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Clinical paper

Beyond STEMI: High-risk ECG patterns as predictors of occlusive myocardial infarction in out-of-hospital cardiac arrest patients

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Abstract

Background/Aim: Immediate coronary angiography (CAG) is recommended for patients with ST-elevation myocardial infarction (STEMI) after out-of-hospital cardiac arrest (OHCA). However, some occlusive myocardial infarctions (OMI) do not meet STEMI criteria. This study investigated whether additional ECG patterns beyond STEMI could more accurately identify OMI in OHCA patients, compared to using STEMI criteria alone.

Methods: This retrospective study categorised patients based on their first post-resuscitation ECG into two groups: STEMI and non-STEMI with high-risk ECG criteria and compared them for OMI by CAG.

Results: Among 97 patients OMI was identified in 55 % (53/97) of patients, specifically in 25 of 31 with STEMI (81 %), 24 of 29 with high-risk ECG (83 %), and 4 of 37 patients with neither (11 %). Combining STEMI and high-risk ECG criteria would have predicted OMI in 92 % (49/53) of cases. Patients with high-risk ECG experienced significantly longer median delays until CAG (101.5 [IQR 63–336.75] vs. 47.5 [25.75–71.25] minutes; p = 0.004) compared to those with STEMI on the ECG. Although 30-day mortality did not differ between STEMI and high-risk ECG patients (p = 0.973), survival-differences could be observed between groups. Syntax-I-Score was significantly higher in the high-risk ECG group (29 [IQR 19–38] vs. 15 [IQR 3–24.5]; p = 0.002).

Conclusion: Combining STEMI and high-risk ECG criteria improves OMI prediction compared to STEMI criteria alone, potentially enabling faster treatment and better OHCA survival.

Keywords: Post-resuscitation care, Coronary occlusion, NSTEMI, Coronary angiogram, Electrocardiogram

Introduction

Sudden cardiac arrest is among the leading causes of death in Europe, with high mortality rates and poor prognosis even for those who are initially resuscitated.[1,2] Acute coronary syndrome (ACS) is a major cause of out-of-hospital cardiac arrest (OHCA),[3,4] and timely identification of acute coronary occlusion may be critical for preventing irreversible myocardial damage. Current guidelines prioritize immediate coronary angiography (CAG) for patients with ST-elevation myocardial infarction (STEMI) post-return of spontaneous circulation (ROSC).[5]

For patients without STEMI post-ROSC, current evidence suggests that immediate CAG may not confer a survival benefit for all.[6–8] However, by relying mostly on STEMI criteria, one distinction may miss a significant subset of patients with acute coronary occlusion without STEMI, who constitute approximately 20–30 % of ACS cases,[4,9,10] leading to the introduction of the OMI-paradigm by Smith

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and Pendell Meyers in 2018.[11–14] These patients may face delays in treatment – like CAG – because of the reliance on traditional STEMI criteria, potentially leading to poorer outcomes.

High-risk conditions in non-STEMI ACS, such as cardiogenic shock or life-threatening arrhythmias, typically justify immediate CAG.[15] However, in OHCA, clinical decision-making is more complex, with limited diagnostic markers like troponin. In such cases, the post-ROSC ECG becomes pivotal in guiding timely interventions. Emerging evidence suggests that incorporating high-risk ECG criteria beyond STEMI could enhance sensitivity in detecting acute occlusions.[16–18]

Our study aimed to investigate whether ECG patterns beyond classic STEMI criteria can reliably indicate coronary occlusion in patients resuscitated after sudden cardiac arrest. We hypothesized that combining additional specific high-risk ECG patterns with traditional STEMI criteria would improve identification of acute occlusive myocardial infarctions (OMI). This approach seeks to amend the limitation of the current STEMI/non-STEMI paradigm, which may delay coronary angiography and life-saving interventions in patients without STEMI.

Material and methods

Study design and setting

In this retrospective single-centre study we analysed patients, successfully resuscitated from OHCA. Between 1 January 2020 to 31 December 2023, we enrolled patients admitted to the medical intensive care unit (ICU) of Kepler University Hospital in Linz, Austria.

Patients aged 18 years or older who experienced OHCA and were admitted to the medical ICU were included. Resuscitation was defined as at least one defibrillation or the performance of chest compressions (manual or mechanical). Synchronised cardioversions in haemodynamically unstable patients were not included.

Decision for CAG followed a protocolized local standard operating procedure that was consistently applied during the study period. A primary PCI strategy was used in patients with STEMI, as well as in non-STEMI patients when an ischemic cause was deemed likely — such as in the presence of hemodynamic or electrical instability or signs of ongoing myocardial ischemia. Revascularization was attempted for significant coronary disease, with PCI preferred over coronary artery bypass grafting. Post-resuscitation care followed local protocols. The study adhered to ethical guidelines and received institutional approval.

The study protocol adheres to the ethical guidelines of the 1975 Declaration of Helsinki. Patient confidentiality was strictly maintained by anonymising data during the analysis phase. This study was approved by the Ethics Committee of Johannes Kepler University Linz.

Data collection and measurements

All data were collected in 2024 and reviewed by three investigators. The information, including demographic characteristics, clinical and laboratory data, emergency medical service-protocols, ECGs, and coronary angiography media, was systematically organised and coded according to a standardized protocol.

We examined the first documented ECG obtained after ROSC and compared patients classified into two groups: those with STEMI and those with high-risk ECG patterns. STEMI criteria were defined according to the Fourth Universal Definition of Myocardial Infarction.[19] We defined modified Sgarbossa Criteria, de Winter Sign, Wellens Sign (types A and B), left-main equivalent, shark-fin sign, hyperacute T-waves and ST-depression in two contiguous leads without ST-elevation or ST-elevation in just one lead (including subtle ST-elevation, Aslanger pattern, South African flag sign, precordial swirl and northern OMI) as our selected high-risk ECG criteria. The selection of criteria was guided by a literature review.[20–31] All ECGs were analysed and grouped accordingly by two senior cardiologists on a consensus basis, blinded to outcomes. While initially three ECG-based groups were defined, only STEMI and high-risk ECG patients were included in the analysis.

CAG media were reviewed by two interventional cardiologists, classifying the cohort based on the degree of stenosis into OMI (acute coronary occlusion or subtotal coronary artery stenosis with impaired coronary flow) and non-OMI (any other coronary stenosis or no stenosis), blinded to the initial ECG. To evaluate the complexity of coronary artery disease the anatomical Synergy between PCI with Taxus and Cardiac Surgery (SYNTAX) score I[32] was assessed by a senior interventional cardiologist, blinded to outcomes. We also recorded the time from the first post-ROSC ECG to CAG.

Statistical analysis

All quantitative variables were summarised using medians and interquartile ranges (IQRs). Categorical variables were presented as absolute and relative frequencies.

Group comparisons were conducted using the Mann–Whitney *U* test for continuous variables and Fisher's exact test for categorical variables. Two-tailed Fisher p-values were calculated conservatively by doubling the smaller of the two one-sided p-values, capped at 1.0. A Kaplan-Meier curve was created to graphically represent the 30-day survival rates.

For some variables, single values were missing in our cohort. All calculations excluded missing values.

A p-value <0.05 was considered significant. SPSS® software (IBM, version 29.0.0.0) and a two-tailed p-value calculator for Fisher's exact test, as described in Rosner's book, (https://statpages.info/ctab2x2.html) was used for data analysis.

Results

Between January 1, 2020, and December 31, 2023, a total of 110 patients who experienced OHCA were admitted alive to the medical ICU of Kepler University Hospital. Of the 110 patients, 6 were excluded from the study because they died immediately after admission, with no further data available for documentation and an additional 7 were excluded due to missing ECG data (Fig. 1). For comparative purposes, analyses were limited to patients with STEMI or high-risk ECG findings; others were excluded.

Characteristics of study population

The final cohort consisted of 97 patients, of whom 31 (32 %) presented with STEMI on the post-ROSC ECG, 29 (30 %) met the criteria for high-risk ECG, while 37 (38 %) showed neither. Supplementary Table 2 summarizes the distribution of high-risk ECG features in the 29 patients classified as high-risk ECG. Patients in the high-risk ECG group were older (median age 71 years [IQR 62–77] vs. 61 years [IQR 54–66]; p = 0.002) and had a higher prevalence of hypertension (69 % vs. 32 %; p = 0.013; Table 1).

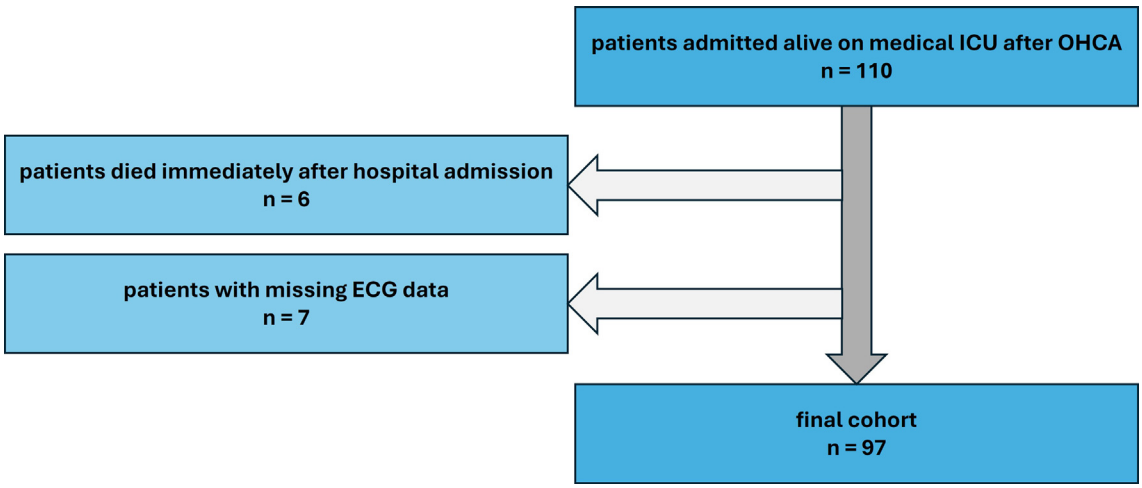

Fig. 1 – Flow diagram of the study population: Of the 110 patients, six were excluded because they died immediately after admission, seven were excluded because ECG data were missing.

Table 1 – Patient demographics and comorbidities.

	STEMI-ECGn = 31	high-risk ECGn = 29	p-value
Median age (IQR) – y	61 (54–66)	71 (62–77)	0.002 [a]
Female sex (%) – no.	10 (32)	7 (24)	0.683[b]
Median BMI (IQR)	26.12 (24.83–27.45)	25.59 (22.68–27.38)	0.888 [a]
Cardiovascular disease[†] (%) – no.	8/29 (28)	12/28 (43)	0.353[b]
Hypertension (%) – no.	10/30 (33)	20/29 (69)	0.013[b]
Diabetes mellitus (%) – no.	4/30 (13)	5/28 (18)	0.909[b]
Dyslipidaemia (%) – no.	7/30 (23)	8/28 (29)	0.876[b]
Cerebrovascular disease (%) – no.	4/30 (13)	3/28 (11)	1.0[b]
Atrial fibrillation (%) – no.	6/30 (20)	7/28 (25)	0.887[b]
Previous cardiac intervention[‡] (%) – no.	5/30 (17)	7/27 (26)	0.595[b]
ACE / Angiotensin-receptor blocker (%) – no.	8/28 (29)	13/27 (48)	0.224[b]
β-receptor blocker (%) – no.	7/28 (25)	9/27 (33)	0.702[b]
Oral anticoagulants (%) – no.	4/28 (14)	2/26 (8)	0.742[b]

Note: If the denominators are smaller than the total size of the group due to missing values, the corresponding numerators and denominators are specified in the table.

BMI: Body mass index; ACE: Angiotensin-converting enzyme.

[†] Including peripheral arterial occlusive disease; coronary heart disease; previous myocardial infarction.

[‡] Including percutaneous coronary intervention / coronary artery bypass grafting; valve-intervention, electrophysiological intervention.

[a] Mann-Whitney *U* test.

[b] Fisher's exact test.

Treatment characteristics during cardiac arrest were comparable between groups, with both having a median time from arrest to ROSC of 20 min. Most patients out of both groups had a shockable rhythm during CPR (93 % STEMI-ECG, 86 % high-risk ECG, p = 0.933). Laboratory parameters did not reveal any statistically significant differences between the groups (Table 2).

Post-resuscitation care and outcome

Although immediate CAG was less frequent in the high-risk group (79 % vs. 97 %), this difference did not reach statistical significance (p = 0.075). In contrast, time to CAG was significantly longer (101.5 vs. 47.5 min; p = 0.004; Fig. 2). OMI was found in 53 out of 97 (55 %) patients, of whom only 25 (47 %) fulfilled the STEMI criteria and 24 (45.2 %) the high-risk ECG criteria. Combining both ECG criteria identified occlusive infarctions in 49 out of 53 (93 %) cases (p < 0.001).

30-day survival did not differ significantly between groups (p = 0.973). At 72 h, survival was 94 % in the STEMI group and 76 % in the high-risk group (p = 0.118; Fig. 3). A difference in the causes of death was observed between the groups (p = 0.019). Cardiac death occurred in 28 % of patients with a high-risk ECG and 10 % of patients in the STEMI group (p = 0.144). Death due to hypoxic brain injury was reported in 29 % of STEMI patients and 7 % of those with a high-risk ECG (p = 0.056). Median delta-NSE levels showed a more favourable neurological condition for high-risk ECG patients (p = 0.047; Table 3).

Regarding the coronary culprit lesion, patients with a STEMI ECG more frequently underwent PCI of the left anterior descending artery (52 % vs. 23 %, p = 0.052). High-risk ECG patients, however, presented with a higher burden of coronary artery disease, as reflected by a higher SYNTAX-I score (29 [IQR 19–38] vs. 15 [IQR 3–24.5]; p = 0.002). Fig. 4 provides a representative example of coronary condition among the cohort.

Table 2 – Baseline characteristics of patients.

	STEMI-ECGn = 31	high-risk ECGn = 29	p-value
Median time from arrest to ROSC (IQR) – min.	20 (8.75–30)	20 (11.5–25.5)	0.822 [a]
Shockable rhythm• (%) – no.	28/30 (93)	25/28 (86)	0.933[b]
Initial VF / PVT (%) – no.	25/30 (83)	19/28 (68)	0.285[b]
Initial asystole/PEA (%) – no.	2/30 (7)	4/28 (14)	0.604[b]
Adrenalin° (%) – no.	12/25 (48)	13/25 (45)	1.0[b]
Amiodarone° (%) – no.	6/25 (24)	10/25 (35)	0.364[b]
Median defibrillation attempts (IQR) – no.	2 (2–3.5)	2 (1–4)	0.450 [a]
Basic life support by lay (%) – no.	15/24 (63)	15/22 (68)	0.926[b]
Arrest at home (%) – no.	14 (45)	13/29 (45)	1.0[b]
GCS 3 at admission (%) – no.	20 (65)	21/29 (72)	0.706[b]
Sinus rhythm (%) (incl. AV block I)	20 (65)	19/29 (66)	1.0[b]
Unphysiological axis deviation (%) – no.	11 (35)	4/29 (14)	0.098[b]
Regional wall motion abnormality (%) – no.	21/27 (78)	13/23 (57)	0.193[b]
Generalised wall motion abnormality (%) – no.	2/27 (7)	3/23 (13)	0.844[b]
No wall motion abnormality (%) – no.	4/27 (15)	7/23 (30)	0.324[b]
Median initial creatinine (IQR) – mg/dL	1.18 (1.08–1.32)	1.18 (1.01–1.43)	0.956 [a]
Median initial eGFR (IQR) – mL/min/1.77	65.2 (49.7–73.6)	65.7 (50–76)	0.755 [a]
Median initial troponin T-hs (IQR) – μg/liter	147.5 (57.13–259)	96 (57.25–392.50)	0.789 [a]
Median initial pH (IQR)	7.28 (7.22–7.31)	7.26 (7.14–7.35)	0.562 [a]
Median initial NSE (IQR) – μg/L	30.6 (22.25–45.1)	29.05 (19.53–38.86)	0.446 [a]

Note: If the denominators are smaller than the total size of the group due to missing values, the corresponding numerators and denominators are specified in the table.

• Shockable rhythm anytime during advanced life support.

° Any administration during CPR.

ROSC: Return of spontaneous circulation; VF: Ventricular fibrillation; PVT: Pulseless ventricular tachycardia; PEA: Pulseless electrical activity; GCS: Glasgow coma scale; AV: Atrioventricular; eGFR: Estimated glomerular filtration rate; NSE: Neuron-specific enolase.

[a] Mann-Whitney *U* test.

[b] Fisher's exact test.

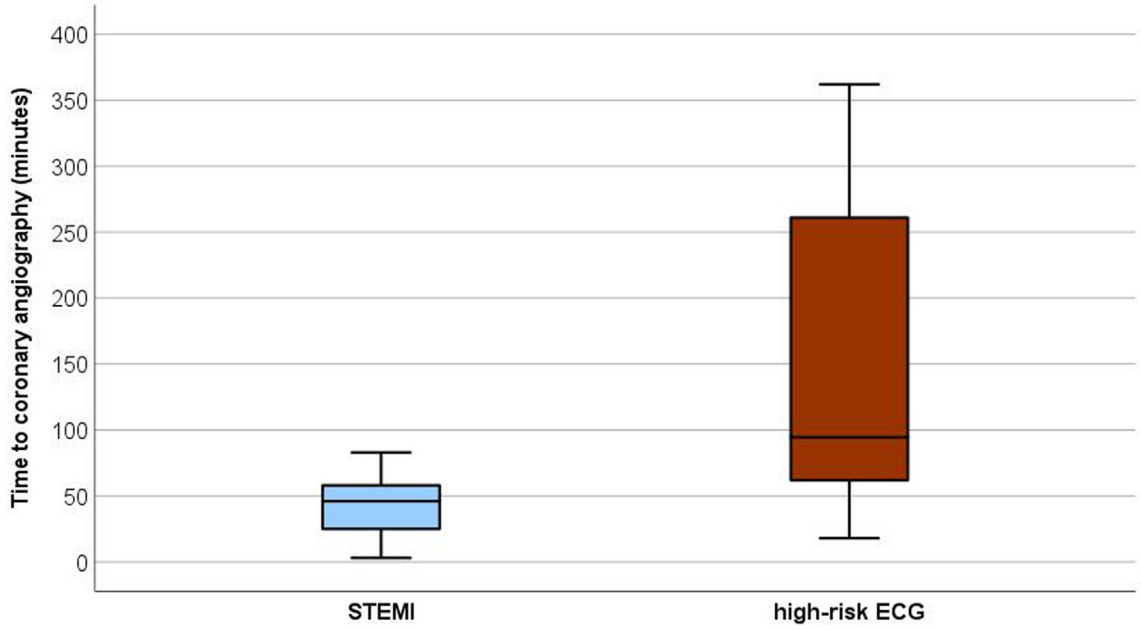

Fig. 2 – Time from post-cardiac arrest ECG to coronary angiography in minutes: Boxplot of times from the first post-cardiac arrest ECG to coronary angiography, with minutes on the y-axis, times significantly longer in the high-risk ECG group (orange, right) compared to STEMI group (blue, left) (median time 101.5 [IQR 63–336.75] vs. 47.5 [25.75–71.25] minutes; p = 0.004). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

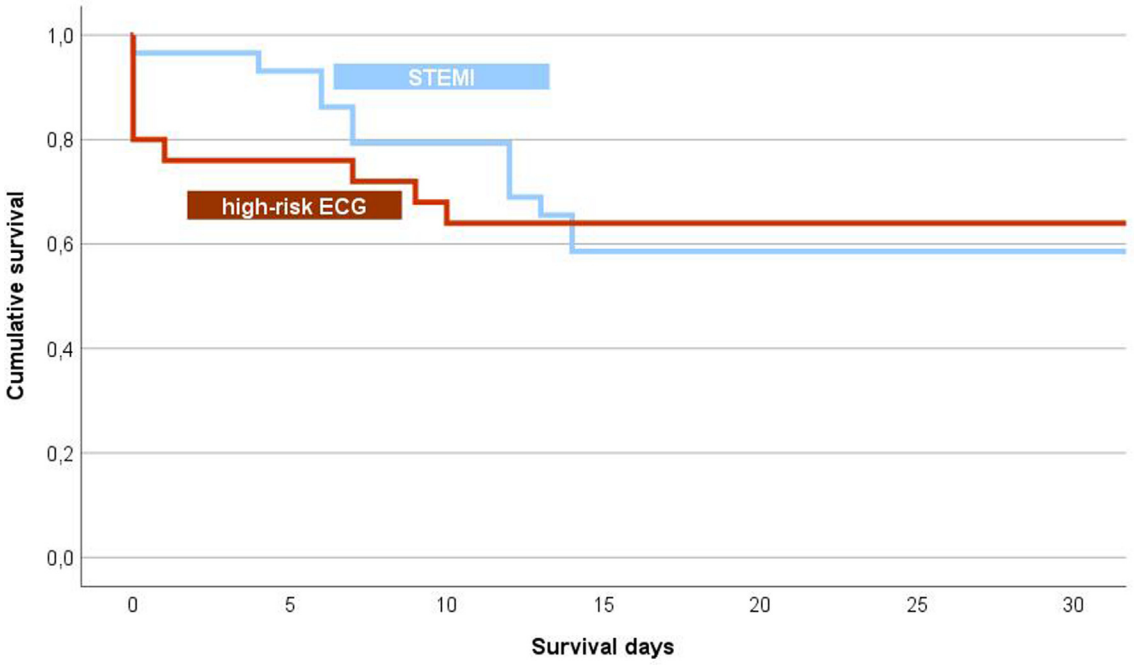

Fig. 3 – Kaplan Meier survival curve 30 days: Survival days on the x-axis, cumulative survival on the y-axis.

Patients without STEMI or high-risk ECG

Patients without STEMI or high-risk ECG (n = 37) had a median age of 70 [IQR 58.5–75.5] years, 20 (54 %) had hypertension, and median time to ROSC was 20 [IQR 8–30] minutes. Immediate CAG was performed in 14 patients (38 %), with OMI being detected in 4 (11 %) (median Syntax Score 0 [IQR 0–1.26], time from ECG to CAG was 150 min [IQR 72–7302]). Further details are provided in the Supplementary Data.

Discussion

Our study highlights the critical role of ECG patterns beyond conventional STEMI criteria in identifying acute OMIs in patients resuscitated from OHCA. The findings suggest that current post-resuscitation recommendations may inadvertently contribute to the undertreatment of patients with high-risk ECG findings, as these patients were both less likely to receive immediate CAG and experienced significant delays when CAG was performed. This disparity likely stems from the limitations of the existing STEMI versus non-STEMI paradigm, which may lead to an underestimation of the urgency for CAG in acute ischemic heart disease after OHCA. These results emphasize the complexity of sudden cardiac arrest and the necessity for highly specialized post-resuscitation care in dedicated cardiac arrest centres.[33] The delays in treatment are particularly concerning given that both high risk-ECG patterns and STEMI were strong predictors of OMI on angiography.

While the optimal timing of coronary angiography for OHCA patients without overt STEMI remains a subject of ongoing debate, our findings add nuance to this discussion. Previous studies have reported no clear advantage of immediate CAG over a delayed or selective approach in patients without ST-Segment elevation and shockable rhythm.[6,7] However, the observed prevalence of OMI was likely unrepresentatively low (22 out of 437; 5 %), and a potential selection bias cannot be excluded, as other studies in comparable populations have reported significantly higher rates of OMI (176 out of 301, 58 %).[6,34] Emerging evidence, including our results, highlights the importance of considering specific subgroups, such as those with high-risk ECG patterns, for early intervention.[35–37] Our findings suggest that reliance solely on the presence of shockable rhythms as a discriminator for acute OMI may be insufficient due to the heterogeneous aetiologies underlying malignant tachyarrhythmias. Coronary artery disease — and even identifiable culprit lesions — can be present across a broad spectrum of OHCA-patients, irrespective of their initial presenting rhythm.[38]

Moreover, our data support earlier findings that STEMI on an ECG is not the sole indicator of coronary occlusion.[39–42] Our study supports these observations, demonstrating that 83 % of patients in the high-risk ECG group exhibited OMI. Additionally, these patients were significantly older, had a higher prevalence of arterial hypertension and had significantly higher SYNTAX-I scores, indicating a more complex presentation of coronary artery disease. These factors could result in a greater coronary disease burden and may explain the absence of ST-elevation due to competing electrical vectors from multiple ischemic zones. Beyond that, resuscitation circumstances, myocardial panischemia, and the complex interplay of inflammation and reperfusion in post-cardiac arrest syndrome can complicate ECG interpretation. In STEMI, a culprit vessel typically generates localised ischemia, leading to extracellular potassium accumulation and a more positive resting membrane potential in this transmural area resulting in an electric vector guiding to it, showing as ST-Segment elevation on the ECG.[43] In contrast, the involvement of multiple ischemic zones, as indicated by the higher SYNTAX-I scores in our high-risk ECG cohort, may generate competing vectors that mitigate ST-elevation. Additionally, collateral circulation to the infarcted territory or non-detectable vector orientations in standard ECG leads may also account for missing ST-elevation.[44,45] Furthermore, the difference in culprit vessel PCI – with higher rates of PCI in

Table 3 – Procedural and outcome data.

	STEMI-ECGn = 31	high-risk ECGn = 29	p-value
Immediate CAG (%) – no.	30 (97)	22/28 (79)	0.075[b]
Delayed CAG (%) – no.	8 (26)	8/27 (30)	0.973[b]
CAG any time during hospitalisation (%) – no.	31 (100)	26/28 (93)	0.442[b]
Occlusive myocardial infarction (%) – no.	25 (81)	24/28 (86)	0.868[b]
TIMI 0–2 (%) – no.	25 (81)	20/28 (71)	0.600[b]
TIMI 3 (%) – no.	5 (16)	4/28 (14)	1.0[b]
PCI (%) – no.	25 (81)	17/26 (65)	0.317[b]
PCI left anterior descending artery (%) – no.	16 (52)	6/26 (23)	0.052[b]
PCI right coronary artery (%) – no.	6 (19)	6/26 (23)	0.982[b]
PCI circumflex artery (%) – no.	2 (6)	5/26 (19)	0.290[b]
One-vessel disease (%) – no.	12 (39)	7/28 (25)	0.398[b]
Multi-vessel disease (%) – no.	18 (58)	19/28 (68)	0.613[b]
Syntax-I-Score (IQR)	15 (3–24.5)	29 (19–38)	0.002 [a]
Time from first post-ROSC ECG to CAG (IQR) – min.	47.5 (25.75–71.25)	101.5 (63–336.75)	0.004 [a]
Median initial ejection fraction (IQR) – %	35 (22.5–45)	40 (31.87–55)	0.058 [a]
Median discharge ejection fraction (IQR) – %	40 (25–45)	47.5 (37.75–60)	0.077 [a]
Cardiac cause (%) – no.	30 (97)	27/28 (96)	1.0[b]
Targeted temperature management (%) – no.	16/24 (67)	13/27 (48)	0.294[b]
Median days on ICU (IQR)	10 (5–13)	8 (2.5–14.5)	0.332 [a]
Invasive ventilation (%) – no.	24/30 (80)	24 (83)	1.0[b]
Median days of invasive ventilation (IQR)	6 (3.75–8)	4.5 (1–9.75)	0.565 [a]
Acute kidney injury (%) – no.	9/29 (31)	10/27 (37)	0.848[b]
Cardiogenic shock (%) – no.	14/30 (47)	8 (28)	0.212[b]
30-day survival (%) – no.	17 (55)	17 (59)	0.973[b]
72-h survival (%) – no.	29 (94)	22 (76)	0.118[b]
Discharge alive (%) – no.	16 (52)	18 (62)	0.579[b]
Cardiac cause of death (%) – no.	3 (10)	8 (28)	0.144[b]
Hypoxic brain injury cause of death (%) – no.	9 (29)	2 (7)	0.056[b]
Median maximum troponin T-hs (IQR) – μg/liter	2635 (1127.5–8609)	1450.5 (631–3536)	0.101 [a]
Median maximum lactate (IQR) – mmol/liter	4.9 (2.9–6.9)	5.2 (3.63–6.93)	0.707 [a]
Median maximum NSE (IQR) – μg/L	52.6 (26.65–139)	37.9 (26.3–53.5)	0.163 [a]
Median Δ NSE (IQR) – μg/L	10.2 (2.1–95.05)	1.6 (0–10.9)	0.047 [a]
CPC 1–2 (%) – no.	16 (52)	18/28 (64)	0.472[b]

Note: If the denominators are smaller than the total size of the group due to missing values, the corresponding numerators and denominators are specified in the table.

CAG: Coronary angiography; TIMI: Thrombolysis in myocardial infarction grade flow; PCI: Percutaneous coronary intervention; ROSC: Return of spontaneous circulation; ICU: Intensive care unit; CPC: Cerebral performance category; NSE: Neuron-specific enolase.

[a] Mann-Whitney *U* test.

[b] Fisher's exact test.

the left anterior descending artery among STEMI patients and more frequent PCI of the circumflex artery in high-risk ECG patients – may reflect the 'hidden' ST-elevation pattern in infarctions involving the circumflex artery, which may go undetected when additional leads such as V7–V9 are not routinely recorded. Identifying OMI on the initial ECG after ROSC remains challenging due to resuscitation-related factors and post-arrest metabolic disturbances. However, when interpreted by experienced readers with these factors in mind, the initial ECG can provide valuable diagnostic guidance.[46] Our findings further highlight the potential consequences of failing to account for these factors, which may adversely impact clinical decision-making and patient outcomes. When it comes to ischemic-pattern recognition on the ECG, future directions may include AI-assisted tools to help address this complex task.[47–49]

Although our study did not reveal statistically significant differences in mortality between groups, short-term survival rates were numerically lower in patients with a high-risk ECG. These findings suggest unresolved coronary compromise, potentially exacerbated by delayed interventions, that may not have been addressed in a timely manner. Moreover, complex coronary morphology can increase the complexity of coronary intervention, particularly in the setting of multivessel PCI or culprit-lesion-only PCI. Supporting this notion, cardiac causes of death were three times more prevalent in the high-risk ECG group than in the STEMI group. Furthermore, high-risk ECG patients showed lower rates of hypoxic brain injury and significantly lower median ΔNSE levels, however, this did not translate into a clear mortality benefit. Previous research highlights that shorter door-to-CAG times in patients with acute OMI are associated with better clinical outcomes.[50,51] Current treatment paradigms, however, appear to contribute to delays in intervention for patients with high-risk ECG, potentially affecting their prognosis adversely.

While immediate coronary angiography may not be appropriate for all patients after cardiac arrest, those with high-risk ECG findings likely represent a subgroup that could significantly benefit from early intervention. Integrating ECG criteria beyond traditional STEMI parameters could enhance the identification of patients most suited for immediate coronary angiography, potentially improving clinical outcomes and shaping future practice. While individualized therapy is a promising approach, it requires a robust and objective

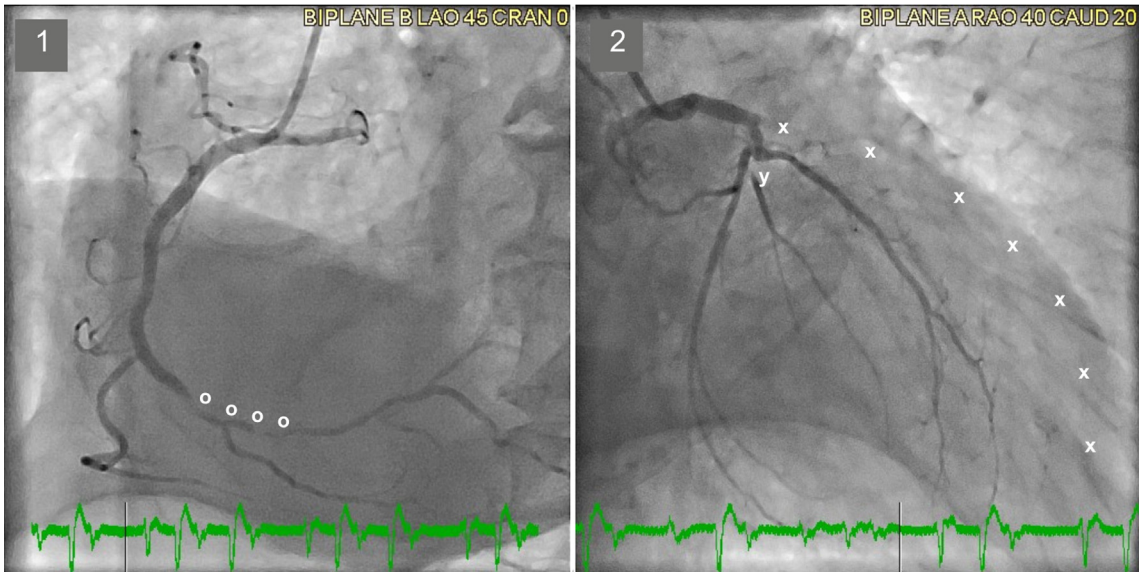

Fig. 4 – Example coronary condition of a high-risk ECG patient, representing the high SYNTAX-I Score as an expression of severity of coronary artery disease: 1) right coronary artery: long-segment subtotal stenosis in the distal third (o); 2) left coronary artery: occlusion in the exit area of the left anterior descending artery (x), after a short course bifurcation of the left circumflex artery with 50–60% lumen restriction in the bifurcation area and subtotal stenosis of a small branch of the marginal vessel (y).

foundation. Developing and implementing decision-making protocols that incorporate advanced ECG criteria into organised post-resuscitation care could help minimize critical delays and ensure timely treatment for high-risk patients.

Limitations

While this study contributes to understanding the importance of high-risk ECG patterns in patients resuscitated from OHCA, it has several limitations that need to be noted. Firstly, the retrospective, single-centre design limits the ability to establish causality and may introduce selection bias. Furthermore, results are limited by the study's sample size. The reliance on data from routine care introduces the possibility of incomplete documentation and missing data, which could affect the robustness of the conclusions. Larger, prospectively recruited cohorts from multiple centres would be essential to strengthen the findings and improve generalizability.

Another limitation is the potential for misclassification of ECG findings, as interpretations were subject to reviewer bias, despite validation by two senior cardiologists. Additionally, interobserver variability in ECG interpretation was not formally assessed, which may further impact the reliability of the results. Furthermore, a potential selection bias must be considered due to the high prevalence of coronary occlusions and STEMI patients in our cohort, likely reflecting the cardiac focus of our ICU. While it may appear intuitive that non STEMI-patients with occlusive myocardial infarction benefit from a PPCI strategy, this has yet to be conclusively demonstrated.

The study also did not evaluate long-term outcomes, such as neurological recovery and quality of life, which are critical for comprehensively understanding the impact of high-risk ECG patterns on patient prognosis. Furthermore, the lack of data on other confounding factors, such as pre-arrest comorbidities and variations in post-resuscitation care, limits the ability to fully account for their potential influence on outcomes.

Conclusion

Our study underscores the importance of recognizing high-risk ECG patterns in managing patients resuscitated from out-of-hospital cardiac arrest. A significant proportion of these patients exhibit critical ECG changes that necessitate immediate coronary angiography, potentially improving outcomes. Although overall mortality did not differ between the groups, the data highlight concerning trends, as short-term survival was significant lower and cardiac death occurred more often in high-risk ECG patients. These findings suggest that high-risk ECG patterns indicate an elevated risk of adverse events and warrant more urgent interventions. Further research is essential to establish the role of high-risk ECG criteria in clinical protocols, aiming to improve the identification and treatment of acute OMI. Prioritizing these indicators could enhance post-resuscitation care, ultimately improving survival and quality of life for affected patients.

CRediT authorship contribution statement

Claudio Silwanis: Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Julian Maier:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Formal analysis, Conceptualization. **Johannes Eder:** Data curation. **Max Groche:** Data curation. **Alexander Nahler:** Validation, Supervision, Resources, Investigation. **Alexander Fellner:** Validation, Supervision, Resources, Investigation. **Hermann Blessberger:** Validation, Supervision, Resources, Investigation. **Jörg Kellermair:** Validation, Supervision, Resources, Investigation. **Clemens Steinwender:** Validation, Supervision, Resources, Investigation. **Thomas Lambert:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resuscitation.2025.110763.

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