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Clinical paper

The effect of immediate coronary angiography after cardiac arrest without ST-segment elevation on left ventricular function. A sub-study of the COACT randomised trial

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Abbreviations: PCI, percutaneous coronary intervention; STEMI, ST-segment elevation myocardial infarction; ECG, electrocardiography; CMR, cardiac magnetic resonance imaging; CABG, coronary artery bypass grafting.

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Abstract

Background: The effect of immediate coronary angiography and percutaneous coronary intervention (PCI) in patients who are successfully resuscitated after cardiac arrest in the absence of ST-segment elevation myocardial infarction (STEMI) on left ventricular function is currently unknown.

Methods: This prespecified sub-study of a multicentre trial evaluated 552 patients, successfully resuscitated from out-of-hospital cardiac arrest without signs of STEMI. Patients were randomized to either undergo immediate coronary angiography or delayed coronary angiography, after neurologic recovery. All patients underwent PCI if indicated. The main outcomes of this analysis were left ventricular ejection fraction and end-diastolic and systolic volumes assessed by cardiac magnetic resonance imaging or echocardiography.

Results: Data on left ventricular function was available for 397 patients. The mean (± standard deviation) left ventricular ejection fraction was 45.2% (±12.8) in the immediate angiography group and 48.4% (±13.2) in the delayed angiography group (mean difference: −3.19; 95% confidence interval [CI], −6.75 to 0.37). Median left ventricular end-diastolic volume was 177 ml in the immediate angiography group compared to 169 ml in the delayed angiography group (ratio of geometric means: 1.06; 95% CI, 0.95−1.19). In addition, mean left ventricular end-systolic volume was 90 ml in the immediate angiography group compared to 78 ml in the delayed angiography group (ratio of geometric means: 1.13; 95% CI 0.97−1.32).

Conclusion: In patients successfully resuscitated after out-of-hospital cardiac arrest and without signs of STEMI, immediate coronary angiography was not found to improve left ventricular dimensions or function compared with a delayed angiography strategy.

Clinical Trial Registration: Netherlands Trial Register number, NTR4973

Keywords: Out of hospital cardiac arrest, Coronary angiography, Percutaneous coronary intervention, Left ventricular function

Introduction

Out-of-hospital cardiac arrest is a leading cause of mortality and morbidity in Europe and the United States. Even if there is restoration of spontaneous circulation in patients after cardiac arrest, the outcome remains poor. A previous study reported that approximately 40% of patients successfully resuscitated from cardiac arrest associated with ventricular fibrillation or pulseless ventricular tachycardia do not survive.[1]

The aetiology of cardiac arrest is diverse however, the most common cause is ischemic heart disease. Studies have reported coronary artery disease in up to 70% of patients who underwent immediate coronary angiography after out-of-hospital cardiac arrest.[2] If myocardial infarction is the cause of the arrest, immediate coronary angiography and percutaneous coronary intervention (PCI) might salvage myocardium and prevent the loss of cardiac function and by doing so, improve outcome. For this reason, current European and American guidelines recommend immediate coronary angiography and PCI in patients who present with ST-segment elevation myocardial infarction (STEMI) and cardiac arrest.[3,4]

However, the role of immediate coronary angiography in patients with cardiac arrest who do not have ST-segment elevation on electrocardiography (ECG), is less clear. The Coronary Angiography After Cardiac Arrest (COACT) trial was designed to test the hypothesis that, in patients successfully resuscitated after cardiac arrest without ST-segment elevation, a strategy of immediate coronary angiography and PCI if necessary, results in better survival compared to a strategy of delayed angiography. However, no difference in 90-day or one-year survival was found between the two treatment groups.[5,6] Nevertheless even in the absence of ST-segment elevation, the cause of the arrest can be an acute coronary syndrome and if this is the result of an acutely occluded coronary artery, an immediate PCI may limit myocardial infarction and preserve left ventricular function, leading to less morbidity and improved long-term survival.

The aim of this prespecified sub-study of the COACT trial is to evaluate the effect of a strategy of immediate coronary angiography (and PCI if necessary) in patients successfully resuscitated from cardiac arrest without STEMI on left ventricular function.

Methods

Study design and oversight

The COACT trial was an investigator-initiated, randomized, open-label, multicentre trial comparing immediate coronary angiography with delayed coronary angiography in patients successfully resuscitated from cardiac arrest without ST-segment elevation on the ECG. The trial design has been published previously.[7] The protocol was designed by the principal authors and was approved by the steering committee (Supplementary Appendix) and all relevant ethics committees. The study complied with the Declaration of Helsinki.

A clinical research organization (Clinical Research Unit Cardiology VUmc) was responsible for maintaining and monitoring the patient data. A data and safety monitoring committee oversaw the trial. The statistician vouches for the accuracy of the statistical analyses.

Patients

Patients were eligible for the study if they had an out-of-hospital cardiac arrest with an initial shockable rhythm, and were unconscious after the return of spontaneous circulation. Patients were excluded if they had signs of STEMI on the ECG in the emergency department, shock, or an obvious non-coronary cause of the arrest. Further inclusion and exclusion criteria and definitions are listed in the Supplemental Appendix. For all enrolled patients, deferred informed consent was obtained with the use of a prespecified procedure (Supplementary Appendix).

For the present sub-study, patients were included from the COACT trial when cardiac magnetic resonance imaging (CMR) or echocardiography images during index hospitalization was available.

Randomization and treatment

Patients eligible for the COACT trial were randomized in a 1:1 ratio to either an immediate or a delayed coronary angiography using a Web-based randomization system (Castor EDC). In patients allocated to the immediate coronary angiography group, coronary angiography was performed as soon as possible and was initiated within 2 h after randomization. In the delayed coronary angiography group, coronary angiography was performed after neurological recovery and in general, following discharge from the intensive care unit. If a patient initially allocated to the delayed coronary angiography group showed signs of cardiogenic shock, recurrent life-threatening arrhythmias, or recurrent ischemia during hospitalization, urgent coronary angiography was performed.

The choice of anticoagulant and revascularization strategy was left to the discretion of the treating physicians, though it was recommended to treat all coronary lesions suspected of being unstable.

Further post-resuscitation care was in line with the resuscitation guidelines.[8]

Imaging

The outcomes of this study were left ventricular function and left ventricular end-diastolic and systolic volumes. These were preferably assessed by Cardiac Magnetic Resonance (CMR) or in the absence of assessable CMR imaging, by echocardiography during index hospitalization. In case more than one echocardiogram was available, images with the highest quality were used. Left ventricular function was represented as ejection fraction in percentage and was further classified as either severely abnormal $<30\%$, moderately abnormal $30-40\%$, mildly abnormal $41-52\%$ or normal $\geq 53\%$.[9]

For CMR evaluation, commercially available software (CMR42; Circle Cardiovascular Imaging Inc., Calgary, Canada) was used to assess left ventricular volumes and function, using the short-axis cine images stack. CMR images were not assessable, if short-axis cine images were absent or the quality of imaging was poor.

For echocardiographic evaluation, Xcelera R4.1 (Philips Medical Systems) was used. If a transthoracic echocardiogram was not available, a transoesophageal echocardiogram was used. Left ventricular ejection fraction was measured using the Modified Simpson method (a two-dimensional measurement strategy). In case the Modified Simpson method could not be used, left ventricular function was estimated visually, following the established ranges of left ventricular function as mentioned above. Echocardiographic images were not assessable, if short-axis, two, three and four-chamber view images were absent.

Two independent blinded experts assessed the outcomes of interest. In case of a discrepancy between the assessors, a third blinded expert accounted for evaluating the results.

Statistical analysis

This sub-study was powered for the quantitative ejection fraction determined by cine short-axis and biplane. Standard deviations of left ventricular ejection fraction reported in previous observational studies ranged from 15% to 20%.[10–12] The number of 206 patients (105 in the immediate and 101 in the delayed group) in this sub-study for which left ventricular ejection fraction obtained by CMR or echocardiography using the Modified Simpson method was available allows detection of an absolute mean differences in left ventricular ejection fraction between the immediate and delayed group of 5.8% and 7.8% with 80% power when standard deviation is 14% and 20%, respectively. Power calculation assumes comparison with an independent samples *t*-test and a two-sided significance level of 5%.

All analyses were performed according to the intention-to-treat principle. Categorical variables were reported as frequency with percentage. Continuous variables that were normally distributed, were reported as mean $\pm$ standard deviation (SD). Continuous variables that were not normally distributed, were reported as median and interquartile range (IQR). Effect sizes with 95% confidence intervals (CIs) are reported for the clinical outcomes, rather than P values, as all analyses presented are for secondary endpoints. Mean differences with 95% CIs are presented for normally distributed endpoints and the ratio of geometric means with 95% CIs are presented for continuous outcomes that are not normally distributed. Odds ratios are reported for categorical outcomes. The delayed strategy group was used as the reference group when calculating the effect sizes. Data was analysed with the Statistical Package for Social Sciences (SPSS) statistics, version 26 software (IBM Corporation Armonk, NY, USA).

Results

Patients

Between January 2015 and July 2018, 552 patients successfully resuscitated from cardiac arrest and without ST-segment elevation on

ECG were enrolled in the trial at 19 participating Dutch centres (Fig. 1). Screening data were available during the final period of inclusion, when all centres were enrolling patients (Supplementary Appendix Fig. 1). After excluding patients for whom informed consent was retrospectively refused, data was available in 538 patients (97.5%). In addition 141 patients were excluded because imaging was not available or assessable, leaving 397 patients (73.8%) in which left ventricular function and dimensions could be assessed; 202 of these patients had been assigned to the immediate angiography group and 195 to the delayed angiography group. The most frequent reason for not having imaging available was because the patient deceased before such imaging was performed. This occurred in 70.9% of cases.

Further baseline characteristics are shown in Table 1. The mean (± SD) age was 63.7 ± 12.8 years and 80.3% of patients were men. The baseline characteristics from patients in this cohort did not differ from the baseline characteristics from all patients included in the COACT study.

Treatment

Procedural and treatment characteristics are shown in Table 2 and Supplementary Appendix Table S1. Coronary angiography was performed in 200 patients (99.0%) in the immediate angiography group and 150 patients (76.9%) in the delayed angiography group. The median time from randomization to coronary angiography was 0.8 h in the immediate angiography group and 137 h in the delayed angiography group. In both groups, the coronary angiogram showed an acute unstable lesion in 14.0% of patients. An acute thrombotic occlusion was found in 3.0% of patients in the immediate angiography group and 6.7% of patients in the delayed angiography group. A chronic total occlusion in one of the coronary arteries was found in 34.0% of patients in both the immediate and the delayed angiography groups. The rate of PCI was 36.6% in the immediate angiography group and 27.2% in the delayed angiography group. Coronary Artery Bypass Grafting (CABG) was performed in 6.9% of patients in the

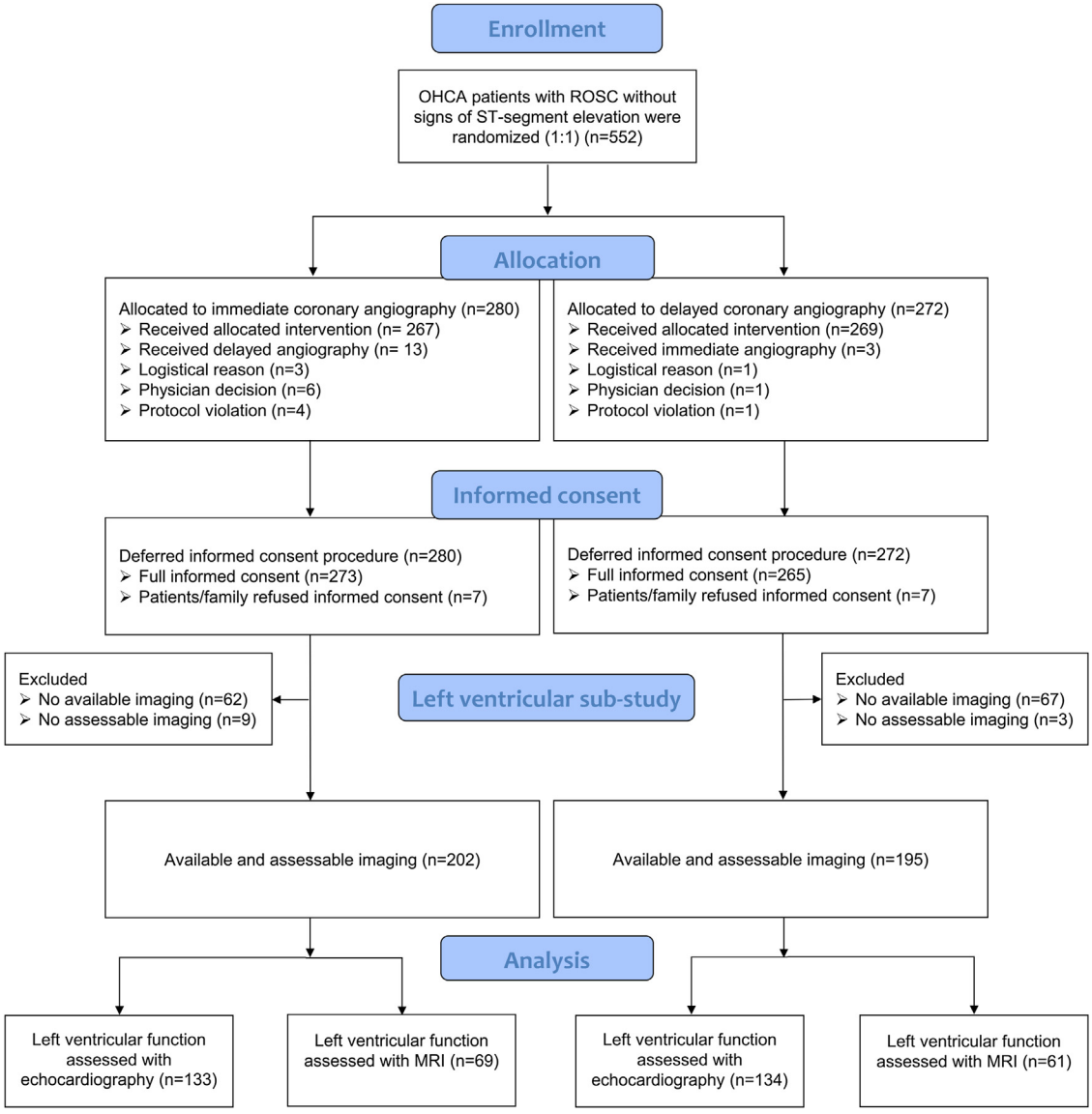

Fig. 1 – Study flowchart. OHCA, out-of-hospital cardiac arrest; ROSC, restore of spontaneous circulation; MRI, magnetic resonance imaging.

Table 1 – Baseline characteristics of the patients.

Characteristic	Immediate angiography group (*N* = 202)	Delayed angiography group (*N* = 195)
Age – yr, mean ± SD	63.7 ± 12.8	63.7 ± 12.8
Male sex – no.	168 (83.2)	151 (77.4)
Hypertension – no./total no.	96/201 (47.8)	90/195 (46.2)
Previous myocardial infarction – no.	51 (25.2)	46 (23.6)
Previous CABG – no./total no.	31/201 (15.4)	17/195 (8.7)
Previous PCI – no./total no.	31/201 (15.4)	36/194 (18.6)
Previous coronary artery disease – no.	69 (34.2)	60 (30.8)
Previous cerebrovascular accident – no./total	11/201 (5.5)	9/195 (4.6)
Diabetes mellitus – no./total no.	35/201 (17.4)	30/195 (15.4)
Current smoker – no./total no.	39/190 (20.5)	49/185 (26.5)
Hypercholesterolemia – no./total no.	53/201 (26.4)	50/194 (25.8)
Peripheral artery disease – no./total no.	10/201 (5.0)	15/195 (7.7)
Arrest witnessed – no.	168 (83.2)	146 (74.9)
Median time from arrest to basic life support (IQR) – min	2 (0–4)	2 (0–4)
Median time from arrest to return of spontaneous circulation (IQR) – min	15 (9–21)	12 (5.5–18.5)
Signs of ischemia on ECG[a]	121/193 (62.7)	127/183 (69.4)
GCS score at admission, median (IQR)[b]	3 (3–3)	3 (3–3)
APACHE IV score, mean ± SD[c]	106 ± 28	103 ± 32
Baseline laboratory values		
pH, mean (SD)	7.22 ± 0.13	7.23 ± 0.13
Lactate, median (IQR), mmol/L	5.2 (3.1–8.8)	4.7 (2.7–7.4)
Bicarbonate, mean (SD), mmol/L	19.3 ± 4.2	19.3 ± 4.3
Partial pressure of oxygen, median (IQR), kPa	15.0 (9.2–26.9)	15.3 (10.5–24.4)
Creatinine, median (IQR), μmol/L	101 (90–118)	100 (85–113)
Creatine kinase, median (IQR),U/L	166 (121–266)	163 (118–251)
Creatine kinase MB, median (IQR), μmol/L	6.0 (4.0–11.3)	6.5 (3.9–20.2)
Troponin T, median (IQR), μmol/L	0.043 (0.028–0.094)	0.055 (0.026–0.112)

Abbreviations: CABG, coronary-artery bypass grafting; PCI, percutaneous coronary intervention. Data is reported as mean ± standard deviation; no. (%); median IQR, interquartile range (25th percentile–75th percentile).

[a] Signs of ischemia on electrocardiography (ECG) are defined as depressions of 1 mm or more in two contiguous leads or T-wave inversion in two contiguous leads, or both.

[b] GCS scores range from 3 to 15, with lower scores indicating a reduced level of consciousness.

[c] APACHE IV scores range from 0 to 286, with higher scores indicating a higher risk of death.

immediate angiography group and 10.3% of patients in the delayed angiography group. Patients allocated to the immediate angiography were more often treated with a glycoprotein IIb/IIIa inhibitor, while patients allocated to the delayed coronary angiography were more likely to be treated with salicylates and/or a P2Y12 inhibitor.

Over 90% of patients in each group were treated with targeted temperature management (TTM) and mechanical ventilation. Time to target temperature for those receiving this treatment was 5.5 h in the immediate angiography group and 4.7 h in the delayed angiography group.

Left ventricular function

Left ventricular ejection fraction was obtained in 206 patients (51.9%) In 130 (32.7%) patients this was assessed by CMR and in 76 (19.1%) by echocardiography using biplane mode. Left ventricular function classified in ranges was gathered in all 397 patients (100%). The median time from arrest to assessment of the left ventricular function was 5[1–9] days for patients in the immediate angiography group and 5[1–10] days for patients in the delayed angiography group.

Echocardiographic and CMR outcomes are reported in Table 3 and Fig. 2. The mean (±SD) left ventricular ejection fraction was 45.2% (±12.8) in the immediate angiography group and 48.4% (±13.2) in the delayed angiography group (mean difference: −3.19; 95% CI −6.75 to 0.37). Furthermore, no difference was found with respect to the left ventricular function, classified in ranges, between the two treatment groups. Left ventricular function was normal (EF ≥53%) in 28.7% of patients in the immediate group and in 34.9% in the delayed group. Left ventricular function was mildly abnormal (EF 41–52%) in 30.2% of patients in the immediate group compared to 28.7% in the delayed group. The odds ratio for mildly abnormal ventricular function relative to normal functioning was 1.28 (95% CI 0.77–2.12). Left ventricular function was moderately abnormal (EF 30–40%) in 22.8% of patients in the immediate group compared to 17.9% in the delayed group. The odds ratio for moderate abnormal function relative to normal functioning was 1.54 (95% CI 0.88–2.70). Finally, left ventricular function was severely abnormal (EF < 30%) in 18.3% of patients in the immediate group compared to 18.5% in the delayed group with the odds ratio for severely abnormal functioning relative to normal functioning being 1.21 (95% CI 0.68–2.15). Proportion of patients on inotropic medications at the time of imaging are reported in Table S2.

Left ventricular dimensions

Median left ventricular end-diastolic volume was 177 ml (geometric mean: 173 ml) in the immediate angiography group compared to 169 ml (geometric mean: 163 ml) in the delayed angiography group

Table 2 – Procedures, characteristics of coronary artery disease and treatments.

Variable	Immediate angiography group (*N* = 202)	Delayed angiography group (*N* = 195)
Coronary angiography performed – no.	200 (99.0)	149 (76.4)
Median time from arrest to coronary angiography (IQR) – h	2 (1.7–2.9)	135 (59.7–210.3)
Median time from randomization to coronary angiography (IQR) – h	0.8 (0.5–1.2)	137 (55.7–219.2)
Severity of coronary artery disease – no./total no.		
Non-significant coronary stenosis	77/200 (38.5)	55/149 (36.9)
One-vessel disease	54/200 (27.0)	42/149 (28.2)
Two-vessel disease	43/200 (21.5)	27/149 (18.1)
Three-vessel disease	26/200 (13.0)	25/149 (16.8)
Acute unstable lesion	28/200 (14.0)	21/149 (14.1)
Acute thrombotic occlusion	7/200 (3.5)	10/149 (6.7)
Chronic total occlusion	68/200 (34.0)	50/149 (33.6)
Revascularization treatment – no.		
CABG	14 (6.9)	20 (10.3)
PCI	74 (36.6)	53 (27.2)
Conservative treatment	116 (57.4)	122 (62.6)
Timing of PCI – no./total no.		
PCI during index coronary angiography	52/74 (70.3)	42/53 (79.2)
Staged PCI	17/74 (23.0)	11/53 (20.8)
PCI both during index coronary angiography and staged	5/74 (6.8)	0/53 (0.0)
Critical care support		
TTM – no.	192 (95.0)	182 (93.3)
Time to target temperature – h	5.5 (2.7–8.4)	4.7 (2.2–7.2)
Mechanical ventilation support – no.	193 (95.5)	184 (94.4)
Inotropic or catecholamine support – no.		
Noradrenaline	174 (86.1)	166 (85.1)
Dopamine	8 (4.0)	14 (7.2)
Dobutamine	49 (24.3)	55 (28.2)
Phosphodiesterase administration	17 (8.4)	18 (9.2)
Drug therapy during hospitalization – no.		
Salicylates	152 (75.2)	169 (86.7)
P2Y12 inhibitor	122 (60.4)	138 (70.8)
Unfractionated heparin/LMWH	187 (92.6)	174 (89.2)
Glycoprotein IIb/IIIa inhibitor	14 (6.9)	7 (3.6)
Bivalirudin	2 (1.0)	1 (0.5)
Betablocker	150 (74.3)	157 (80.5)
ACE-inhibitor or angiotensin II receptor blocker	137 (67.8)	139 (71.3)
Amiodarone	58 (28.7)	55 (28.2)

Abbreviations: CABG, coronary-artery bypass grafting; PCI, percutaneous coronary intervention; TTM, targeted temperature management; LMWH, low-molecular-weight heparin, ACE, angiotensin-converting-enzyme.
Data is reported as mean ± standard deviation; no. (%); median IQR, interquartile range (25th percentile–75th percentile).

(ratio of geometric means: 1.06; 95% CI, 0.95–1.19). Mean left ventricular end-systolic volume was 90 ml (geometric mean: 93 ml) in the immediate angiography group compared to 78 ml (geometric mean: 82 ml) in the delayed angiography group (ratio of geometric means: 1.13; 95% CI 0.97–1.32).

Discussion

The COACT trial compared immediate coronary angiography with delayed coronary angiography in patients successfully resuscitated from out-of-hospital cardiac arrest without ST-segment elevation on the ECG and in the absence of an obvious non-coronary cause of the arrest. In the COACT trial, 90-day and one-year survival did not differ significantly between the two treatment strategies.[5,6] We found no significant difference in left ventricular ejection fraction between the immediate and delayed groups in the analysis reported here. Furthermore, we observed no significant difference in left ventricular end-diastolic volume, left ventricular end-systolic volume and left ventricular function, classified in ranges, between the two treatment groups.

These findings are consistent with the previous observation that myocardial injury quantified as area's under the curve of troponin, creatine kinase and creatine kinase MB levels did not differ between the two treatment groups in the COACT study.[5]

Our findings are further in line with previous observational studies that found no difference in left ventricular function between post-cardiac arrest patients treated with immediate coronary angiography and those treated with delayed coronary angiography.[11,13] In the COACT trial the mean left ventricular ejection fraction was 46.7%, similar to the 47.0% reported by Garcia et al.[11]

The recently published PEARL trial, a small randomized pilot study of 99 patients, found no difference in the rates of a normal wall motion score index or left ventricular ejection fraction ≥50% on echocardiogram, between post-cardiac arrest patients treated with early coronary angiography versus no early coronary angiography. However, the

Table 3 – Clinical outcomes imaging.

Outcomes	Immediate angiography group (*N* = 202)	Delayed angiography group (*N* = 195)	Effect size[b] (95%CI)
Mean left ventricular ejection fraction – %[a]	45.2 ± 12.8	48.4 ± 13.2	−3.19 (−6.75 to 0.37)
Left ventricular function ranges – no. (%)			
Severely abnormal – <30%	37 (18.3)	36 (18.5)	1.21 (0.68–2.15)
Moderately abnormal – 30 to 40%	46 (22.8)	35 (17.9)	1.54 (0.88–2.70)
Mildly abnormal – 41 to 52%	61 (30.2)	56 (28.7)	1.28 (0.77–2.12)
Normal – ≥53%	58 (28.7)	68 (34.9)	[c]
Median left ventricular end-diastolic volume – ml			
Median (IQR)	177 (130–239)	169 (120–215)	
Geometric mean (95% CI)	173 (160–188)	163 (151–176)	1.06 (0.95–1.19)
Median left ventricular end-systolic volume – ml			
Median (IQR)	90 (58–140)	78 (58–120)	
Geometric mean (95% CI)	93 (83–103)	82 (74–91)	1.13 (0.97–1.32)

[a] Analysis done with patients of whom left ventricular ejection fraction was assessable by cine short-axis or biplane; immediate group *N* = 105, delayed group *N* = 101.
[b] The effect size is the ratio of geometric means for the left ventricular end-systolic and end-diastolic volumes. The delayed angiography group is used as the reference group for odds ratios and mean differences.
[c] Normal left ventricular function was used as the reference category.

PEARL study did not report on the mean left ventricular ejection fraction and the study was terminated prematurely due to slow recruitment.[14]

The majority of patients in our study had a normal or mildly abnormal left ventricular function. This might explain the previous reported low rates of hospitalization due to heart failure at one year of 0.8% in the immediate coronary angiography group and 0.4% in the delayed coronary angiography group.[6] As well as the low rates of mortality between 90 days and one year of 3.0% in the immediate coronary angiography group and 3.5% in the delayed coronary angiography group.[6] Seeing that an earlier reported study found increased mortality rates in patients who survived out-of-hospital cardiac arrest with left ventricular dysfunction, while patients with a normal left ventricular function showed long-term survival rates similar to that of the general healthy population.[15]

The comparable left ventricular function between the two treatment groups is also in line with the similar rates of ICD shocks at one year in the COACT trial reported before,[6] since left ventricular function is found to be an independent predictor of the reoccurrence of ventricular arrhythmias in recipients of an ICD for secondary prevention.[16]

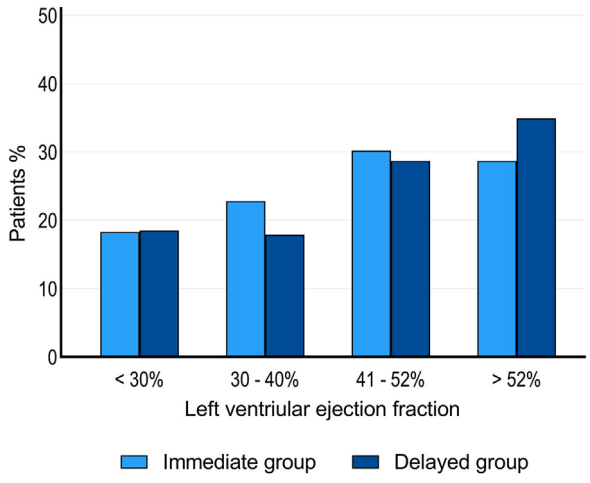

Fig. 2 – Left ventricular function in ranges in patients with OHCA without STEMI. OHCA, out-of-hospital cardiac arrest; STEMI, ST-elevation myocardial infarction.

In addition, our results are also consistent with the LIPSIA-NSTEMI trial. This randomized study addressed the role of immediate versus delayed coronary angiography in patients with myocardial infarction without ST-segment elevation and who had not presented with cardiac arrest and also found no difference in left ventricular function between the two treatment strategies. The left ventricular ejection fraction was 55% in both groups in this study.[17]

An important explanation for the lack of benefit of immediate coronary intervention on left ventricular function might be that although coronary artery disease was found in 62.2% of patients who underwent coronary angiography, most patients had stable coronary artery disease. Lesions that require immediate PCI to prevent loss of myocardium were encountered in a minority of patients, with only 5% of patients having an acute thrombotic occlusion.

In the COACT trial, patients assigned to the immediate coronary angiography group reached their target temperature later than patients in the delayed coronary angiography group. And although the role of TTM as means of protecting left ventricular function after cardiac arrest is still a matter of debate, while studies have shown conflicting outcomes,[18–20] one could argue that a later achievement of target temperature might have attenuated any potential benefit gained from immediate coronary angiography.

Our study has several limitations. First, left ventricular function could be evaluated in only 73.8% of patients. The most frequent reason for not assessing left ventricular function being that the patient deceased before such evaluation was performed. This may result in potential selection bias for survivors. Second, the timing of imaging was not fixed in the protocol. Left ventricular function was assessed at a median of 5 days after the arrest in both groups which is relatively early as cardiac stunning may play a role in these patients and left ventricular function may improve over time. Third, these results do not apply to patients with shock, severe renal dysfunction, or persistent ST-segment elevation since patients with these conditions were excluded from the COACT trial. Fourth, left ventricular function prior to arrest was not available. Finally, all the left ventricular function outcomes should be considered exploratory as the COACT

study was powered for the analysis of the primary endpoint of survival at 90-days.

In conclusion, in this randomized, multicentre trial of patients who were successfully resuscitated from out-of-hospital cardiac arrest and without signs of STEMI, an immediate angiography strategy did not improve left ventricular dimensions or function compared with a delayed angiography strategy.

Conflict of interest statement

The COACT trial was supported by unrestricted research grants from the Netherlands Heart Institute, Biotronik, and AstraZeneca. Dr. Vlachojannis reports receiving grant support from MicroPort Orthopedics and Daiichi Sankyo; and Dr. van Royen, receiving grant support from Philips, Biotronik, and Abbott and honoraria from Medtronic.

Authors' contribution

All authors have made substantial contributions to all of the following: (1) the conception and design of the study, or acquisition of data, or analysis and interpretation of data, (2) drafting the article or revising it critically for important intellectual content, (3) final approval of the version to be submitted.

Declaration of Competing Interest

The authors report no declarations of interest.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at https://doi.org/10.1016/j.resuscitation.2021.04.020.

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