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Clinical paper

Coronary angiographic findings and outcomes in patients with sudden cardiac arrest without ST-elevation myocardial infarction: A SWEDEHEART study[☆]

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ABSTRACT

Background/aim: Sudden cardiac arrest (SCA) has a substantial mortality rate and the acute coronary syndrome constitutes the major cause. Post-resuscitation electrocardiogram ST-elevation SCA (STE-SCA) is a strong indication for emergency coronary angiography, but the role of early angiography and PCI in patients without ST-elevation (NSTE-SCA) remains to be established. This paper aimed to describe this patient group and evaluate the prognostic effect of early PCI in a large nationwide cohort of NSTE-SCA patients undergoing coronary angiography.
Methods: Data from SCAAR (Swedish Coronary Angiography and Angioplasty Registry) and RIKS-HIA (Register of Information and Knowledge about Swedish Heart Intensive Care Admissions) on 4308 SCA patients in Sweden between 2005 and 2016 were descriptively analyzed and related to mortality within 30-days in both unadjusted and adjusted analyses using Cox proportional hazard models.
Results: NSTE-SCA patients had more often serious comorbidities than STE-SCA patients. Among NSTE-SCA patients, 36.4% had no significant coronary artery stenosis while severe coronary stenosis ($\geq$90%) was present in 43.9% (1271/2896). In NSTE-SCA patients with significant stenosis ($\geq$90%), PCI was performed in 59.2% (753/1271) with an increased unadjusted 30-day mortality (40.9% vs. 32.7%; p = .011). However, after adjustments for confounders, no difference in mortality was observed (hazard ratio 1.07; 95% CI 0.84–1.36; p = .57).
Conclusion: In resuscitated SCA patients without ST-elevation who underwent coronary angiography, this large retrospective study found severe coronary artery stenosis in 43.9% but found no clear benefit of early PCI. Prospective randomized controlled trials are needed to accurately define the role of coronary angiography and PCI in post-resuscitation care.

Introduction

Sudden cardiac arrest (SCA) has, despite advances in acute medical care, a persistently high mortality rate and the acute coronary syndrome (ACS) still constitutes the major cause [1–3]. The "chain of survival" denotes the importance of post-resuscitation care, including coronary angiography with subsequent percutaneous coronary intervention (PCI) when indicated to save the heart and avoid recurrent arrest [4,5]. Most deaths before day three after SCA are due to post SCA multi-organ failure, a condition that occurs in 68% of out-of-hospital SCA (OHCA) patients [6]. The multi-organ failure is characterized by haemodynamic instability that is reversible within three days [7].

Abbreviations: EAPCI, European Association for Percutaneous Cardiovascular Interventions; NSTE-SCA, sudden cardiac arrest without ST-elevation; RIKS-HIA, Register of Information and Knowledge about Swedish Heart Intensive Care Admissions; SCAAR, Swedish Coronary Angiography and Angioplasty Registry; SFL, Stent for Life; STE-SCA, post-resuscitation electrocardiogram ST-elevation sudden cardiac arrest; SWEDEHEART, Swedish Websystem for Enhancement of Evidence-Based Care in Heart Disease Evaluated According to Recommended Therapies

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Post-resuscitation electrocardiogram (ECG) ST-elevation SCA (STE-SCA) is a strong indication for emergent coronary angiography [5]. However, ECG has been shown to be a poor predictor of acute occlusion as approximately one in three to one in four OHCA patients without ST-elevation have acute occlusions [8–16]. Moreover, acute angiography and PCI were associated with improved survival in some observational studies [8,11,16], however, other studies report conflicting outcome data [17,18].

It is important to determine the characteristics of SCA patients without ST-elevation on the post-resuscitation ECG (NSTE-SCA), in order to identify those who may benefit from angiography and PCI. To date, no nationwide study has investigated this matter. The aim of this nationwide study was therefore to describe the demographics, angiographic findings, mortality rate and prognostic value of PCI and identify any factors associated with coronary artery stenosis (≥90%) in NSTE-SCA patients undergoing coronary angiography.

Methods

National registries and patient selection

Data were obtained from SCAAR (Swedish Coronary Angiography and Angioplasty Registry) and RIKS-HIA (Register of Information and Knowledge about Swedish Heart Intensive Care Admissions), both of which are part of the SWEDEHEART registry (Swedish Websystem for Enhancement of Evidence-Based Care in Heart Disease Evaluated According to Recommended Therapies) [19]. SCAAR contains data from all angiographies and PCI that have been performed at any of the 30 PCI centers in Sweden, whereas RIKS-HIA contains data from all patients hospitalized at any of the Swedish intensive coronary care units. A total of 387694 patients underwent coronary angiography in Sweden between January 2005 and December 2016 (Fig. 1). All patients who underwent coronary angiography due to SCA (n = 4308) or ACS (n = 212643) in Sweden during the study period were included. Cardiac arrest was categorized into STE-SCA (1412; 32.8%) and NSTE-SCA (2896; 67.2%) either by the interventional cardiologist or using the admission ECG assessment obtained from RIKS-HIA. Coronary artery occlusions were deemed chronic if they were estimated to be more than three months of age by the interventional cardiologist. Coronary angiography was performed during index hospitalization.

Endpoints

The endpoints studied in NSTE-SCA patients undergoing coronary angiography were the probability of having coronary artery stenosis of at least 90% severity, the probability of undergoing a coronary intervention (coronary artery bypass grafting (CABG) or PCI), and 30-day mortality. STE-SCA patients were used as a reference population. ACS patients without SCA were included as an illustrative reference population and were not included in comparative analyses.

Statistical analyses

Histograms were produced to assess normality. Continuous variables were compared using student's *t*-test when assumptions were met. Differences between categorical variables were analyzed with the chi-square test. Kaplan-Meier event rates were used for survival analyses. Unadjusted and adjusted Cox regression models were fitted to assess mortality. Adjustments were made for age, gender, previous MI, previous CABG, previous PCI, hypertension, hyperlipidemia, diabetes, current smoking, and cardiogenic shock. Cardiogenic shock was defined as Killip Class III or IV. Schoenfeld residuals were assessed to verify the proportional hazards assumption. Logistic regression analyses were performed to determine factors that contributed to significant coronary artery stenosis (≥90%) in NSTE-SCA patients. The Hosmer-Lemeshow test was used to assess goodness of fit ($p > .05$) for the logistic regression models and receiver operating characteristics (ROC) analyses were used to assess predictive accuracy. A two-tailed p-value $< .05$ was considered statistically significant. All statistical analyses were performed using IBM SPSS (version 24) or STATA (version 14).

Study ethics

The study was conducted in accordance with the ethical principles of the Helsinki declaration and approved by the Lund University ethical committee (dnr 2015/297). All patient subjects were anonymized with

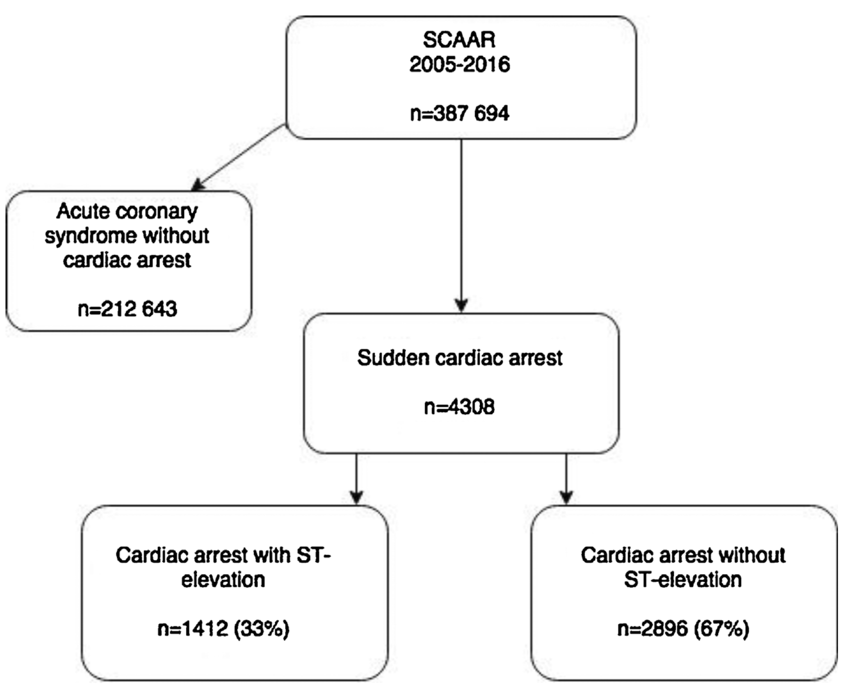

Fig. 1. Study design. Acute coronary syndrome and sudden cardiac arrest (SCA) patients in the SCAAR (Swedish Coronary Angiography and Angioplasty Registry) registry between January 2005 and December 2016 were included. SCA patients were categorized into post-resuscitation ST-elevation SCA or no-ST-elevation SCA.

Table 1
Patient characteristics and angiographic findings for STE-SCA and NSTE-SCA patients as well as for ACS patients without cardiac arrest.

	STE-SCA n = 1412	NSTE-SCA n = 2896	p-value	ACS n = 212643	Missing or unknown SCA	Missing or unknown ACS
Age mean ± SD (years)	65.9 ± 11.4	64.9 ± 12.6	.008	67.4 ± 11.5	51(1.2)	201(0.1)
Male n(%)	1105(78.3)	2220(76.7)	.24	143606(67.5)	0(0.0)	0(0.0)
Medical history n(%)						
Current smoker	231(16.4)	422(14.6)	.13	42726(20.1)	1895(44.0)	14571(6.9)
Diabetes	216(15.3)	561(19.4)	< .001	40853(19.2)	603(14.0)	3773(1.8)
Hypertension	582(41.2)	1349(46.6)	< .001	112980(53.1)	864(20.1)	5955(2.8)
Hyperlipidemia	321(22.7)	981(33.9)	< .001	89536(42.1)	944(21.9)	6922(3.3)
Previous MI	223(15.8)	735(25.4)	< .001	41911(19.7)	796(18.5)	6893(3.2)
Previous CABG	85(6.0)	358(12.4)	< .001	16090(7.6)	27(0.6)	137(0.1)
Previous PCI	170(12.0)	423(14.6)	.010	27053(12.7)	22(0.5)	184(0.1)
Day of angiography n(%)			< .001		2307(53.6)	181280(85.3)
Admission day	751(87.5)	868(75.9)		25413(12.0)		
Day 1	83(9.7)	142(12.4)		4980(2.3)		
Day 2	3(0.3)	28(2.4)		349(0.2)		
Day 3 or later	21(2.4)	105(9.2)		611(0.3)		
Cardiogenic shock	295(24.4)	334(16.0)	< .001	2180(1.0)	1068(24.8)	75187(35.4)
Angiographic findings n(%)			< .001		42(1.0)	1251(0.6)
Normal/atheromatosis	80(5.7)	1051(36.4)		35799(16.8)		
1 VD, no LM	568(40.3)	579(20.1)		72711(34.2)		
2 VD, no LM	347(24.6)	438(15.2)		46319(21.8)		
3 VD, no LM	252(17.9)	501(17.4)		39605(18.6)		
Multivessel disease involving LM	135(9.6)	278(9.6)		16252(7.7)		
LM only	17(1.2)	20(0.7)		706(0.3)		
Occlusion n(%)			< .001		2077(48.2)	73794(34.7)
Acute	680(56.5)	275(26.3)		39343(18.5)		
Chronic	54(4.5)	140(13.4)		3269(1.5)		
Coronary stenosis ≥90%					0(0.0)	0(0.0)
Any artery	1131(80.1)	1271(43.9)	< .001	112919(53.1)		
RCA	458(32.4)	675(23.3)	< .001	52195(24.5)		
LM	57(4.0)	92(3.2)	.15	3454(1.6)		
LAD	719(50.9)	721(24.9)	< .001	59137(27.8)		
Cx	328(23.2)	547(18.9)	.001	37880(17.8)		
Other	35(2.5)	61(2.1)	.44	3833(1.8)		
Intervention (stenosis ≥90) n(%)					0(0.0)	0(0.0)
PCI	1047(92.6)	753(59.2)	< .001	87978(77.9)		
CABG	17(1.5)	100(7.9)	< .001	11472(10.2)		
PCI or CABG	1064(94.1)	853(67.1)	< .001	99444(88.1)		
Patients undergoing PCI						
DES n(%)	758(63.3)	454(45.8)	< .001	67081(50.9)	107(5.9)	8069(6.5)
Target vessel n(%)			< .001		0(0.0)	0(0.0)
RCA	308(25.7)	248(24.4)		42639(32.3)		
LM	73(6.1)	75(7.6)		2278(1.7)		
LAD	623(52.0)	417(42.1)		57058(43.3)		
Cx	177(14.8)	233(23.5)		27761(21.0)		
Other	17(1.4)	24(2.4)		2162(1.6)		
Complete revascularization n(%)	622(52.7)	414(42.5)	< .001	81968(62.8)	0(0.0)	0(0.0)

NSTE-SCA = sudden cardiac arrest without ST-elevation, STE-SCA = sudden cardiac arrest with ST-elevation, ACS = acute coronary syndrome, SD = standard deviation, MI = myocardial infarction, CABG = coronary artery bypass grafting, PCI = percutaneous coronary intervention, VD = vessel disease, LM = left main coronary artery, RCA = right coronary artery, LAD = left anterior descending artery, Cx = circumflex artery, DES = drug-eluting stent.

Table 2
30-day mortality for STE-SCA and NSTE-SCA patients.

Entire cohort n = 4308	STE-SCA n = 1412	NSTE-SCA n = 2896	95% CI	p-value	ACS	SCA missing n(%)	ACS missing n(%)
Kaplan-Meier event rates (%)	41.1	35.9		< .001	2.8	231(5.4)	3168(1.5)
Unadjusted HR	1.20	1.00	1.08–1.33	.001			
Adjusted HR	0.98	1.00	0.87–1.10	.72		1199(27.8)	
NSTE-SCA patients n = 2896	**No stenosis ≥ 90% n = 1625**	**Stenosis ≥ 90% n = 1271**					
Kaplan-Meier event rates (%)	34.6	37.5		.11		147(5.1)	
Unadjusted HR	1.00	1.11	0.98–1.26	.11			
Adjusted HR	1.00	1.04	0.89–1.22	.63		925(31.9)	
NSTE-SCA patients with stenosis ≥ 90% n = 1271	**No PCI n = 518**	**PCI n = 753**					
Kaplan-Meier event rates	32.7	40.9		.011		68(5.4)	
Unadjusted HR	1.00	1.31	1.08–1.59	.006			
Adjusted HR	1.00	1.07	0.84–1.36	.57		333(26.2)	

Adjustments were made for age, gender, previous myocardial infarction, previous coronary artery bypass grafting, previous percutaneous coronary intervention, hypertension, hyperlipidemia, diabetes, current smoking, and cardiogenic shock. NSTE-SCA = sudden cardiac arrest without ST-elevation, STE-SCA = sudden cardiac arrest with ST-elevation, ACS = acute coronary syndrome, CI = confidence interval, HR = hazard ratio, PCI = percutaneous coronary intervention.

Table 3
Patient characteristics and angiographic findings for NSTE-SCA patients with a coronary stenosis of ≥90% stratified by PCI or no PCI.

NSTE-SCA patients with stenosis ≥90% n = 1271	No PCI n = 518	PCI n = 753	p-value	Missing or unknown
Age mean ± SD (years)	69.1 ± 10.2	67.0 ± 10.8	.001	12(0.9)
Male n(%)	441(85.1)	618(82.1)	.15	0(0.0)
Medical history n(%)				
Current smoker	84(16.2)	129(17.1)	.005	499(39.3)
Diabetes	138(26.6)	184(24.4)	.12	169(13.3)
Hypertension	320(61.8)	397(52.7)	.003	212(16.7)
Hyperlipidemia	277(53.5)	289(38.4)	< .001	231(18.2)
Previous MI	255(49.2)	233(30.9)	< .001	208(16.4)
Previous CABG	184(35.5)	90(12.0)	< .001	7(0.6)
Previous PCI	104(20.1)	125(16.6)	.24	8(0.6)
Day of angiography n(%)			< .001	688(54.1)
Admission day	152(63.6)	276(80.2)		
Day 1	39(16.3)	39(11.3)		
Day 2	10(4.2)	4(1.2)		
Day 3 or later	38(15.9)	25(7.3)		
Cardiogenic shock n(%)	41(10.6)	126(20.9)	< .001	
Angiographic findings n(%)			< .001	3(0.2)
Normal/atheromatosis	7(1.4)	5(0.7)		
1 VD, no LM	95(18.3)	237(31.5)		
2 VD, no LM	100(19.3)	226(30.0)		
3 VD, no LM	202(39.0)	187(24.8)		
Multivessel disease involving LM	108(20.8)	87(11.6)		
LM only	4(0.8)	10(1.3)		
Occlusion n(%)			.004	509(40.0)
Acute	0(0.0)	235(31.2)		
Chronic	1(5.3)	113(15.0)		
Coronary stenosis ≥90% n(%)				0(0.0)
RCA	322(62.2)	353(46.9)	< .001	
LM	43(8.3)	49(6.5)	0.23	
LAD	307(59.3)	414(55.0)	0.13	
Cx	236(45.6)	311(41.3)	0.13	
Other	28(5.4)	33(4.4)	0.40	

NSTE-SCA = sudden cardiac arrest without ST-elevation, PCI = percutaneous coronary intervention, SD = standard deviation, MI = myocardial infarction, CABG = coronary artery bypass grafting, VD = vessel disease, LM = left main coronary artery, RCA = right coronary artery, LAD = left anterior descending artery, Cx = circumflex artery.

a unique SWEDEHEART identification number.

Results

Patient characteristics

NSTE-SCA patients more often had diabetes, hypertension, hyperlipidemia, previous MI, previous CABG, or previous PCI compared to STE-SCA patients (all $p < .001$; Table 1). No differences in gender, current smoking status or age were observed between NSTE-SCA and STE-SCA patients. A total of 75.9% of NSTE-SCA patients underwent coronary angiography on the admission day, with corresponding numbers being 12.4% day one, 2.4% day two, and 9.2% day three or later. NSTE-SCA patients had less cardiogenic shock at admission to the angiography lab compared to STE-SCA patients ($p < .001$; Table 1). In NSTE-SCA patients with a significant coronary artery stenosis (≥90%), those who underwent PCI had less often hypertension ($p = .003$), hyperlipidemia, previous MI, or previous CABG (all $p < .001$) compared to the no PCI group. Furthermore, the PCI group more often underwent coronary angiography on the admission day and had less often three vessel disease (both $p < .001$). However, the PCI group had twice the incidence of cardiogenic shock at admission to the angiography lab ($p < .001$), compared to those who were not treated with PCI (Table 3).

Angiographic findings

Among patients with NSTE-SCA, 36.4% had normal coronary arteries (i.e. no stenosis ≥50%) compared to 5.7% in the STE-SCA group ($p < .001$) and 16.8% in the ACS group (Table 1). Significant coronary artery stenosis (≥90%) was present in 43.9% of the NSTE-SCA patients (1271 of 2896) while the same was present in 80.1% (1131 of 1412) of the STE-SCA patients ($p < .001$). Among 2231 SCA patients with available data on acute or chronic presentation at lesion level, there were less acute total occlusions (26.3% vs. 56.5%), but more chronic total occlusions (13.4% vs. 4.5%; $p < .001$) in NSTE-SCA patients compared to STE-SCA patients (Table 1).

Interventions during index hospitalization

NSTE-SCA patients (5.2%; 150 of 2896) underwent CABG more often than STE-SCA patients (1.8%; 25 of 1412; $p < .001$). Among the NSTE-SCA patients, 34.2% (991 of 2896) underwent PCI compared to 84.8% (1198 of 1412) in the STE-SCA group ($p < .001$). PCI was performed in 59.2% (753 of 1271) of the NSTE-SCA patients with significant coronary stenosis (≥90%) and 92.6% (1047 of 1131) of STE-SCA patients with stenosis ≥90% ($p < .001$). In NSTE-SCA patients undergoing PCI, the target vessel was more often the circumflex (Cx) artery (23.5%; 233 of 991) compared to STE-SCA patients (14.8%; 177 of 1198; $p < .001$; Table 1). Drug-eluting stents (DES) were less frequently used in NSTE-SCA patients (45.8%) compared to STE-SCA patients (63.3%; $p < .001$). Complete revascularization after PCI was less often achieved in those with NSTE-SCA (42.4%) compared to those with STE-SCA (52.7%; $p < .001$). Compared to the group as a whole, a similar percentage of PCI procedures was performed in ECG-silent territories (circumflex artery including marginal branches and diagonal branches) as well as in the left main coronary artery (Supplementary Table S2).

30-day mortality

The longest follow-up time for SCA patients was 3480 days. The Kaplan-Meier event rate for 30-day mortality was 35.9% for NSTE-SCA patients compared to 41.1% in STE-SCA patients ($p < .001$; Fig. 2A).

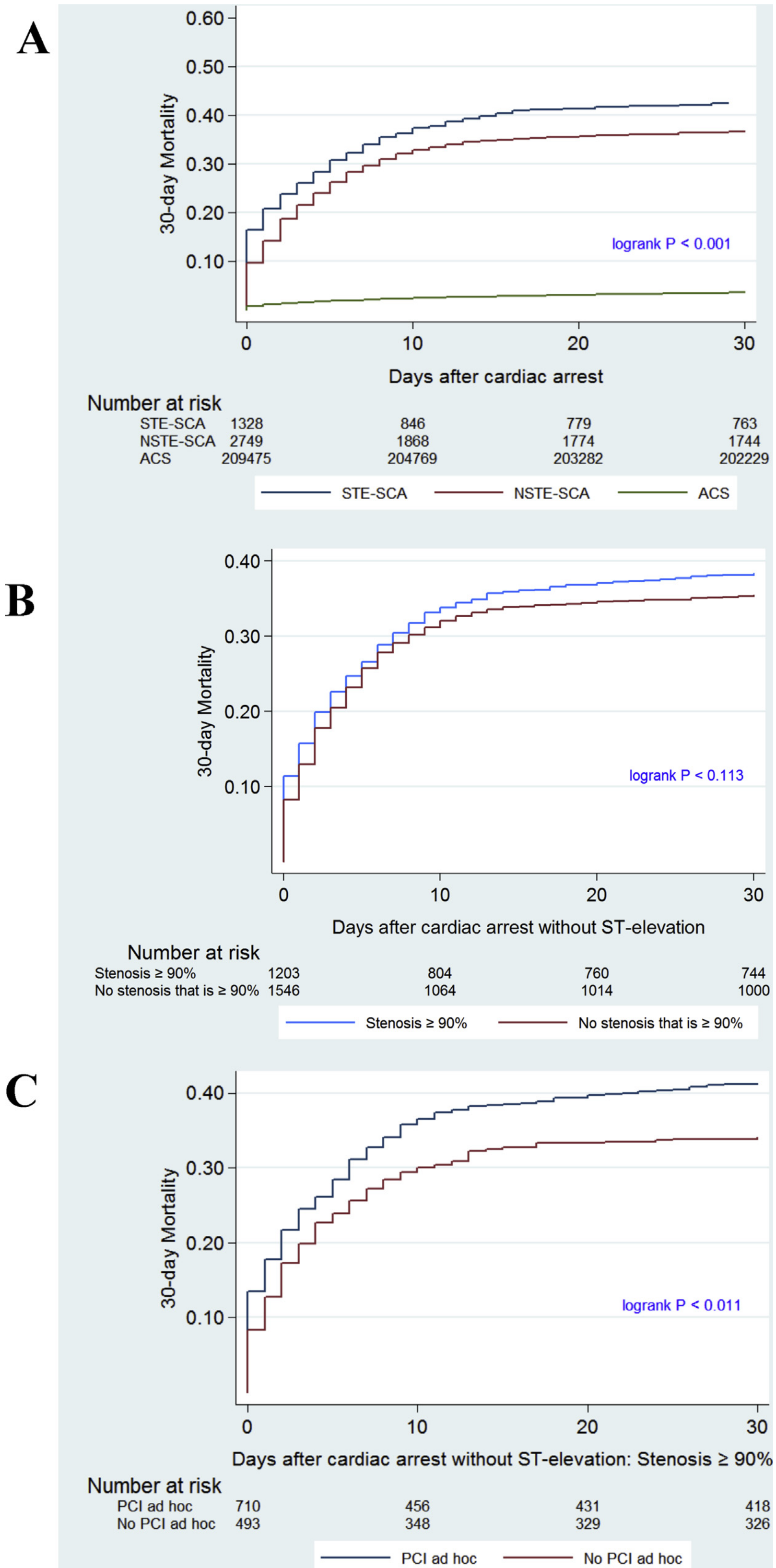

Fig. 2. Kaplan-Meier failure functions for 30-day mortality.
(A) Resuscitated sudden cardiac arrest (SCA) patients with (STE-SCA) (blue line) and without ST-elevation on the post-resuscitation electrocardiogram (NSTE-SCA) (red line) who underwent coronary angiography. Acute coronary syndrome (ACS) (green line) patients without cardiac arrest are presented as a visual reference.
(B) NSTE-SCA patients who underwent coronary angiography stratified by the presence of significant coronary stenosis of at least 90% (blue line). The red line indicates NSTE-SCA patients without a stenosis of at least 90%.
(C) NSTE-SCA patients with significant coronary stenosis of at least 90% who underwent coronary angiography stratified by percutaneous coronary intervention (PCI) (blue line) or no PCI. The red line indicates NSTE-SCA patients with a stenosis of at least 90% who did not undergo PCI.

After adjustments for confounders, there was no difference between groups (hazard ratio (HR) 0.98; 95% CI 0.87–1.10; p = .72). In NSTE-SCA patients, the presence of significant coronary artery stenosis (≥90%) did not significantly affect the mortality rate (37.5% vs. 34.6%; p = .11; Fig. 2B) [adjusted HR 1.04; 95% CI 0.89–1.22; p = .63]. In the group of NSTE-SCA patients with significant coronary artery stenosis (≥90%), an unadjusted increase in mortality was observed in patients who underwent PCI (40.9%) compared to those who did not (32.7%; p = .011; Fig. 2C). However, after adjustments for potential confounders, no difference in mortality was found between patients undergoing PCI compared to no PCI [adjusted HR 1.07; 95% CI 0.84–1.36; p = .57] (Table 2). Similar results were found when coronary stenosis cut-offs of ≥50% or ≥70% were used.

Explanatory model for significant coronary artery stenosis (≥90%) in NSTE-SCA patients

In univariable analyses, significant coronary artery stenosis (≥90%) was more likely in NSTE-SCA patients with higher age, male gender, previous MI, previous PCI, hypertension, hyperlipidemia, diabetes (all $p < .001$), and current smoking (p = .02; Supplementary Table S1). In multivariable analysis, these results were mostly consistent. However, previous PCI turned out to be a protecting factor. The strongest explanatory factor was previous MI (odds ratio (OR) 3.58; 95% CI 2.79–4.60; $p < .001$). The model showed adequate goodness of fit. Furthermore, the model was analyzed in a ROC curve with an area under the curve of 0.71 (95% CI 0.69–0.73; $p < .001$).

Discussion

In this study, we aimed to describe patients with sudden cardiac arrest without ST-elevation on the post-resuscitation ECG that underwent coronary angiography. A total of 63.6% of NSTE-SCA patients referred for a coronary angiography had a coronary artery stenosis of at least 50% and 43.9% of patients had a severe significant coronary stenosis of at least 90%. Independent predictive factors for a severe coronary artery stenosis (≥90%) were previous MI, advanced age, male gender, diabetes, current smoking status, and hypertension. PCI was performed in 59.2% of NSTE-SCA patients with severe coronary artery stenosis. However, PCI was not associated with a better prognosis.

Previous studies

The proportion of highly significant coronary stenosis in NSTE-SCA patients was slightly higher compared to previously published articles [9, 10.12]. The explanation for this is probably that all patients in the present study underwent coronary angiography, whereas other studies have investigated overall SCA populations in the intensive care units. Presence of markedly significant stenosis did not increase 30-day mortality in the present study. Moreover, PCI was associated with higher mortality in unadjusted analyses. After adjustments for confounders, there was no difference in 30-day mortality between NSTE-SCA patients who underwent PCI and those who did not. This result is in line with some [8,17,18] but not all previous publications [11,16]. Dumas et al. reported an increased survival at hospital discharge when successful PCI was performed in NSTE-SCA patients undergoing angiography and Kern et al. found an increased survival when immediate angiography was performed compared to no angiography. Hollenbeck et al. found that more patients survived to discharge when acute angiography was performed in NSTE-SCA patients. However, no difference was observed in patients who received PCI compared to those who did not in that study. In a post hoc analysis from the TTM-trial, early angiography (within 6 h) in NSTE-SCA patients was not associated with an increased survival compared to no or late angiography [17]. Additionally, in a recent randomized trial, multivessel PCI in acute myocardial infarction patients with cardiogenic shock was associated with a higher mortality rate [20].

There are some possible explanations for the absence of benefit of PCI in the NSTE-SCA group in the present study. First, it cannot be ruled out that PCI may pose harm to the already fragile post SCA patient. A benefit of reperfusion might be counteracted with the harm of an invasive procedure and concomitant medication. In NSTEMI patients without SCA, the incidence of bleeding related to PCI may range from 1.3% to 12.4% and is associated with an increased 30-day mortality [21].

Second, the effect of adenosine diphosphate-receptor (ADP-receptor) antagonists may be impaired in patients early after resuscitation and during hypothermia. This may in part be caused by an altered metabolism as well as a reduced absorption in the gastrointestinal tract due to the shunt of blood to vital organs and has been documented for clopidogrel, prasugrel and ticagrelor [22,23]. In the setting of PCI with an implanted stent, this might lead to stent thrombosis, which is a serious complication post-PCI that may increase the mortality following OHCA [24]. In some studies the frequency of stent thrombosis in resuscitated OHCA patients has been reported to be as high as 10.9% [24,25] while other investigators found lower numbers (1.5% and 2.7%) [26,27]. Again, the benefit of PCI might thus be neutralized by a high rate of stent thrombosis.

Third, finding the correct timing of when to perform the angiography and subsequent PCI might be a critical factor. Some investigators found a prognostic benefit from angiography performed within the first 24 h [8] while others found no benefit from angiography within the first 6 h [17,18]. One study found that delayed angiography was associated with a better prognosis than early (defined as the first 2 h after cardiac arrest) [11], although this result may be biased as the first group will have survived long enough to receive a delayed angiography. In the present study, the majority of NSTE-SCA patients underwent angiography on the admission day. Moreover, no difference was previously observed in a systematic review between an early versus a late invasive approach in NSTEMI patients without SCA [28].

Fourth, the absence of benefit of PCI may have been caused by selection bias as the patients who underwent PCI were more haemodynamically compromised. Although, we adjusted for this, as well as other factors in our adjustment model, a certain degree of residual confounding cannot be ruled out. Also, it is conceivable that patients with haemodynamic failure due to the post-cardiac arrest syndrome were selected for acute angiography, which might bias the results against PCI. On the other hand, our study also included patients who received an angiography on day three or later. At this point, a poor neurological prognosis is often evident and patients with a severe prognosis do not usually receive invasive management, potentially biasing the results in favor of PCI.

Guidelines and comparison to STE-SCA patients

Taken together, it is currently challenging to guide clinical management from these observational studies alone. The important question of if and when it is best to perform an invasive investigation with possible PCI in NSTE-SCA patients remains unanswered. However, the European Association for Percutaneous Cardiovascular Interventions (EAPCI) and Stent for Life (SFL) recommend angiography within 2 h in NSTE-SCA patients without an obvious non-cardiac cause [29], but the level of evidence is low and more prospective studies are warranted.

The unadjusted 30-day mortality in NSTE-SCA patients was lower than that for STE-SCA patients. This result appears likely as STE-SCA patients had more extensive coronary artery disease. Previously published data report conflicting results in mortality between NSTE-SCA and STE-SCA [13,21].

The NSTE-SCA patients more frequently had serious comorbidities compared to STE-SCA patients, which is in line with previous investigations [11,18,21]. As NSTE-SCA patients more often had previous coronary events, their coronary arteries may be preconditioned and they may have more collateral arteries, possibly indicated by the fact that they more frequently had chronic occlusions compared to STE-SCA patients.

Limitations

There are several limitations in this study. Only patients who underwent coronary angiography were included in our study. This may introduce selection bias and it was not possible to make comparisons with patients who did not undergo angiography because they are not enrolled in SCAAR. Furthermore, the primary endpoint in the survival analyses was 30-day mortality and we did not have data on neurological outcome. We also did not have data to determine the proportions of comatose and conscious patients in the groups, which may bias the results. Additionally, we lacked peri-arrest data. For example, patients with initial rhythm of ventricular fibrillation have an increased probability of a coronary lesion. There might also have been imbalances in time to return of spontaneous circulation that could impact the results. Moreover, we did not have data on targeted temperature management. Finally, this was an observational study, and as such, conclusions cannot be drawn about causality. Consequently, prospective and randomized controlled trials are needed to conclude whether NSTE-SCA patients benefit from early routine coronary angiography and PCI.

The advantages of the present study are that it constitutes the largest nationwide study of consecutively diagnosed cardiac arrest patients spanning over 12 years. SCAAR is an established and validated registry with few missing values. We also tried to adjust for confounding by multivariable adjustment models, although a certain degree of residual confounding cannot be ruled out.

Conclusions

In this large nationwide observational study of resuscitated sudden cardiac arrest patients without ST-elevation who underwent coronary angiography, two thirds of patients had at least one coronary artery stenosis exceeding 50% and a total of 43.9% had a coronary artery stenosis exceeding 90%. Multiple risk factors were identified that correlated with severe coronary artery stenosis of at least 90%. The presence of highly significant coronary artery stenosis ($\geq$90%) did not significantly increase mortality. In sudden cardiac arrest patients without ST-elevation with a highly significant coronary artery stenosis ($\geq$90%), PCI was not associated with higher survival rate. Prospective and randomized controlled trials are needed to accurately define the role of coronary angiography and PCI in post-resuscitation care after sudden cardiac arrest without ST-elevation.

Conflicts of interest

None.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.resuscitation.2018.01.044.

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