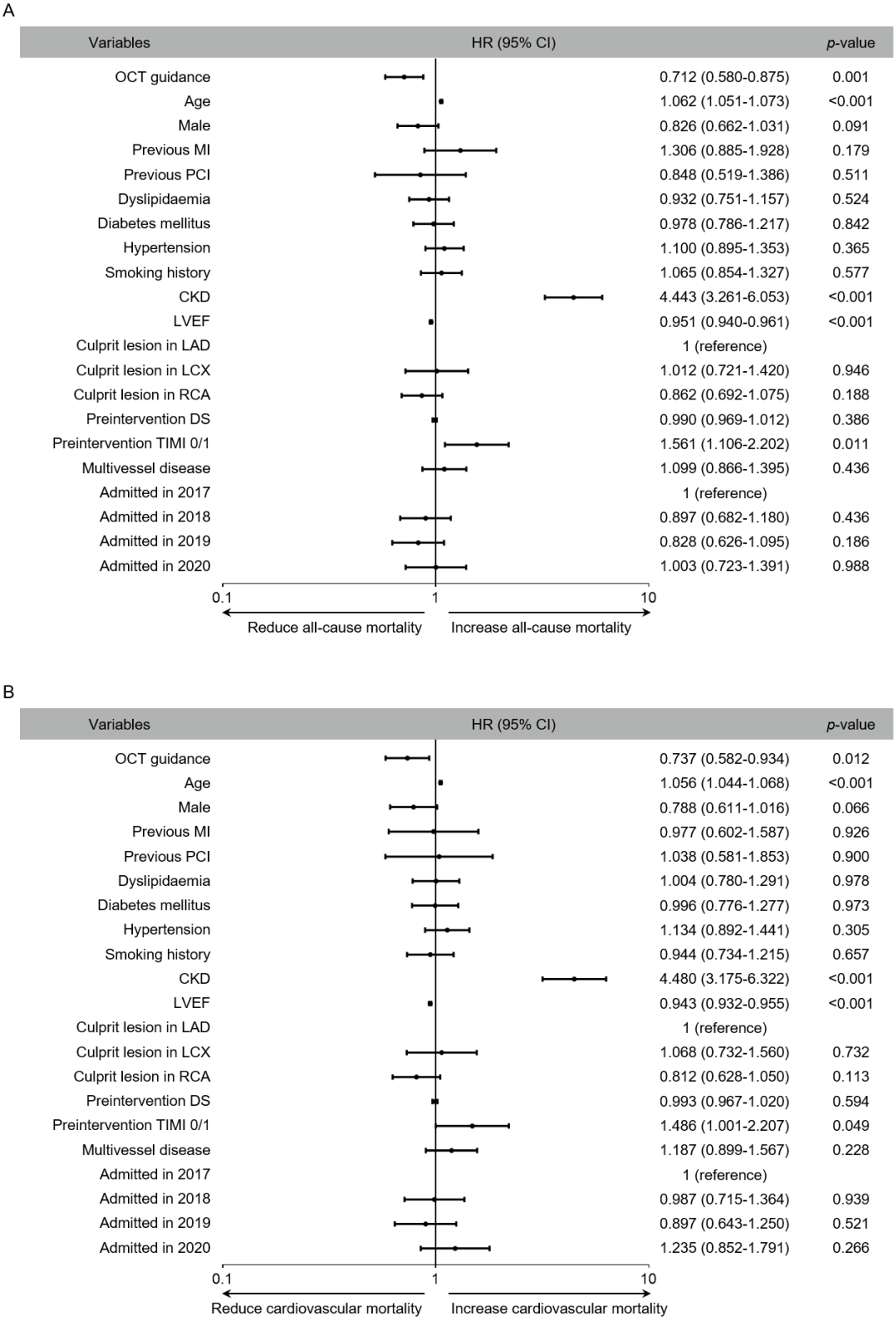
Figure legend: The rate of OCT application remained high and varied in different years in our center. Absolute number of OCT usage increased yearly from 2017 to 2019 and decreased in 2020 due to coronavirus disease 2019; OCT: optical coherence tomography.



Supplementary Figure 2. Predictors of 5-year mortality in multivariate model 1.

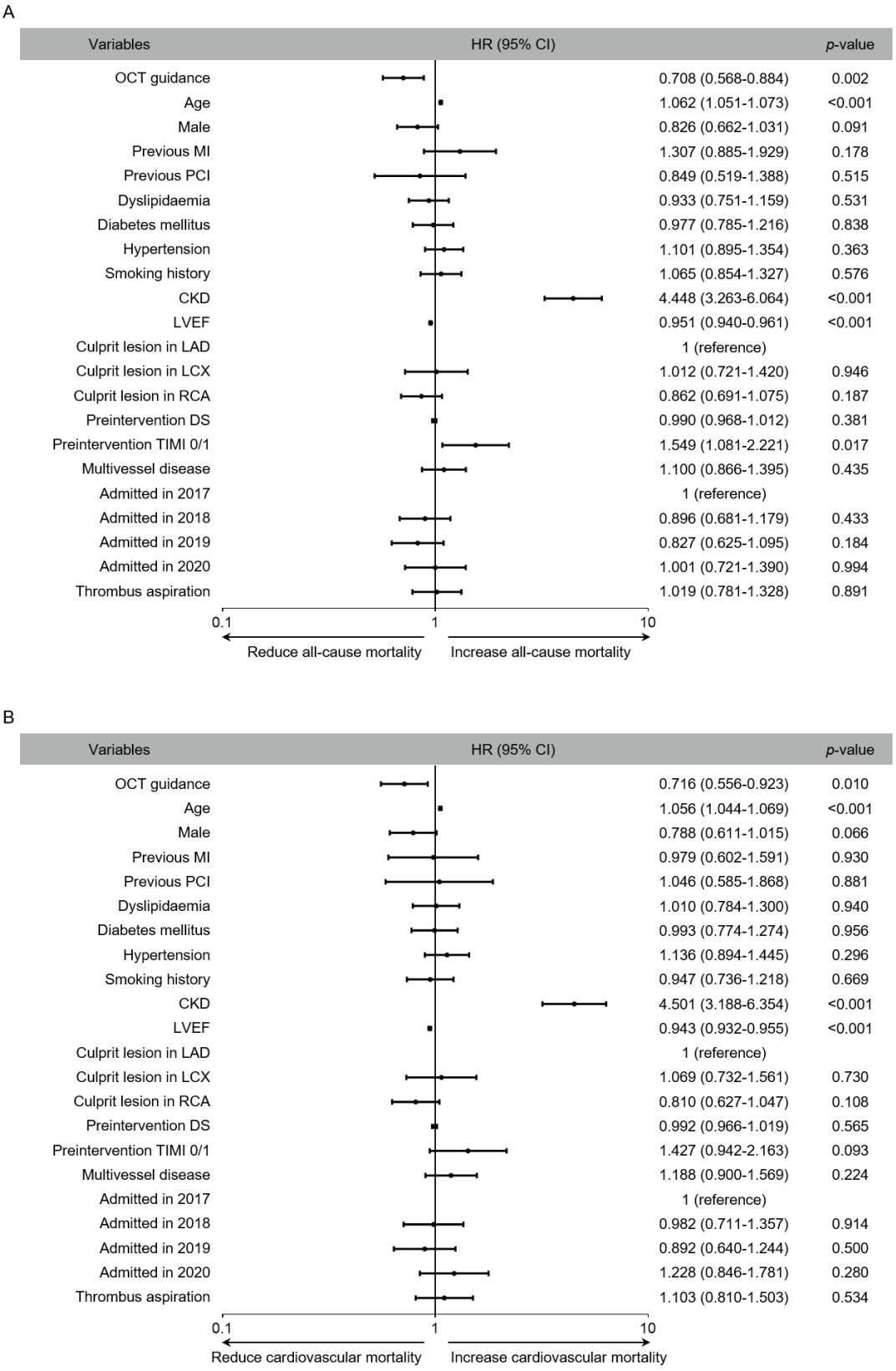
Figure legend: After adjusting for baseline clinical and angiographic characteristics, OCT guidance was an independent protective factor for 5-year all-cause mortality (A) and cardiovascular mortality (B) in Model 1. Other independent risk factors included age, CKD, and LVEF. Preintervention TIMI 0/1 was an independent risk factor for 5-year all-cause

mortality, but not for cardiovascular mortality. The scale of forest plot was transformed by $\log_{10}$. CI: confidence interval; CKD: chronic kidney disease; DS: diameter stenosis; HR: hazard ratio; LAD: left anterior descending artery; LCX: left circumflex artery; LVEF: left ventricular ejection fraction; MI: myocardial infarction; OCT: optical coherence tomography; PCI: percutaneous coronary intervention; RCA: right coronary artery; TIMI: Thrombolysis In Myocardial Infarction.



Supplementary Figure 3. Predictors of 5-year mortality in multivariate model 2.

Figure legend: After adjusting for factors in Model 1 and the year of admission, OCT guidance was also an independent protective factor for 5-year all-cause mortality (A) and cardiovascular mortality (B) in Model 2. Other independent risk factors include age, CKD, LVEF and preintervention TIMI 0/1. The year of admission was not independently associated with 5-year mortality. The scale of forest plot was transformed by $\log_{10}$. Abbreviations as in Supplementary Figure 2.



Supplementary Figure 4. Predictors of 5-year mortality in multivariate model 3.

Figure legend: After adjusting for factors in Model 2 and thrombus aspiration, OCT guidance was still an independent protective factor for 5-year all-cause mortality (A) and cardiovascular mortality (B) in Model 3. Other independent risk factors included age, CKD, and LVEF. Preintervention TIMI 0/1 was an independent risk factor for 5-year all-cause mortality, but not for cardiovascular mortality. Thrombus aspiration was not independently associated with 5-year mortality. The scale of forest plot was transformed by $\log_{10}$. Abbreviations as in Supplementary Figure 2.