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Original Article

Frequency and Classification of Myocardial Infarction with Non-Obstructive Coronary Arteries Among Young Adults Presenting with Acute Myocardial Infarction in Multan District, Pakistan

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ABSTRACT

Background: Myocardial infarction with non-obstructive coronary arteries (MINOCA) is a heterogeneous clinical entity that is particularly relevant in younger adults and women. Accurate differentiation from obstructive myocardial infarction and identification of the underlying mechanism are important because clinical presentation, diagnostic pathways, and management may differ substantially. **Objective:** To characterize the frequency, etiological distribution, clinical profile, treatment patterns, and short-term outcomes of working MINOCA compared with obstructive myocardial infarction among young adults aged 18–45 years. **Methods:** An analytical cross-sectional framework was applied to a dataset of 290 acute myocardial infarction observations classified according to coronary angiographic findings. Working MINOCA was defined by the absence of ≥50% stenosis in any major epicardial coronary artery. Demographic, cardiovascular, psychosocial, clinical, treatment, and in-hospital outcome variables were compared between groups. Binary logistic regression was used to examine factors associated with working MINOCA classification. **Results:** Working MINOCA accounted for 43 of 290 observations (14.8%). Female sex was more frequent in the MINOCA group than in the obstructive myocardial infarction group (44.2% vs. 21.5%, p=0.001). MINOCA was also characterized by lower body mass index, less current smoking, less frequent ST-segment elevation, lower peak troponin I, and higher perceived-stress scores. Plaque disruption and coronary vasospasm were the most frequent assigned mechanisms. Female sex was associated with working MINOCA classification in multivariable analysis (adjusted OR 2.94; 95% CI 1.46–5.92; p=0.003). **Conclusion:** Working MINOCA represented a clinically distinct subgroup within the analytical dataset. Mechanism-oriented classification and broader clinical profiling may improve the structured evaluation of young adults presenting with myocardial infarction and non-obstructive coronary arteries. **Keywords:** Acute Myocardial Infarction; MINOCA; Non-Obstructive Coronary Arteries; Young Adults; Coronary Vasospasm; Microvascular Dysfunction; Risk Factors.

Introduction

Acute myocardial infarction (AMI) in young adults presents distinct diagnostic challenges because the relative contribution of conventional atherosclerotic disease decreases as alternative coronary and systemic mechanisms become more relevant. In addition to premature atherosclerosis, AMI in younger individuals may be associated with coronary vasospasm, spontaneous coronary artery dissection (SCAD), coronary thromboembolism, hypercoagulable or inflammatory disorders, substance-related mechanisms, and other non-atherosclerotic conditions (1). Consequently, an angiographic presentation without severe obstructive coronary disease requires a broader diagnostic approach than conventional plaque-mediated myocardial infarction alone.

Myocardial infarction with non-obstructive coronary arteries (MINOCA) is generally defined as an AMI presentation in which coronary angiography demonstrates no stenosis of 50% or greater in a major epicardial vessel and no immediately apparent alternative explanation for the clinical presentation. Contemporary evidence indicates that MINOCA accounts for approximately 5%–15% of myocardial infarction presentations and occurs disproportionately among women and relatively younger patients (2,3). Importantly, MINOCA is considered a working diagnosis rather than a definitive disease entity because the same angiographic presentation can arise from multiple pathophysiological processes requiring different diagnostic and therapeutic strategies (2–4).

The coronary mechanisms underlying MINOCA include disruption or erosion of a non-obstructive atherosclerotic plaque, epicardial coronary vasospasm, coronary microvascular dysfunction, SCAD, and coronary thromboembolism (2–5). Coronary vasomotor abnormalities are particularly important because both epicardial spasm and microvascular dysfunction may produce clinically significant myocardial ischaemia despite the absence of fixed obstructive disease (5). Inflammatory and autoimmune disorders may also contribute to vasomotor abnormalities or myocardial injury, while myocarditis and Takotsubo syndrome can resemble MINOCA during the initial clinical evaluation and must be distinguished from true ischaemic myocardial infarction (2–4).

This mechanistic heterogeneity has important diagnostic implications. Conventional coronary angiography primarily delineates the coronary lumen and may not reliably identify plaque erosion, subtle plaque disruption, intramural haematoma, microvascular dysfunction, or transient vasospasm. Intracoronary imaging with optical coherence tomography (OCT) or intravascular ultrasound (IVUS) can provide additional assessment of coronary wall pathology, whereas cardiac magnetic resonance imaging can help distinguish myocardial infarction from myocarditis, Takotsubo syndrome, and other myocardial disorders (3,6). Contemporary diagnostic approaches therefore emphasize systematic investigation beyond the initial angiogram when the underlying cause remains uncertain (3,4,6).

Sex-related differences are also prominent in the MINOCA literature. Women are more likely than men to present with myocardial infarction in the absence of obstructive coronary disease, and several mechanisms relevant to MINOCA—including SCAD, coronary vasomotor dysfunction, and microvascular disease—show important sex-related patterns (2,3). These observations reinforce the need to consider demographic characteristics alongside conventional cardiovascular risk factors when evaluating young adults with AMI rather than assuming that the same risk profile applies uniformly to obstructive and non-obstructive presentations.

Premature myocardial infarction is particularly relevant in South Asian populations, where cardiovascular disease often presents at younger ages and modifiable risk factors remain common. Pakistani studies of adults younger than 45 years with myocardial infarction have identified smoking, obesity, hypertension, diabetes, dyslipidaemia, and family history of premature coronary disease as recurring clinical characteristics (7). However, most local studies have focused on conventional cardiovascular risk factors or angiographic burden rather than specifically examining the heterogeneous subgroup presenting with myocardial infarction and non-obstructive coronary arteries.

The distinction between working MINOCA and obstructive myocardial infarction may therefore be especially relevant in younger populations, in whom both conventional risk factors and alternative coronary mechanisms can coexist. Comparative evaluation of demographic characteristics, smoking, metabolic risk factors, autoimmune disease, psychosocial characteristics, electrocardiographic presentation, cardiac biomarker patterns, treatment, and short-term outcomes may help define a more structured analytical profile. Etiological subdivision of working MINOCA can further separate potential plaque-mediated disease from vasomotor disorders, SCAD, embolic mechanisms, microvascular dysfunction, and conditions that mimic myocardial infarction.

Accordingly, the present study aimed to characterize the frequency and etiological classification of working MINOCA within a young-adult AMI dataset and to compare its demographic, cardiovascular, psychosocial, clinical, treatment, and in-hospital outcome profile with obstructive myocardial infarction. A secondary objective was to examine selected characteristics associated with classification into the working MINOCA group, providing a structured framework for future mechanism-oriented investigation of young adults presenting with AMI in Multan District, Pakistan.

Materials and Methods

An analytical cross-sectional framework was used to examine working myocardial infarction with non-obstructive coronary arteries (MINOCA) among young adults with acute myocardial infarction (AMI). The clinical framework was centered on a tertiary-care cardiology setting in Multan District, Pakistan, with the Chaudhary Parvaiz Ellahi Institute of Cardiology serving as the reference clinical context.

The analytical population comprised adults aged 18–45 years with an AMI presentation and coronary angiographic information sufficient to distinguish working MINOCA from obstructive myocardial infarction. AMI was defined according to the Fourth Universal Definition of Myocardial Infarction, requiring an acute rise and/or fall in cardiac troponin with at least one value above the relevant upper reference limit together with clinical evidence of acute myocardial ischaemia (8).

Observations were eligible when age was between 18 and 45 years, the presentation fulfilled accepted criteria for AMI, and angiographic findings permitted classification into either working MINOCA or obstructive myocardial infarction. Observations characterized only by elevated troponin without supporting evidence of myocardial ischaemia, without angiographic assessment, with a clearly established alternative non-coronary diagnosis at initial classification, or representing duplicate inclusion were excluded.

The analytical dataset comprised 290 observations. The dataset size corresponded to a single-proportion calculation based on an expected MINOCA proportion of 22%, a 95% confidence level, and an absolute precision of 5%. An additional 10% allowance was incorporated into the target size, resulting in approximately 290 observations for analysis.

The analytical framework incorporated demographic, anthropometric, cardiovascular, behavioural, psychosocial, clinical, angiographic, therapeutic, and short-term outcome variables. Demographic and cardiovascular variables included age, sex, body mass index, current smoking, diabetes mellitus, hypertension, dyslipidaemia, autoimmune disease, and other relevant cardiovascular risk characteristics.

Clinical variables included ST-segment elevation, peak troponin I concentration, angiographic classification, potential underlying MINOCA mechanism, treatment received during the index episode, length of hospital stay, in-hospital complications, and mortality.

Psychosocial assessment incorporated the 10-item Perceived Stress Scale (PSS-10), a widely used instrument for assessing the degree to which circumstances in an individual's life are perceived as stressful (9). Anxiety was represented using the seven-item Generalized Anxiety Disorder scale (GAD-7) (10), while depressive symptoms were assessed within the analytical framework using the nine-item Patient Health Questionnaire (PHQ-9) (11). Physical activity was represented according to the short form of the International Physical Activity Questionnaire (IPAQ-SF), which provides a standardized approach to characterizing physical activity across different intensity levels (12).

For multivariable analysis, psychosocial variables were additionally represented using predefined categories of moderate-to-high perceived stress and moderate-to-severe anxiety.

The primary dependent variable was the angiographic classification of working MINOCA versus obstructive myocardial infarction. Working MINOCA was defined as an AMI presentation in which no major epicardial coronary artery demonstrated stenosis of 50% or greater. Obstructive myocardial infarction was defined as AMI associated with stenosis of at least 50% in one or more major epicardial coronary arteries. This distinction is consistent with contemporary descriptions of MINOCA as an initial working diagnosis that requires further evaluation of the underlying mechanism rather than being considered a single definitive disease entity (2–4).

Working MINOCA was coded as 1 and obstructive myocardial infarction as 0 for binary analysis.

Cases entering the working MINOCA pathway were further categorized according to the probable underlying mechanism. The principal coronary categories were plaque disruption, epicardial coronary vasospasm, coronary microvascular dysfunction, spontaneous coronary artery dissection (SCAD), and coronary embolism. Myocarditis and Takotsubo syndrome were retained as non-ischaemic mimics because they may initially resemble MINOCA in patients presenting with chest pain, cardiac biomarker elevation, electrocardiographic abnormalities, and non-obstructive coronary arteries. An indeterminate category was retained when no specific mechanism could be assigned (2–5).

The classification framework reflects the recognized heterogeneity of MINOCA and the need to distinguish atherosclerotic, vasomotor, microvascular, dissecting, embolic, and non-ischaemic mechanisms when interpreting a non-obstructive angiographic presentation (2–5).

Treatment variables comprised percutaneous coronary intervention (PCI), aspirin, P2Y12 inhibitor therapy, and statin use. Short-term outcome variables included length of hospital stay, occurrence of any in-hospital complication, and in-hospital mortality. These variables were evaluated comparatively between the working MINOCA and obstructive myocardial infarction groups.

Categorical variables were summarized as frequencies and percentages. Group differences were evaluated using Pearson's chi-square test or Fisher's exact test, as appropriate.

Continuous variables were summarized as mean ± standard deviation when represented by approximately normal distributions and as median with interquartile range when distributional characteristics warranted non-parametric presentation. Independent-samples *t*-tests were used for comparisons of normally distributed continuous variables, whereas the Mann–Whitney U test was used for non-normally distributed variables.

Binary logistic regression was performed to examine characteristics associated with classification into the working MINOCA group. Seven prespecified variables were entered into the model: female sex, age, diabetes mellitus, current smoking, dyslipidaemia, moderate-to-high perceived stress, and moderate-to-severe anxiety. Associations were expressed as adjusted odds ratios (ORs) with 95% confidence intervals.

Range checks and logical-consistency procedures were applied before analysis to identify incompatible values and ensure internal consistency across related variables. No additional statistical analyses beyond those specified in the analytical framework were introduced.

Ethical considerations and dataset provenance are presented in the disclosure statement following the References.

Results

The dataset comprised 290 acute myocardial infarction observations. Of these, 43 (14.8%) fulfilled the criteria for the working MINOCA pathway, whereas 247 (85.2%) were classified as obstructive myocardial infarction.

The mean age of the overall cohort was 36.3 ± 6.6 years. Age did not differ significantly between the working MINOCA and obstructive myocardial infarction groups (35.6 ± 6.3 vs. 36.5 ± 6.7 years; p=0.418). Female sex was more frequent in the working MINOCA group than in the obstructive myocardial infarction group (44.2% vs. 21.5%; p=0.001).

Mean body mass index was lower in the working MINOCA group (24.2 ± 2.6 vs. 25.2 ± 2.8 kg/m²; p=0.022), and current smoking was less frequent (27.9% vs. 44.5%; p=0.042). Autoimmune disease was more frequent among working MINOCA cases (9.3% vs. 2.4%; p=0.045). Perceived stress scores were also higher, with a median PSS-10 score of 21.0 (IQR 12.0–29.5) compared with 17.0 (IQR 10.0–26.0) in the obstructive myocardial infarction group (p=0.034).

Chest pain was the predominant presenting symptom in both groups and occurred in more than 90% of observations. ST-segment elevation was less frequent in working MINOCA than in obstructive myocardial infarction (41.9% vs. 66.0%; p=0.003). Median peak troponin I concentration was also lower in the working MINOCA group at 438 ng/L (IQR 301–630) compared with 884 ng/L (IQR 523–1342) in the obstructive myocardial infarction group (p<0.001).

Table 1. Baseline Sociodemographic and Clinical Characteristics

Characteristic	Working MINOCA (n=43)	Obstructive MI (n=247)	p-value
Age, years, mean ± SD	35.6 ± 6.3	36.5 ± 6.7	0.418
Female sex, n (%)	19 (44.2%)	53 (21.5%)	0.001
BMI, kg/m², mean ± SD	24.2 ± 2.6	25.2 ± 2.8	0.022
Current smoking, n (%)	12 (27.9%)	110 (44.5%)	0.042
Autoimmune disease, n (%)	4 (9.3%)	6 (2.4%)	0.045
ST-segment elevation, n (%)	18 (41.9%)	163 (66.0%)	0.003
Peak troponin I, ng/L, median (IQR)	438 (301–630)	884 (523–1342)	<0.001
PSS-10 stress score, median (IQR)	21.0 (12.0–29.5)	17.0 (10.0–26.0)	0.034

BMI, body mass index; IQR, interquartile range; MI, myocardial infarction; MINOCA, myocardial infarction with non-obstructive coronary arteries; PSS-10, 10-item Perceived Stress Scale; SD, standard deviation.

The 43 observations entering the working MINOCA pathway were further classified according to the probable underlying mechanism. Plaque disruption and coronary vasospasm were the most frequent categories, each accounting for 9 cases (20.9%). Microvascular dysfunction accounted for 8 cases (18.6%), followed by spontaneous coronary artery dissection in 6 cases (14.0%).

Myocarditis accounted for 4 cases (9.3%), coronary embolism for 3 (7.0%), and Takotsubo syndrome for 2 (4.7%). The underlying mechanism remained indeterminate in 2 cases (4.7%).

Table 2. Etiological Classification of Working MINOCA

Etiological Category	Number of Cases (n=43)	Percentage (%)
Plaque disruption	9	20.9
Coronary vasospasm	9	20.9
Microvascular dysfunction	8	18.6
Spontaneous coronary artery dissection (SCAD)	6	14.0

Etiological Category	Number of Cases (n=43)	Percentage (%)
Myocarditis (non-ischaemic mimic)	4	9.3
Coronary embolism	3	7.0
Takotsubo syndrome (non-ischaemic mimic)	2	4.7
Indeterminate	2	4.7
Total	43	100.0

MINOCA, myocardial infarction with non-obstructive coronary arteries; SCAD, spontaneous coronary artery dissection.

Treatment patterns differed substantially between the two angiographic groups. Percutaneous coronary intervention was performed in 3 working MINOCA cases (7.0%) compared with 167 obstructive myocardial infarction cases (67.6%; p<0.001).

Aspirin use was high in both groups, occurring in 90.7% of working MINOCA and 96.4% of obstructive myocardial infarction cases, without a statistically significant difference (p=0.109). P2Y12 inhibitor use was less frequent in the working MINOCA group (74.4% vs. 86.6%; p=0.039), as was statin use (88.4% vs. 96.0%; p=0.038).

Median length of hospital stay was shorter in the working MINOCA group at 3.1 days (IQR 2.6–3.6) compared with 4.1 days (IQR 3.3–5.1) in the obstructive myocardial infarction group (p<0.001). In-hospital complications occurred in 4 working MINOCA cases (9.3%) and 39 obstructive myocardial infarction cases (15.8%), with no statistically significant difference between groups (p=0.355).

No in-hospital deaths occurred in the working MINOCA group, whereas 7 deaths (2.8%) occurred in the obstructive myocardial infarction group; this difference was not statistically significant (p=0.599).

Table 3. Treatment Patterns and In-Hospital Outcomes

Treatment / Outcome	Working MINOCA (n=43)	Obstructive MI (n=247)	p-value
Percutaneous coronary intervention (PCI), n (%)	3 (7.0%)	167 (67.6%)	<0.001
Aspirin, n (%)	39 (90.7%)	238 (96.4%)	0.109
P2Y12 inhibitor, n (%)	32 (74.4%)	214 (86.6%)	0.039
Statin, n (%)	38 (88.4%)	237 (96.0%)	0.038
Any in-hospital complication, n (%)	4 (9.3%)	39 (15.8%)	0.355
Length of stay, days, median (IQR)	3.1 (2.6–3.6)	4.1 (3.3–5.1)	<0.001
In-hospital mortality, n (%)	0 (0.0%)	7 (2.8%)	0.599

IQR, interquartile range; MI, myocardial infarction; MINOCA, myocardial infarction with non-obstructive coronary arteries; PCI, percutaneous coronary intervention.

In binary logistic regression, female sex was associated with higher odds of classification into the working MINOCA group, with an adjusted odds ratio of 2.94 (95% CI 1.46–5.92; p=0.003). The model included female sex, age, diabetes mellitus, current smoking, dyslipidaemia, moderate-to-high perceived stress, and moderate-to-severe anxiety as prespecified covariates.

Discussion

The present analysis identified working MINOCA in 14.8% of the 290 AMI observations, placing the proportion toward the upper end of the range commonly described in contemporary MINOCA literature (2–4). An important feature was the greater representation of women in the working MINOCA group, with female sex accounting for 44.2% of this group compared with 21.5% of the obstructive myocardial infarction group. Sex-related differences in acute myocardial infarction are increasingly recognized, and women are disproportionately represented among patients presenting with myocardial infarction in the absence of obstructive coronary disease (3,4,13,14). Differences in the relative occurrence of SCAD, coronary vasomotor dysfunction, microvascular disease, plaque phenotype, and other non-obstructive mechanisms may contribute to this pattern (3,4,14).

The cardiovascular risk-factor profile also differed between the two groups. Current smoking and higher body mass index were more prominent in obstructive myocardial infarction, whereas autoimmune disease and higher perceived-stress scores were more frequent in working MINOCA. Conventional cardiovascular risk factors remain highly relevant in young adults with myocardial infarction, including South Asian populations, even when their distribution differs according to the underlying coronary phenotype (1,7). Therefore, the presence of non-obstructive coronary arteries should not lead to under-recognition of modifiable cardiovascular risk. The higher PSS-10 scores observed in the working MINOCA group also highlight the potential value of integrating psychosocial assessment into the broader evaluation of young adults with AMI. However, because stress was assessed within a cross-sectional analytical framework, its temporal relationship with the acute event cannot be determined.

The clinical presentation of working MINOCA overlapped substantially with obstructive myocardial infarction. Chest pain predominated in both groups, although ST-segment elevation and peak troponin I concentrations were lower in the working MINOCA group. Such differences may contribute to clinical characterization but cannot reliably identify the underlying mechanism before angiographic and mechanism-specific evaluation. MINOCA remains a working diagnosis because similar clinical presentations can arise from fundamentally different pathophysiological processes (2–4).

The etiological distribution illustrates this heterogeneity. Plaque disruption and coronary vasospasm were the most frequently assigned categories, followed by coronary microvascular dysfunction and SCAD. Epicardial vasospasm and coronary microvascular dysfunction are increasingly recognized as important causes of myocardial ischaemia in patients without fixed obstructive coronary disease. Contemporary guidelines and reviews emphasize that abnormalities of coronary vasomotion may involve epicardial vessels, the microcirculation, or both and often require functional assessment beyond standard angiography for definitive characterization (5,15,16).

The distinction is clinically important because treatment directed toward vasomotor dysfunction differs from management of plaque-mediated infarction, SCAD, embolic disease, or other MINOCA mechanisms.

A non-obstructive angiogram should therefore be considered the beginning rather than the end of the diagnostic process. Conventional angiography primarily depicts the coronary lumen and may fail to demonstrate plaque erosion, subtle plaque rupture, intramural pathology, microvascular dysfunction, or transient vasospasm. Intracoronary imaging with OCT or IVUS can provide detailed assessment of coronary wall pathology, while CMR can identify myocardial infarction patterns and distinguish ischaemic injury from myocarditis, Takotsubo syndrome, and other non-ischaemic myocardial disorders (3,4,6,17–19). A structured multimodality approach can consequently convert an initial working diagnosis of MINOCA into a more specific mechanism-based diagnosis and provide a stronger basis for individualized management.

The higher frequency of autoimmune disease in the working MINOCA group is also clinically noteworthy. Inflammatory and autoimmune processes can influence coronary vasomotor function, endothelial integrity, microvascular circulation, and myocardial tissue. Associations between myocarditis and variant angina have been described, while individual clinical reports have documented coronary spasm accompanying acute myocarditis and systemic vasculitic disorders (20–23). These observations provide biological plausibility for considering inflammatory or autoimmune mechanisms in selected patients with non-obstructive coronary presentations, although case-based evidence cannot establish their population frequency or causal contribution.

Treatment patterns differed markedly according to angiographic classification. PCI was uncommon in working MINOCA but frequent in obstructive myocardial infarction, which is consistent with the absence of a flow-limiting epicardial lesion in most MINOCA presentations. Use of P2Y12 inhibitors and statins was also lower in working MINOCA. These differences reinforce the importance of mechanism-specific treatment rather than assuming that every patient with MINOCA requires an identical secondary-prevention strategy (2–5,17,19). Plaque-mediated MINOCA may justify an atherosclerotic secondary-prevention approach, whereas vasospastic disease, SCAD, thromboembolism, microvascular dysfunction, and non-ischaemic mimics require different therapeutic considerations.

Short-term outcomes were comparatively favorable within the working MINOCA group, including a shorter median hospital stay and numerically fewer in-hospital complications and deaths. However, the absence of a statistically significant difference in complications or mortality should not be interpreted as evidence that MINOCA is benign. A large systematic review and meta-analysis from the MINOCA Global Collaboration demonstrated clinically meaningful risks of mortality and recurrent myocardial infarction after suspected MINOCA, despite generally more favorable outcomes than myocardial infarction associated with obstructive coronary artery disease (24). Prognosis is strongly influenced by the underlying mechanism, comorbidity profile, completeness of diagnostic evaluation, and duration of follow-up.

Several limitations should be considered when interpreting the present analysis. First, the cross-sectional structure precludes determination of temporal or causal relationships between cardiovascular, psychosocial, and clinical characteristics and working MINOCA classification. The reported adjusted association for female sex should therefore be interpreted as an association within the analytical model rather than evidence of causality or clinical prediction. Second, mechanism-specific classification depends heavily on access to CMR, OCT, IVUS, and coronary functional assessment. Incomplete application of advanced diagnostic testing can result in misclassification or an indeterminate diagnosis and can substantially influence the apparent distribution of MINOCA mechanisms (3,6,17–19).

The multivariable analysis was also limited to seven prespecified variables, and the available results provide a fully reported adjusted estimate only for female sex. Therefore, no comparative ranking of the remaining covariates can be established from the available analysis. In addition, outcomes were limited to the index hospitalization; recurrent myocardial infarction, rehospitalization, persistent angina, functional status, major adverse cardiovascular events, and longer-term mortality were not evaluated. Longer follow-up would be required to determine the prognostic implications of the different etiological categories.

Despite these limitations, the analytical framework integrates angiographic classification with cardiovascular risk factors, psychosocial characteristics, potential mechanisms, treatment patterns, and short-term outcomes in a young-adult AMI population. Its principal value lies in emphasizing that MINOCA should not be treated as a homogeneous diagnosis. Future investigations should use standardized AMI and MINOCA definitions, prospectively document the use and findings of CMR and intracoronary or functional coronary testing, distinguish coronary causes from non-ischaemic mimics, and incorporate longitudinal follow-up (3,4,6,17–19). Such an approach would permit more reliable assessment of the epidemiology, determinants, treatment, and prognosis of MINOCA among young adults in Pakistan.

Conclusion

Working MINOCA constituted a distinct subgroup within the analytical dataset and demonstrated differences from obstructive myocardial infarction in sex distribution, cardiovascular risk profile, clinical presentation, treatment, and short-term outcomes. The diversity of assigned mechanisms reinforces that MINOCA represents a diagnostic starting point rather than a final clinical explanation. A structured, mechanism-oriented approach incorporating angiographic findings, appropriate advanced cardiac imaging, coronary functional assessment where indicated, and individualized cardiovascular risk evaluation provides a coherent framework for investigating young adults presenting with myocardial infarction and non-obstructive coronary arteries.

DECLARATIONS

Author Contributions:	Concept: SAAR, SHK; Design: SAAR, SHK, SB; Data Collection: SAAR, TZ, KY, QZ; Analysis: MA, UH; Drafting: SAAR, TZ, QZ.
Ethical Approval:	Ethical approval was obtained from the Multan Medical and Dental College, Multan, Pakistan. Permission for data collection was obtained from the participating healthcare institution(s) in Multan District, Pakistan.
Informed Consent:	Written informed consent was obtained from all participants before enrollment. Trial Registration: Not applicable.
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Data Availability:	Data are available from the corresponding author on reasonable request.

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AI Declaration: Generative AI tools were used solely for language and grammatical refinement. The authors verified the final manuscript and remain fully responsible for its accuracy, integrity, and scientific content.

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