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Research Article

Simple Risk Scores in Patients with Myocardial Infarction Undergoing Transradial Coronary Interventions: Focus on Ejection Fraction

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Abstract

Since their introduction in 1977, percutaneous coronary interventions have gained significance due to their excellent results and improving both quality of life and patients' prognosis. In patients with myocardial infarction, transradial coronary interventions with implantation of drug eluting stents have become widely performed and recommended as first-line therapy. The proper risk stratification in acute cases has been discussed in the literature for the last two decades but no consensus exists. In this paper, data from 285 patients treated with transradial coronary intervention due to myocardial infarction (both STEMI and NSTEMI) were analyzed retrospectively. The goal was to evaluate simple risk scores in predicting possible complications and short-term mortality. The analysis showed that both ejection fraction and a simple ACEF score were able to predict an unfavorable event (OR 0.945, 95% CI; 0.920 to 0.970, p<0.001; OR 2.29, 95%CI; 1.498 to 5.694, p=0.002; respectively). This effect needs validation in larger patients' cohorts.

Keywords: Ejection Fraction, Transradial Coronary Intervention, Myocardial Infarction, Risk Score

Abbreviations

ACEF : Age, Creatinine, Ejection Fraction Score
MACEF : Modified Age, Creatinine, Ejection Fraction Score
BMI : Body Mass Index
CABG : Coronary Artery Bypass Grafting
CACS : Canada Acute Coronary Syndrome Score
CX : Circumflex Artery
DAPT : Dual Antiplatelet Therapy
DES : Drug Eluting Stent
EF : Ejection Fraction
EGFR : Estimated Glomerular Filtration Rate
ESC : European Society for Cardiology
GRACE : Global Registry of Acute Coronary Events
IRA : Infarct-Related Artery
LAD : Left Anterior Descending Artery
LM : Left Main Coronary Artery
NSTEMI : Non-Elevation Myocardial Infarction
PCI : Percutaneous Coronary Intervention
RCA : Right Coronary Artery
SD : Standard Deviation
STEMI : ST-Elevation Myocardial Infarction
SYNTAX : Synergy between PCI with Taxus and Cardiac Surgery
TRA : Transradial Artery Approach

1. Introduction

Most patients with myocardial infarction, both STEMI and NSTEMI, are treated with primary percutaneous intervention, usually with implantation of at least one drug-eluting stent (DES). Since the introduction of transradial artery access (TRA), the rate of complications, especially vascular site complications and bleedings, has decreased significantly [1-8]. Due to the invasive nature of any percutaneous coronary intervention (PCI), however, some complications still occur, among them coronary perforation, dissection, no-reflow, or cerebral injury. This might be more attenuated in acute interventions, performed at night or at weekends, by less experienced operators [9-11].

Risk stratification in coronary patients has been well examined in the literature and lots of potential risk scores have been introduced [10]. No single risk score, which can be applied to all patients, has ever been demonstrated to predict patients' outcome [5].

Introduced in 2003, the Global Registry of Acute Coronary Events (GRACE) score evaluated initially in-hospital mortality in NSTEMI patients but was extended to STEMI individuals due to its excellent validation [4]. The Age, Creatinine and

Ejection Fraction (ACEF) risk score, developed in 2009, was included into the revascularization guidelines to estimate the short-term outcome [1]. The modified Age, Creatinine and Ejection Fraction (mACEF) score, introduced in 2016, focused on renal dysfunction and clinical adverse events after myocardial infarction and complex coronary interventions [12-15]. The Canada Acute Coronary Syndrome (CACS) risk score enables simple risk assessment in patients with acute coronary syndromes [11].

Apart from the risk scores, several single predictors of potential complications worse and outcome have been identified, among them female gender, advanced age, renal dysfunction, and diabetes. Apparently, one of the strongest variables of patient's outcome seems to be reduced left ventricular ejection fraction (EF) [14]

This paper deals with the impact of ejection fraction and simple risk scores on the development of selected complications in patients diagnosed with myocardial infarction, both STEMI and NSTEMI, and treated with transradial emergent or urgent percutaneous coronary interventions (PCI).

2. Methods

2.1 Study Population

The interim data from the ongoing study in the author's institution have been included. The interim data analysis and the detailed description of the patients were published and can be found elsewhere. In summary, out of 349 individuals with diagnosed myocardial infarction (both STEMI and NSTEMI) admitted to Agaplesion General Hospital Hagen, Germany, between 2019 and 2020, 318 patients were scheduled for a diagnostic coronary angiography, and 301 individuals were treated with an emergent or urgent PCI with implantation of at least one drug-eluting stent according to the current guidelines. In 285 (94.5 %) cases, transradial artery approach (TRA) was performed and only this group was further evaluated in this paper (Figure 1). During the interventions, unfractionated heparin adjusted for body weight (70-100 units pro kg body weight) and dual antiplatelet therapy (DAPT) were implemented according to the guidelines. The interventions were performed by a team of four senior cardiologists with at least three years of experience in interventional cardiology. The study was approved by a local ethics committee and was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. All the collected data can be made available upon special request of the authors.

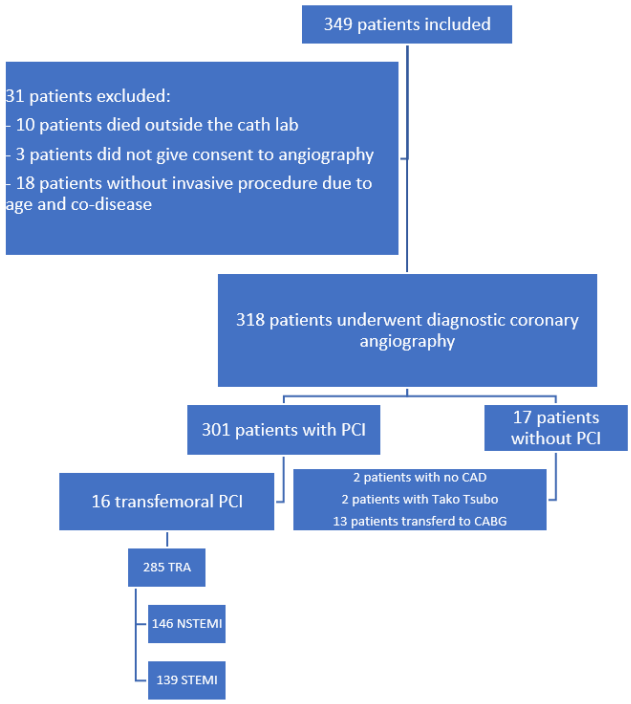


Figure 1: Flow Chart for the Selection of Study Population

2.2 Definitions

ST Elevation Myocardial Infarction (STEMI):- STEMI is defined as acute and persistent (> 20 min) chest discomfort (or equivalent symptoms such as dyspnoe, epigastric pain, pain in the left arm) and persistent ST-segment elevation in at least two contiguous leads on a 12-lead ECG (i.e., ≥ 2.5 mm in men < 40 years, ≥2 mm in men ≥ 40 years, or ≥ 1.5 mm in women in leads V2–V3 and/or ≥ 1 mm in the other leads). This generally reflects an acute total or subtotal coronary occlusion [9].

Non ST Elevation Myocardial Infarction (NSTEMI):- NSTEMI is defined as acute chest discomfort in patients with no persistent ST elevation on a 12-lead ECG and proof of myocardial necrosis (increase and/or decrease of a highly sensitive cardiac troponin, T or I, at least one value above the 99th percentile of the upper reference limit). The ECG may be completely normal or may reveal transient ST elevation, ST depression, T-wave inversion, or flat T waves [9].

Diabetes:- Diabetes was defined as having (1) a history of diabetes, (2) receiving anti-diabetes agents, (3) several increased serum glucose levels, or (4) glycated hemoglobin A1c concentration of 6.5% and over at discharge [11].

Global Registry of Acute Coronary Events (GRACE) score: - GRACE risk score was calculated for all the PCI patients using the available online calculator (https://www.mdcalc.com/grace-acs-risk-mortality-calculator). The evaluated variables are age, heart rate, systolic blood pressure on admission, Killip class on admission, serum creatinine and cardiac biomarker levels, ST-segment deviation on admission and the presence of cardiac arrest at presentation. In case of creatinine and troponin levels, the first available blood samples were analyzed. The Killip classification of acute heart failure

is defined as follows: class I no symptoms, class II rares or crackles in the lungs, class III pulmonary edema, and class IV cardiogenic shock [5].

Age, Creatinine and Ejection Fraction (ACEF) score:- Using the original formula, the ACEF was calculated as follows: (Age/left ventricular ejection fraction) + 1 point if serum creatinine > 2.0 mg/dl [5, 11].

Modified Age, Creatinine and Ejection Fraction (MACEF) score:- MACEF score was estimated with the following equation: (Age/left ventricular ejection fraction) + 1 point for each 10 mL/min decreased in creatinine clearance (CRCl) below 60 mL/min/1.73 m2 (up to 6 points) [4, 5, 11].

Canada Acute Coronary Syndrome (CACS) score:- CACS risk score ranges between 0 and 4. For each four positive variables, one point is scored: heart rate > 100 beats per minute, age > 75 years, systolic blood pressure < 100 mmHg, and Killip class II – IV [5, 11].

Academic Research Consortium 2 (ARC 2) definition of complications:- In 2018, the ARC 2 initiative suggested several standardized clinical and angiographic end point definitions in coronary device studies [7]. This paper deals with procedural complications, which are defined as follows:

a. Major dissection is any dissection of the treated vessel greater than type B (from National Heart, Lung, and Blood Institute classification),
b. Slow flow or no flow is a significantly delayed coronary flow (TIMI 2 for slow flow, TIMI 0 or 1 for no flow) in the treated vessel with minimal residual stenosis (< 30%) within the stented segment and there is no evidence of flow-limiting dissection,
c. Loss of patency of major vessel, graft, or side branch is an abrupt vessel closure (i.e., TIMI 0 or 1 flow after the procedure when TIMI 3 or 2 flow is at baseline, or TIMI 0 flow after the procedure when TIMI 1 flow is at baseline, or TIMI 0 flow after the procedure when TIMI 0 flow is at baseline and transient vessel patency during the procedure). In case of side branch occlusion (>1,5 mm): TIMI 0 or 1 flow after the procedure when initially patent with TIMI 2 or 3,
d. Embolization is the presence of an abrupt cutoff in the distal vessel after the procedure,
e. Neurological injury related to cardiovascular procedures spans a very broad spectrum from typical stroke to minimal covert asymptomatic injury. The detailed description and classification of this issue is beyond the description of this paper and can be found elsewhere [7].
f. Major vascular complication is major bleeding with the necessity of blood transfusion and any local issue transferred to surgery,
g. Coronary perforation is any perforation of a target vessel, regardless of Ellis classification.

Due to reduced number of specific complications and to maintain the acceptable power of the study, all the described complications were analyses in the binary fashion (overall complication vs. no complication). The exact analysis of each complication is beyond the scope of this paper.

2.3 Statistics

Continuous variables are expressed as means±standard deviations (SD) and compared by means of the Mann-Whitney U test. Categorical data are presented as frequencies and percentages and compared using the chi-square test. The level of statistical significance was set as p-value <0.05. Logistic binary regression was performed to establish potential odds ratios (SPSS version 28). The remaining statistical analysis was performed with the Python software program (version 3.8).

3. Results

3.1 Baseline characteristics

The baseline clinical features are provided in Table 1. Among 285 individuals incorporated into this paper, 204 (71.6%) were males and the average age of the sample population was 66 years. The mean ejection fraction was 47.13±11.98. Whereas most patients suffered from hypertension (87%) and hyperlipidemia (mean LDL 130.76±23.52), only 128 individuals (44.9%) were diagnosed with diabetes. All the patients were treated with a PCI with at least one drug-eluting stent (100%) and received dual antiplatelet therapy. The in-hospital mortality was 2.5%. In 47 cases (13.4%) a complication occurred.

Table 1: Baseline characteristics of the study group

Variable	Study group (N=285)
Gender	
males	204 (71.6%)
females	81 (28.4%)
Infarct type	
NSTEMI	146 (51.2%)
STEMI	139 (48.8%)
Diabetes	128 (44.9%)
Hypertension	248 (87%)
Cardiac arrest	28 (9.8%)
ST deviation	257 (90.2%)
IRA	
LM	8 (2.8%)
LAD	123 (43.2%)
CX	54 (18.9%)
RCA	93 (32.6%)
Graft	7 (2.5%)
Timing	
Daytime	195 (68.4%)
Night	32 (11.2%)
Weekend	58 (20.4%)
Mortality	7 (2.5%)
Killip class	
1	244 (85.6%)
2	13 (4.6%)
3	5 (1.8%)
4	23 (8.1%)
Complication	47 (13.4%)
Age	66.64±13.442
BMI	27.37±2.639
EF	47.13±11.98
creatinine	1.17±0.756
eGFR	76.31±28.91
HR	78.82±20.28
BP	136.43±26.501
LDL	130.76±23.52
GRACE	126.58±36.43
SYNTAX	24.62±5.79
ACEF	1.61±0.787
mACEF	2.15±1.494
CACS	0.66±0.786

3.2 STEMI and NSTEMI patients

As demonstrated in Table 2, the STEMI and NSTEMI individuals differed significantly in terms of age, BMI, EF, EGFR, diabetes, systolic blood pressure on admission, cardiac arrest on admission, SYNTAX score and LDL. In summary, the STEMI patients were usually older, with lower BMI, had higher EF, but lower EGFR, suffered more often from diabetes, experienced more cardiac arrest on admission, and had higher SYNTAX score. The CACS score was significantly higher in the NSTEMI group (0.69±0.84 vs, 0.54±0.73, p=0.037). The in-hospital mortality was low in both groups and without statistically significant difference (p=0.112). The complication rate did not differ in both groups (p=0.510; Figure 2).

Table 2: Infarct Type and Clinical Variables

	NSTEMI	STEMI	p-value
Gender			
Males	106 (72.60%)	98 (70.55%)	0.79
Females	40 (27.40%)	41 (29.50%)	
Age	62.63±12.74	70.45±13.01	<0.001
BMI	27.94±2.77	26.82±2.39	<0.001
EF	45.28±12.38	48.88±11.35	<0.001
creatinine	1.16±0.97	1.18±0.48	0.285
eGFR	80.36±30.46	72.46±26.88	0.02
diabetes	54 (36.99%)	74 (53.24%)	0.0018
Hypertension	131 (89.73%)	117 (84.17%)	0.22
HR	81.06±23.35	76.70±16.93	0.055
Systolic BP	132.63±29.71	140.03±22.58	0.04
Cardiac arrest	8 (5.48%)	20 (14.39%)	0.02
GRACE	126.51±37.92	126.82±35.03	0.588
Killip class			
1 to 2	137 (93.84%)	120 (86.33%)	0.054
3 to 4	9 (6.16%)	19 (13.67%)	
SYNTAX	23.04±5.87	26.12±5.32	<0.001
LDL	137.15±21.66	124.36±23.85	<0.001
Complication	17 (11.64%)	29 (20.86%)	0.510
Death	1 (0.68%)	6 (4.32%)	0.112
Timing			
Daytime	99 (67.81%)	96 (69.06%)	0.733
Night	15 (10.27%)	17 (12.23%)	
Weekend	32 (21.92%)	26 (18.71%)	
IRA			
LM	7 (4.79%)	1 (0.72%)	<0.001
LAD	59 (40.41%)	64 (46.04%)	
CX	37 (25.34%)	17 (12.23%)	
RCA	37 (25.34%)	56 (40.29%)	
Graft	6 (4.11%)	1 (0.72%)	
ACEF	1.58±0.80	1.63±0.77	0.165
mACEF	2.00±1.44	2.29±1.54	0.069
CACS	0.69±0.84	0.54±0.73	0.0373

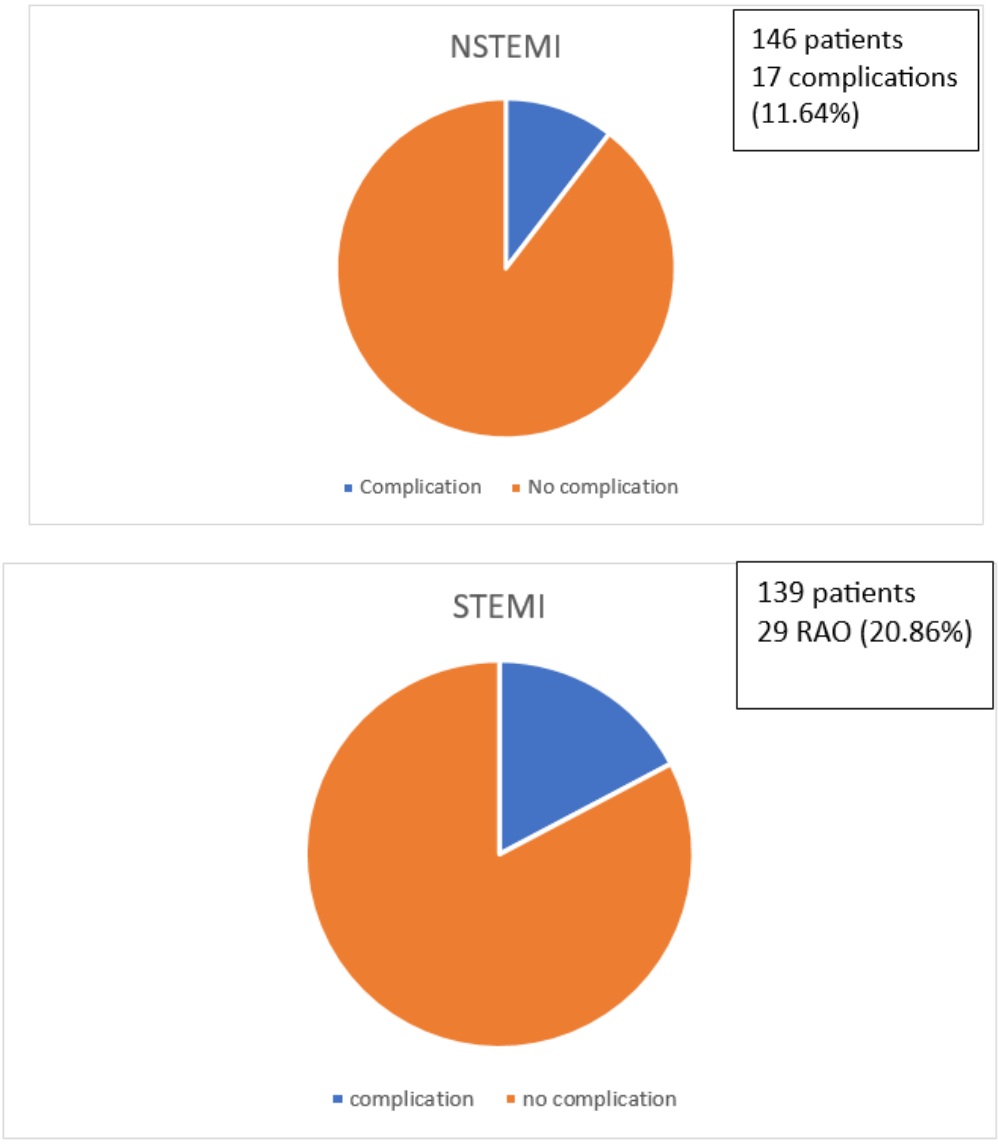


Figure 2: Complications in NSTEMI and STEMI Patients

3.4 Risk scores and Complications

The results of the logistic regressions are presented in Table 3. Only the ACEF score was able to predict potential complications (OR 2.29, 95%CI; 1.498 to 5.694, p=0.002). The ROC analysis showed a moderately strong effect with AUC 0.633, 95% CI; 0.537 to 0.729, p=0.04). The ACEF score was divided into three subgroups: low risk (<1.0225), medium risk (1.0225 to 1.277) and high risk (>1.277) according to the current literature [15]. Figure 3 shows the rate of complications among the subgroups. Most complications occurred in the high-risk group (p=0.003).

Table 3: Logistic regression: risk scores and complication risk

Score	OR	95% CI; lower to upper value	p value
CACS	1.235	95%; 0.587 to 2.598	0.579
GRACE	0.986	95%; 0.969 to 1.004	0.127
mACEF	0.860	95%; 0.607 to 1.219	0.397
ACEF	2.29	95%; 1.498 to 5.694	0.002
SYNTAX	0.998	95%; 0.942 to 1.058	0.947

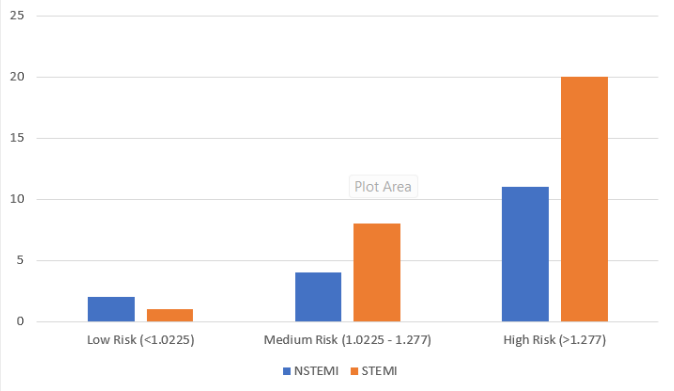


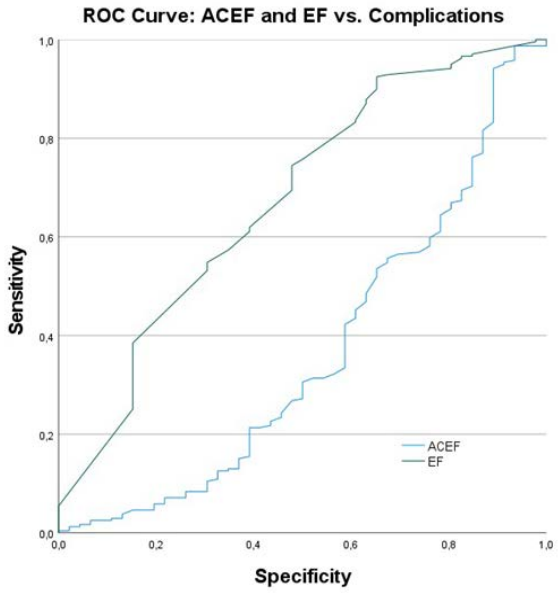
Figure 3: Subgroup analysis according to ACEF and infarct type

3.5 Ejection fraction

Whereas the mean EF in the whole study group was 47.13±11.98, EF differed significantly between the NSTEMI und STEMI patients (45.28±12.38 vs. 48.88±11.35, respectively; p<0.001). The logistic regression demonstrated a significant relationship between EF and complication occurrence (OR 0.945, 95% CI; 0.920 to 0.970, p<0.001; Table 4, Figure 4). The ROC analysis showed a moderately positive effect with AUC 0.675, 95% CI; 0.586 to 0.763, p<0.001.

Table 4: Logistic regression: ejection fraction and complication risk

	OR	95% CI; lower to upper value	p value
EF	0.945	95%; 0.920 to 0.970	<0.001



ACEF: AUC 0.633, 95% CI; 0.537 to 0.729, p=0.04
EF: AUC 0.675, 95% CI; 0.586 to 0.763, p<0.001

Figure 4: The impact of EF and ACEF on complications: logistic regression.

4. Discussion

Risk stratification in patients undergoing emergent or urgent coronary interventions remains a highly complex issue. Even though several predictors and risk scores have been established and validated in the last decades, there is no single predictor or risk score which can be applied to all cases [8, 10]. Some of existing scores are complicated and their usefulness restricted. Whereas in elective procedures it is possible to calculate complex scores and discuss them with colleagues and patients, acute interventions do not offer enough time and comfort to preform advanced calculations. Thus, any simple risk score that can predict potential complications and outcome, and can be used in each interventional setting (especially acute) is of utmost importance.

The present study was able to demonstrate that reduced ejection fraction may predict an adverse event and influence mortality (OR 0.945, 95% CI; 0.920 to 0.970, p<0.001). This simple observation has been found across the literature data and merits more attention. Due to its simplicity and availability, echocardiography should be performed in every patient undergoing a PCI, preferably pre-procedural. Obtaining a quick bedside echocardiography may be possible in majority of patients, even with ST elevation infarct, without relevant delay in door-to-balloon time [8, 11].

The second finding of the paper is the possible usefulness of the simple Age, Creatinine and Ejection Fraction (ACEF) score in acute transradial coronary interventions. The binary logistic regression demonstrated a moderately favorable effect (OR 2.29, 95%CI; 1.498 to 5.694, p=0.002). This may be mainly explained by the overall effect of ejection fraction since both age and creatinine did not show any special contribution. Still, the simplicity of the score may make it a valuable tool in everyday clinical practice [15].

4.1 Study Limitations

The potential information and selection bias in this retrospective analysis cannot be fully excluded. Thus, the limited number of patients, short follow-up and single-center design may not reveal the overall outcome in the general population.

5. Conclusion

Not only ejection fraction but also a simple Age, Creatinine and Ejection Fraction (ACEF) score may be able to predict overall complications and patients' outcome in acute tran-

sradial coronary interventions. This observation needs further evaluation.

Declarations

1. Funding: no external funding, self-funding only

2. Conflicts of interest: On behalf of all authors, the corresponding author states that there is no conflict of interest.

3. Ethics approval: Westfalen-Lippe Ethics Committee in Muenster, Germany, No. 2022-699-f-S

4. Written consent for publication: On behalf of all authors, the corresponding author confirms the authors' consent for publication.

5. Authors' contributions:

MR and CA: equal contribution; main conception of the paper, performed and verified the analysis, wrote the results and conclusion sections.

KK: contributed to the main theoretical background, verified the analysis, supervised the project. All authors discussed the results and contributed to the final manuscript.

CE: performed and verified the analysis, contributed to the theoretical background, wrote the results and conclusions sections.

MF: contributed to the main theoretical background, verified the analysis and results.

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