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Research Article

Symptomatic Radial Artery Occlusion in Patients with Myocardial Infarction Undergoing Coronary Interventions: The Impact of Diabetes.

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Abstract

Radial artery occlusion remains the most common complication of the transradial coronary interventions, occurring in up to 15% of cases. Whereas both symptomatic and asymptomatic scenarios have been identified, only symptomatic cases are treated routinely in the clinical practice. Among many predictors for radial occlusion, diabetes was found to be associated with this complication. In the current study, 285 diabetes and non-diabetes patients with myocardial infarction (both STEMI and NSTEMI), were analyzed retrospectively. Radial artery occlusion occurred in 12 cases (2.5%). Logistic regression showed no statistically significant difference in RAO presence in the diabetes and non-diabetes group (OR 0.569; 95% CI, 0.176 to 1.836). This result may be, however, underestimated due to a limited number of patients and merits further investigation.

Keywords: Diabetes, Coronary Intervention, Myocardial Infarction, Radial Artery Occlusion

Abbreviations

BMI	Body mass index
CABG	Coronary artery bypass grafting
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
RAO	Radial artery occlusion
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

Conventional (non-distal) transradial artery access (TRA) has become the default approach in modern interventional treatment of patients with coronary artery disease, in both acute and elective settings [1]. Compared with transfemoral approach, TRA has been associated with fewer bleeding complications und favorable outcome [2, 4-7]. In high-risk groups, such as patients presenting with acute coronary syndromes, TRA has been demonstrated to reduce in-hospital mortality [8-19].

Radial artery occlusion (RAO) is the most frequent post-procedural complication, occurring in up to 15% of cases based on the current literature data [3, 8, 19]. Even though most cases are asymptomatic (with spontaneous recanalization in over 30% of cases), RAO excludes future ipsilateral interventions (which may be beneficial in patients with high bleeding risk) and the usage of radial arterial conduit in case of coronary artery bypass grafting surgery [12]. Several potential risk factors for RAO have been identified so far, among them larger sheath size (>6F), suboptimal anticoagulation, substandard patent hemostasis and female gender. Diabetes has been demonstrated as a potential predictor for RAO, but no consistency has been found in the literature [4, 6, 13].

Given that diabetes patients benefit more from arterial than venous bypass grafts, long-time patency of radial artery in this group may be of utmost importance. No single standard management of symptomatic and asymptomatic RAO has ever been established [14]. In the clinical routine, symptomatic cases are mostly addressed; pharmacological, interventional, and surgical methods are possible and have been adopted according to local availability, expertise and patients' and physicians' preferences [1].

This paper deals with the impact of diabetes on the development of symptomatic RAO 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.

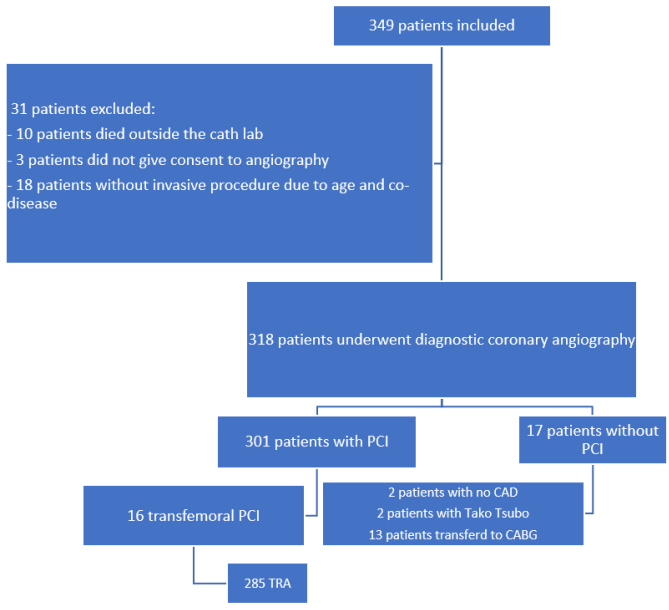

Figure 1: Flow chart for the selection of study population

All the transradial PCIs were performed with the 6-in-5 slender sheaths (Terumo) and the patent hemostasis with the TerumoBand according to the manufacturer's recommendations was achieved. 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.

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 [14].

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 [14].

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 [10].

Symptomatic Radial Artery Occlusion: For the sake of this study, symptomatic occlusion is defined as any (partial or total) thrombotic occlusion of radial artery (diagnosed by color Doppler ultrasound) occurring within 24 hours of TRA together with typical symptoms (i.e., pain, paresthesia, function loss).

Asymptomatic Radial Artery Occlusion: Any (partial or total) thrombotic occlusion of radial artery (diagnosed by color Doppler ultrasound) occurring withing 24 hours of TRA without typical symptoms (i.e., pain, paresthesia, function loss).

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. Result

3.1. Baseline Characteristics

The baseline clinical features are provided in Table 1. Among 285 individuals incorporated into this paper, 128 (44.9%) suffered from diabetes. The average age of the sample population was 66 years, and 71.6% were males. The mean ejection fraction was 47.13±11.98. Most patients suffered from hypertension (87%) and hyperlipidemia (mean LDL 130.76±23.52). All the patients were treated with a PCI (using the 6-in-5 radialis slender sheath) with at least one drug-eluting stent (100%) and received dual antiplatelet therapy. The in-hospital mortality was 2.5%. RAO occurred in 12 cases (4.2%).

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%)
RAO	12 (4.2%)
Killip class	
1	244 (85.6%)
2	13 (4.6%)
3	5 (1.8%)
4	23 (8.1%)
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
GRACE	126.58±36.43
SYNTAX	24.62±5.79
LDL	130.76±23.52

3.2. Diabetes and Non-Diabetes Patients

As demonstrated in Table 2, diabetes patients were more often males with overweight and moderately reduced ejection fraction. Apart from infarct type, there were only three additional variables with statistical significance. The diabetes patients had higher BMI (OR 1.24; 95% CI, 1.12 to 1.37), lower EF (OR 0.959; 95% CI, 0.939 to 0.98) and less hypertension (OR 0.245; 95% CI, 0.104 to 0.578).

Table 2: Diabetes and its impact on the clinical variables

	Diabetes patients	Non-Diabetes patients	p-value
Gender			
Males	112 (71.34%)	92 (71.88%)	0.99
Females	45 (28.66%)	36 (28.12%)	
Infarction			
NSTEMI	92 (58.6%)	54 (42.19%)	0.008
STEMI	65 (41.4%)	74 (57.81%)	
Age	65.38±12.07	67.66±14.42	0.22
BMI	28.12±2.66	26.75±2.46	0.0083
EF	44.01±12.14	49.67±11.26	<0.001
creatinine	1.20±0.88	1.14±0.63	0.63
eGFR	76.05±29.71	76.53±28.33	0.81
Hypertension	127 (80.89%)	121 (94.53%)	<0.001
HR	78.26±21.95	79.27±19.09	0.362
Systolic BP	135.84±29.95	136.91±23.43	0.661
Cardiac arrest	11 (7.01%)	17 (13.28%)	0.116
GRACE	126.90±36.01	126.32±36.89	0.987
Killip class			
1 to 2	146 (92.99%)	111 (86.72%)	0.116
3 to 4	11 (7.01%)	17 (13.28%)	
SYNTAX	24.80±5.64	24.48±5.93	0.865
LDL	132.15±23.88	129.62±23.24	0.280
RAO	5 (3.18%)	7 (5.47%)	0.510
Death	2 (1.27%)	5 (3.91%)	0.297
Timing			
Daytime	111 (70.70%)	84 (65.62%)	0.648
Night	16 (10.19%)	16 (12.50%)	
Weekend	30 (19.11%)	28 (21.88%)	
IRA			
LM	7 (4.46%)	1 (0.78%)	0.205
LAD	71 (45.22%)	52 (40.62%)	
CX	28 (17.83%)	26 (20.31%)	
RCA	46 (29.30%)	47 (36.72%)	
Graft	5 (3.18%)	2 (1.56%)	

3.3 RAO among Clinical Variables

The results of the logistic regressions are presented in Table 5. No clinical variable was found to show statistical significance.

Table 5: RAO among clinical variables

Variable	OR	95% CI (lower to upper)	P value
Sex	1.55	0.33 to 7.195	0.576
Infarct type	0.746	0.154 to 3.611	0.716
Age	1.1	0.954 to 1.268	0.190
BMI	0.952	0.728 to 1.243	0.715
EF	0.971	0.916 to 1-030	0.325
Creatinine	0.364	0.08 to 17.609	0.610
eGFR	1.0	0.956 to 1.046	0.99
Diabetes	0.436	0.103 to 1.844	0.259
hypertension	4.33	0.821 to 22.88	0.84
HR	0.992	0.952 to 1.034	0.709
BP	0.984	0.946 to 1.024	0.429
Cardiac arrest	0.37	0.000 to 3.578	0.157
GRACE	0.958	0.891 to 1.031	0.250
SYNTAX	1.081	0.967 to 1.208	0.173
LDL	0.972	0.939 to 1.006	0.109

3.4. Diabetes and RAO

The occurrence of RAO did not differ between diabetes and non-diabetes patients (3.18% vs 5.47%, p=0.510). The logistic regression showed OR 0.569; 95% CI, 0.176 to 1.836 (Figure 2).

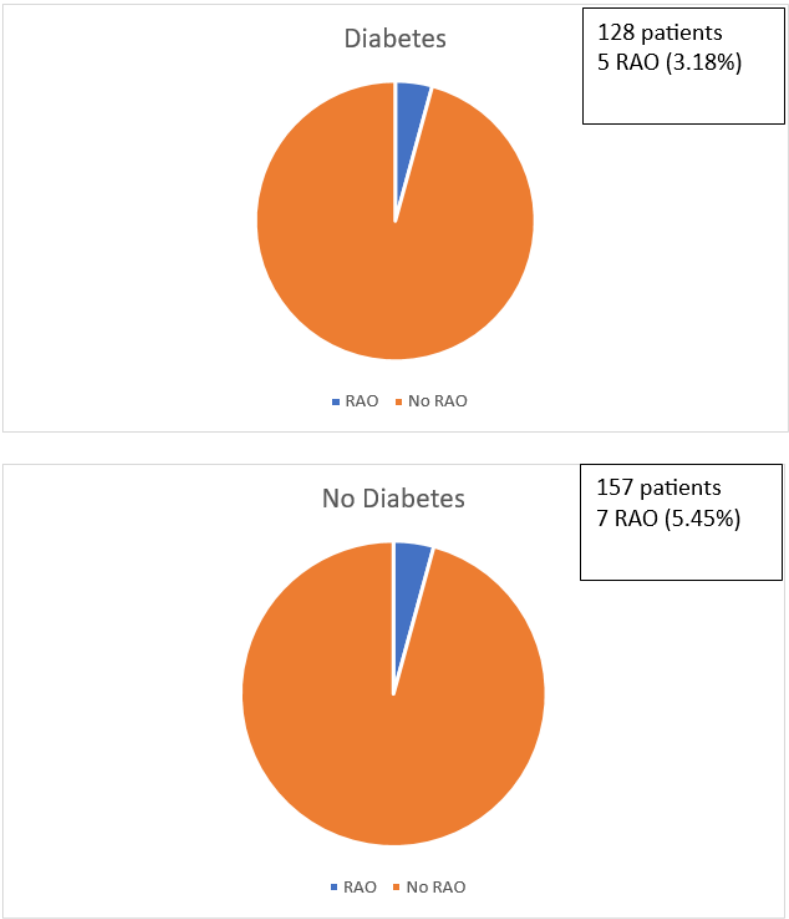

Figure 2 : RAO in diabetic and non-diabetic patients

Between diabetes and no-diabetes patients no statistically significant difference was found (OR 0.569; 95% CI, 0.176 to 1.836).

The subgroup analysis (Table 3 and 4; Figure 3) provided no relevant additional information regarding the impact of gender.

Table 3: The impact of diabetes and gender: male patients

	Diabetes patients	Non-Diabetes patients	p-value
Infarction			
NSTEMI	69 (61.61%)	37 (40.22%)	0.003
STEMI	43 (38.39%)	55 (59.78%)	
Age	64.71±11.25	66.27±13.92	0.493
BMI	27.82±2.36	26.83±2.43	0.0058
EF	43.41±12.64	49.58±10.16	<0.001
creatinine	1.15±0.46	1.19±0.70	0.77
eGFR	73.97±22.93	73.96±28.35	0.63
Hypertension	88 (78.57%)	88 (95.65%)	<0.001
HR	79.22±24.08	78.04±20.35	0.947
Systolic BP	132.59±30.66	137.19±24.48	0.184
Cardiac arrest	7 (6.25%)	13 (14.13%)	0.116
GRACE	128.01±37.32	123.15±38.54	0.354
Killip class			
1 to 2	105 (93.75%)	78 (84.78%)	0.062
3 to 4	7 (6.25%)	14 (15.22%)	
SYNTAX	24.50±5.75	24.96±5.92	0.499
LDL	133.22±21.10	130.57±23.88	0.263
RAO	5 (4.46%)	4 (4.35%)	0.981
Death	1 (0.89%)	5 (5.43%)	0.131
Timing			
Daytime	77 (68.75%)	64 (69.57%)	0.931
Night	11 (9.82%)	10 (10.87%)	
Weekend	24 (21.43%)	18 (19.57%)	
IRA			
LM	4 (3.57%)	1 (1.09%)	0.370
LAD	51 (45.54%)	37 (40.22%)	
CX	18 (16.07%)	21 (22.83%)	
RCA	35 (31.25%)	32 (34.78%)	
Graft	4 (3.57%)	4 (1.09%)	

Table 4: The impact of diabetes and gender: female patients

	Diabetes patients	Non-Diabetes patients	p-value
Infarction			
NSTEMI	23 (51.11%)	17 (47.22%)	0.901
STEMI	22 (48.89%)	19 (52.78%)	
Age	67.08±13.97	71.13±15.20	0.224
BMI	28.92±3.20	26.56±2.56	0.0010
EF	45.53±10.76	49.89±13.76	0.0832
creatinine	1.33±1.50	1.01±0.41	0.427
eGFR	81.36±42.37	82.91±27.56	0.469
Hypertension	39 (86.67%)	33 (91.67%)	0.722
HR	75.83±15.29	82.31±15.31	0.06
Systolic BP	144.06±26.74	136.22±20.83	0.140
Cardiac arrest	4 (8.89%)	4 (11.11%)	1
GRACE	124.14±32.84	134.22±31.43	0.163
Killip class			
1 to 2	41 (91.11%)	33 (91.67%)	0.981
3 to 4	4 (8.89%)	3 (8.33%)	
SYNTAX	25.56±5.38	23.29±5.83	0.156
LDL	129.42±30.00	127.27±21.64	0.946
RAO	0 (0 %)	3 (8.33%)	0.051
Death	1 (2.22%)	0 (0 %)	0.384
Timing			
Daytime	34 (75.56%)	20 (55.56%)	0.151
Night	5 (11.11%)	6 (16.67%)	
Weekend	6 (13.33%)	10 (27.78%)	
IRA			
LM	3 (6.67%)	0 (0 %)	0.282
LAD	20 (44.44%)	15 (41.67%)	
CX	10 (22.22%)	5 (13.89%)	
RCA	11 (24.44%)	15 (41.67%)	
Graft	1 (2.22%)	1 (2.78%)	

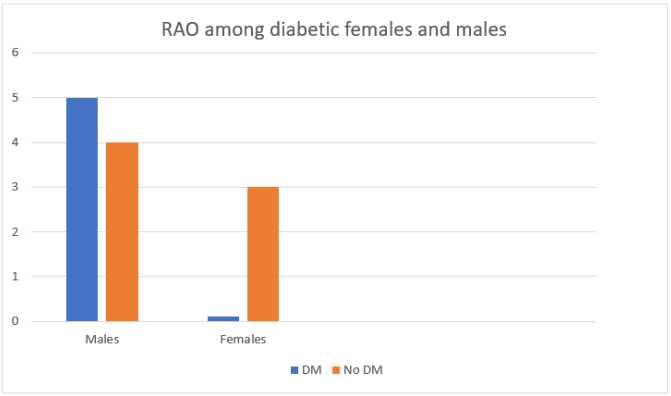

Figure 3: The impact of diabetes and gender on RAO
Among diabetes and non-diabetes males and females no statistical significance was found (OR 1.023; 95% CI, 0.609 to 1.718).

3.5. In-hospital mortality

The overall short-term mortality was as low as 2.5%. No difference was found between diabetes and non-diabetes individuals (1.27% vs. 3.91%, p=0.297).

Discussion

In the literature data, the prevalence of radial artery occlusion, both symptomatic and asymptomatic, varied up to 15% and was usually lower in acute settings [15, 18]. The typical mechanism of RAO seems to involve endothelial injury of the arterial wall, blood flow decrease after sheath insertion, and finally thrombus formation [3, 8]. In acute settings, strict procedural anticoagulation regime, dual antiplatelet therapy, and operator's experience in performing transradial interventions, may contribute to further reduction of RAO rates. Many potential predictors have been identified so far. They can be classified as follows:

- patient-related such as age, female sex, lower BMI, or diabetes,
- PCI-related such as sheath size, procedure timing, anticoagulation, post -PCI patent hemostasis [19].

Whether the radial artery occlusion is symptomatic or not, is of utmost importance. The traditional arguments in favor of maintaining vessel patency regardless of symptoms have been described as follows:

(1) being able to perform TRA in future (especially in high-risk bleeding patients),
(2) being able to use the radial artery as an arterial graft for CABG,
(3) being able to use the radial artery as dialysis shunt, or for invasive for invasive measurement of blood pres- sure [15].

Still, it is a matter of debate of these arguments apply to all patients [17].

Diabetes, with its increasing prevalence and devastating complications, can be found in up to 60% of patients treated interventionally [9, 13]. The data describing diabetes as a risk factor for RAO are scarce: in a single non-randomized study (N=142), diabetes was found to be a possible predictor [12].

The current study was not able to find statistically significant association between RAO and diabetes, but it reveals several interesting aspects of daily routine in the interventional cardiology unit. Most procedures were performed transradially (94.5%) which illustrates high compliance to the current guidelines and best medical practice. The only clinical issue before an arterial puncture was the presence of palpable radial pulse. The patent hemostasis was achieved using the TerumoBand up to 4 hours (with lowering the pressure after 2 hours) according to the manufacturer's recommendations. Post-PCI, the only routine clinical step was a pulse control, usually one day after the PCI. In asymptomatic patients, no further evaluation was performed, regardless of pulse presence on the clinical examination. In symptomatic patients, the diagnosis of RAO was confirmed with color Doppler ultrasound. If RAO was diagnosed, the patient was referred to the angiology department for further management. Out of 12 patients, six were scheduled for interventional recanalization, three underwent open surgery, and three were given oral anticoagulation for 3 months.

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. This study does not include cases of distal ('snuffle-box') TRA and deals with conventional TRA patients only.

5. Conclusion

The impact of diabetes on the development of RAO cannot be confirmed by this study but it may remain underestimated due to a limited number of patients.

Declarations

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Authors' contributions:
MR and CA: equal contribution; main conception of the paper, performed and verified the analysis, wrote the results and conclusion sections.
CE: performed and verified the analysis, contributed to the theoretical background, wrote the results and conclusions 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.
MF: contributed to theoretical and practical background, verified statistics and supervised the project.

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