Retrospective Cohort Study

Comparative assessment of clinical profile and outcomes after primary percutaneous coronary intervention in young patients with single vs multivessel disease

Atif Sher Muhammad, Tariq Ashraf, Ayaz Mir, Syed Alishan, Faiza Farooq, Ali Ammar, Musa Karim, Syed Nadeem Hassan Rizvi, Tahir Saghir, Jawaid Akbar Sial, Naveed Ullah Khan

ORCID numbers: Atif Sher Muhammad (0000-0003-4541-9393); Tariq Ashraf (0000-0002-6680-1017); Ayaz Mir (0000-0003-2932-8475); Syed Alishan (0000-0002-6005-0961); Faiza Farooq (0000-0003-3709-3071); Ali Ammar (0000-0001-7778-4278); Musa Karim (0000-0001-7941-8191); Syed Nadeem Hassan Rizvi (0000-0001-3648-0343); Tahir Saghir (0000-0002-3148-8964); Jawaid Akbar Sial (0000-0003-3700-127X); Naveed Ullah Khan (0000-0002-3338-1642).

Author contributions: Muhammad AS, Ashraf T, Mir A, Alishan S, Farooq F, Ammar A, Karim M, Rizvi SNH, Saghir T, Sial JA, Khan NU contributed to the writing, revising of this manuscript.

Institutional review board statement: This study was conducted after the approval of the Ethical Review Committee of the National Institute of Cardiovascular Diseases (ERC-29/2019).

Informed consent statement: Informed consent was obtained from all the patients.

Conflict-of-interest statement: None to declare.

Data sharing statement: No additional data.

STROBE statement: The guidelines of the STROBE statement have been adopted.

Abstract

BACKGROUND

Even though percutaneous coronary intervention (PCI) improved the survival of patients with acute myocardial infarction, still multivessel coronary artery disease remains an important factor burdening prognosis and it is being associated with a worse prognosis compared to single-vessel disease (SVD).

AIM

To compare the clinical profile and outcomes after the primary PCI in young patients with SVD vs multivessel disease (MVD).

METHODS

The retrospective cohort of patients were divided into two groups: SVD and MVD group. The study population consisted of both male and female young (≤ 45 years) patients presented with ST-elevation myocardial infarction (STEMI) at the National Institute of Cardiovascular Disease, Karachi, Pakistan and undergone primary PCI from 1st July 2017 to 31st March 2018. Pre and post-procedure management of the patients was as per the guidelines and institutional protocols.

RESULTS

A total of 571 patients with STEMI, ≤ 45 years were stratified into two groups by the number of vessels involved, 342 (59.9%) with SVD and 229 (40.1%) with MVD. The average age of these patients was 39.04 ± 4.86 years. A lower prevalence of hypertension and diabetes was observed in SVD as compare to MVD group (25.1% vs 38%, P < 0.01; 11.7% vs 27.5%, P < 0.001) respectively.
INTRODUCTION

Coronary artery disease (CAD) have been surging day by day, in the third world countries[1]. The 45 years or below is one of the globally accepted cutoff value for premature CAD[2], the cutoff value for young CAD in various studies varying from 35 to 55 years[3,4]. The field of cardiology has received great attention in the last decades with the young CAD with varying risk profiles and different prognosis and the length of severe coronary phase[5]. The ischemic coronary disease appears in young patients, generally below 40 to 45 years, when multiple coronary risk factors occur: Hyperlipidemia, diabetes mellitus, obesity, arterial hypertension, smoking and a family history of ischemic heart disease. Among the conventional risk factors of CAD, premature myocardial infarction (MI) was reported to be associated with smoking, family related history of coronary artery disease and dyslipidemia[6,7].

The worst presentation of coronary artery disease is ST-elevation MI (STEMI)[8], and primary percutaneous coronary intervention (PCI) is the guidelines recommended treatment for the patients with STEMI[9]. The primary purpose of revascularization is to open the infarct-related (culprit) artery in the setting of STEMI[10]. A significant atherosclerotic cardiovascular disease in more than one coronary artery is not an uncommon angiographic finding and in the setting of acute MI, significant atherosclerotic cardiovascular disease in multiple vessels is observed to be associated with increased complications and adverse clinical course[10-12].

Despite its prognostic importance, there is a paucity of data regarding the role of the number of vessels diseased in determining the outcome of management in young patients presenting with STEMI. Therefore, this study was conducted to carry out the comparative assessment of clinical profile and outcomes after the primary PCI in young patients with single-vessel disease (SVD) vs multivessel disease (MVD).

While, smoking was more prevalent among the SVD group as compare to MVD group (56.3% vs 28.4%, P = 0.05). The high-C Lesion was observed in a significantly higher number of younger patients with MVD as compared to SVD group (48.8% vs 39.2%, P = 0.021). Post-procedure thrombolysis in myocardial infarction flow grade was found to be not associated with the number of diseased vessels with a P value of 0.426 and thrombolysis in myocardial infarction flow grade III was observed in 98% vs 96.5% of the patients is SVD vs MVD group.

CONCLUSION

The MVD comprised of around 40% of the young patients presented with STEMI. Also, this study shows that diabetes and hypertension have a certain role in the pathogenesis of multivessel diseases, therefore, preventive measures for diabetes and hypertension can be effective strategies in reducing the burden of premature STEMI.

Key words: Young; Multivessel disease; Primary percutaneous coronary intervention; ST-elevation myocardial infarction; Premature coronary artery diseases; Single-vessel disease
MATERIALS AND METHODS

This retrospective study was conducted after the approval of the ethical review committee of the institution (ERC-29/2019). The study population consisted of both male and female young (≤ 45 years) patients presented with STEMI at the National Institute of Cardiovascular Disease, Karachi, Pakistan and undergone primary PCI from 1st July 2017 to 31st March 2018. Data for the study were extracted from the institution database of prospectively collected National Cardiovascular Data Registry (NCDR™ CathPCI Registry®). Patients with a prior history of any cardiac-related surgery or intervention were excluded from the study. Informed consent was obtained from all the patients and all the diagnostic and primary PCI procedures were performed by the consultant cardiologists (with more than five years of experience) and only culprit artery was attempted with conventional stenting technique followed by post-dilation. Pre and post-procedure management of the patients was as per the guidelines and institutional protocols. Patient’s baseline characteristics, demographic details, angiographic findings, and in-hospital outcome and complications were retrieved for this study. Patients with significant stenosis, ≥ 50%, in more than one vessels or left main artery were labelled as MVD.

The clinical profile consisted of demographic details [gender, age (years), and body mass index (kg/m²)], angina status within past two weeks (Canadian Cardiovascular Society angina grade), and angiographic findings [number of diseased vessels, localization of culprit lesion, lesion complexity, pre and post-procedural thrombolysis in MI (TIMI) flow grade, presence of thrombus and bifurcating lesion]. The post-procedural outcomes included death, re-infarction, heart failure, cardiogenic shock, and needed dialysis.

Statistical analysis

Statistical analysis of extracted data was performed using IBM SPSS Statistics for Windows (IBM Corp., Armonk, NY, United States), Version 21.0. Patients were categorized into two groups i.e., patients with SVD and patients with MVD (two or three vessels). Summary statistics such as mean ± SD for age (years) and body mass index (kg/m²) and frequency and percentage for all other study variables were computed for both of the groups. The comparative assessments of results between the SVD and MVD group were performed by applying appropriate t-test or Mann-Whitney U test for continuous variables and χ² test or Fisher exact test for the categorical response variables. Any P value ≤ 0.05 was considered statistically significant.

RESULTS

A total of n = 571 patients with ST-segment elevation myocardial, less than and equal to 45 years were stratified into two groups by the number of vessels involved, 342 (59.9%) with SVD and 229 (40.1%) with MVD. The average age of these patients was 39.04 ± 4.86 years and a significant difference was observed in the average age of young patients in SVD group as compared to MVD group, 38.24 ± 5.18 years vs 40.24 ± 4.06 years (P < 0.001). We observed a lower prevalence of hypertension and diabetes in SVD group as compare to MVD group (25.1% vs 38%, P < 0.01) and (11.7% vs 27.5%, P < 0.001) respectively. While, smoking was more prevalent among the SVD group as compare to MVD group (36.3% vs 28.4%, P = 0.05). A positive family history of premature CAD and obesity were not significantly differed in both SVD and MVD groups. Similarly, gender and Canadian Cardiovascular Society angina grade within past two weeks were statistically insignificant in both SVD and MVD group. The baseline clinical and demographic characteristics stratified by the number of vessels involved are presented in Table 1.

The angiographic and pre-procedural characteristics stratified by the number of vessels involved are presented in Table 2. Culprit left anterior descending artery occurred in a significantly higher number of patients in single vessel as compare to multivessel groups (71.9% vs 50.2%), while, culprit right coronary artery (RCA) and circumflex artery (LCX) were more frequent in patients with MVD as compared to SVD, (34.5% vs 21.3%) and (12.7% vs 5.3%) respectively. The high-C Lesion was observed in a significantly higher number of younger patients with MVD as compared to SVD group (48.8% vs 39.2%, P = 0.021).

Post-procedure outcomes stratified by the number of vessels involved are presented in Table 3. Post-procedure TIMI flow grade was found to be not associated with the number of diseased vessels with a P value of 0.426 and TIMI flow grade III was observed in 98% vs 96.5% of the patients is SVD vs MVD group. In-hospital mortality rate was 1.7% vs 0.9%, P = 0.335, for MVD and SVD group respectively.
| Characteristics | Total | Involved vessels | $P$ value |
|-----------------|-------|------------------|-----------|
|                 |       | Single vessel    | Multivessel |           |
| Total           | 571   | 342 (59.9)       | 229 (40.1) | -         |
| Clinical characteristics |       |                 |            |           |
| Age (mean ± SD, yr) | 39.04 ± 4.86 | 38.24 ± 5.18 | 40.24 ± 4.06 | < 0.001  |
| Body mass index (mean ± SD, kg/m$^2$) | 26.24 ± 4.01 | 26.25 ± 4.07 | 26.22 ± 3.94 | 0.929    |
| Male gender     | 501 (87.7) | 303 (88.6) | 198 (86.5) | 0.446    |
| Hypertension    | 173 (30.3) | 86 (25.1) | 87 (38) | 0.001    |
| Diabetes        | 103 (18) | 40 (11.7) | 63 (27.5) | < 0.001  |
| Positive family history | 41 (7.2) | 27 (7.9) | 14 (6.1) | 0.419    |
| Smoking         | 189 (33.1) | 124 (36.3) | 65 (28.4) | 0.050    |
| Obesity         | 89 (15.6) | 55 (16.1) | 34 (14.8) | 0.690    |
| CCS angina grade (within past two weeks) |       |                 |            |           |
| No symptoms, no angina | 272 (47.6) | 158 (46.2) | 114 (49.8) | 0.367    |
| CCS I           | 33 (5.8) | 22 (6.4) | 11 (4.8) |           |
| CCS II          | 66 (11.6) | 35 (10.2) | 31 (13.5) |           |
| CCS III         | 105 (18.4) | 70 (20.5) | 35 (15.3) |           |
| CCS IV          | 95 (16.6) | 57 (16.7) | 38 (16.6) |           |

CCS: Canadian Cardiovascular Society.

Similarly, post-procedure in-hospital rate of cardiogenic shock, heart failure, and dialysis were observed higher MVD group as compared to SVD group, but not statistically significant.

DISCUSSION

To the best of our knowledge, this study is first of its kind in Pakistani young population. Aim of this study was to assess the differences in clinical profile and outcomes after primary PCI in young patients with SVD vs MVD. Main findings of our study are, 40.1% (229) young patients presented with STEMI had MVD. The MVD in young patients was found to be associated with age (years), hypertension, and diabetes mellitus, whereas, SVD were found to be associated with smoking. Young patients with MVD were more likely to have the angiographic finding of culprit RCA and LCX as against left anterior descending artery for the young patients with SVD and more likely to have high/C lesions. Post-procedure in-hospital outcomes among young patients were not significantly different between SVD and MVD patients, however, mortality and other complications, such as cardiogenic shock, heart failure, or dialysis, were relatively more frequent among patients with MVD.

In our study the prevalence of MVD was 40.1% among the young (≤ 45 years) patients presenting with STEMI, similarly, a recently published local study by Batra et al[13] reported MVD in 38% of young (≤ 40 years) patients diagnosed with STEMI. Noor et al[14] reported MVD in 36.6% among the patients under 35 years of age presented with acute coronary syndrome (ACS) and another study by Anjum et al[15] reported 28% of young (≤ 35 years) patients with MVD among patients presented with ACS. In our population, MVD reported increasing with age and severity of presentation. Studies from the various parts of the world reported MVD ranging from 16% to 55.6% of the young patients with ACS depending on the cutoff value of age for the classification of young[16-21].

Batra et al[21] reported that MVD was a predictor of increased morbidity and mortality in patients undergoing primary PCI for STEMI. Although, MVD is observed to be less frequent in cases of premature CAD patients[13], however, it is important to understand its association with risk factors in order to control the burden of disease in productive years of life. In our study MVD in young was found to be associated with relatively older age, 40.24 ± 4.06 years vs 38.24 ± 5.18 years ($P < 0.001$). However, this wasn’t the case in various other parts of the world[15,21]. It was reported that diabetes mellitus and hypertension were less commonly observed risk factors among young
Table 2  Angiographic and pre-procedural characteristics stratified by number of vessels involved, n (%)

| Characteristics                     | Total  | Involved vessels | P value |
|-------------------------------------|--------|------------------|---------|
|                                     | 571    | 342 (59.9)       | 229 (40.1) | -       |
| **Culprit vessel**                  |        |                  |         |
| Left anterior descending artery     | 361 (63.2) | 246 (71.9) | 115 (30.2) | < 0.001 |
| Right coronary artery               | 152 (26.6) | 73 (21.3)   | 79 (24.5)   |         |
| Circumflex artery                   | 47 (8.2) | 18 (5.3)      | 29 (8.7)    |         |
| Posterior descending artery         | 6 (1.1) | 3 (0.9)       | 3 (1.3)     |         |
| Left main                           | 5 (0.9) | 2 (0.6)       | 3 (1.3)     |         |
| **Pre-procedure TIMI flow grade**   |        |                  |         |
| TIMI - 0                            | 321 (56.2) | 185 (54.1) | 136 (59.4) | 0.066   |
| TIMI - 1                            | 58 (10.2) | 38 (11.1)   | 20 (8.7)    |         |
| TIMI - 2                            | 111 (19.4) | 61 (17.8)  | 50 (21.8)   |         |
| TIMI - 3                            | 81 (14.2) | 58 (17)     | 23 (10)     |         |
| **Lesion complexity**               |        |                  |         |
| Non-high/non-C lesion               | 325 (56.9) | 208 (60.8) | 117 (31.1) | 0.021   |
| High/C lesion                       | 246 (43.1) | 134 (39.2) | 112 (48.9) |         |
| **Thrombus presence**               |        |                  |         |
| No                                  | 102 (17.9) | 58 (17)     | 44 (19.2)   | 0.491   |
| Yes                                 | 469 (82.1) | 284 (83)    | 185 (80.8)  |         |
| **Bifurcation lesion**              |        |                  |         |
| No                                  | 427 (74.8) | 254 (74.3) | 173 (75.5)  | 0.731   |
| Yes                                 | 144 (25.2) | 88 (25.7)   | 56 (24.5)   |         |

TIMI: Thrombolysis in myocardial infarction.

patients\(^{[10]}\), but both have significant associations with MVD\(^{[11]}\). Similar to these past findings, in our study, we observed that MVD in young STEMI patients was significantly associated with hypertension, and diabetes mellitus with 27.5% \(\text{vs}\) 11.7%, \(P < 0.001\) and 38% \(\text{vs}\) 25.1%, \(P < 0.01\) respectively.

In our study angiographic findings of culprit RCA (34.5% \(\text{vs}\) 21.3%) and LCX (12.7% \(\text{vs}\) 5.3%) were more common in young patients with MVD as compared to SVD and these were the similar observations made for young as well as entire STEMI patients in the past studies\(^{[11,18,19]}\). Similarly, MVD among young is found to be associated with poor pre-procedural TIMI flow grade and complex (high C) lesions.

The presence of MVD is a prognostic indicator for the patients undergoing primary PCI\(^{[11]}\), however, despite multiple investigations the mechanism behind its prognostic value is unexplained. MVD was reported to be associated with the increased use of contrast volume (172.46 ± 28.39 mL \(\text{vs}\) 150.25 ± 33.2 mL, \(P < 0.001\))\(^{[11]}\), which increases the risk of post-procedural morbidities including contrast-induced acute kidney injury. Continuing the observations made by Anello et al\(^{[18]}\), in our study post-procedural in-hospital outcomes of primary PCI for STEMI were not significantly different for young patients with MVD as compared to SVD. However, MVD patients tends to have relatively higher rate of in-hospital mortality (1.7% \(\text{vs}\) 0.9%, \(P = 0.355\)), cardiogenic shock (0.9% \(\text{vs}\) 0.0%, \(P = 0.083\)), heart failure (0.9% \(\text{vs}\) 0.0%, \(P = 0.083\)), and dialysis (0.4% \(\text{vs}\) 0.0%, \(P = 0.221\)).

The most recent evidence suggests that as against the culprit vessel only strategy, multivessel PCI or complete revascularization in STEMI patients with MVD was superior with reduced risk of re-infarction or cardiovascular mortality\(^{[22]}\). However, more targeted research efforts are required in young patients to ensure the early returning to work.

In conclusion, MVD comprised of around 40.1% of young patients (≤ 45 years) presented with STEMI. It was found to be associated with age, hypertension, and diabetes mellitus. In-hospital outcomes of primary PCI in patients with MVD were not significantly different from the patients with SVD. Also, this study shows that diabetes mellitus and hypertension have a certain role in the pathogenesis of MVD in young patients, preventive measures for diabetes mellitus and hypertension can be
### Table 3 Post-procedure outcomes stratified by number of vessels involved, n (%)

| Characteristics                          | Total | Involved vessels | P value |
|------------------------------------------|-------|------------------|---------|
|                                          |       | Single vessel    | Multivessel |       |
| **Total**                                | 571   | 342 (59.9)       | 229 (40.1) | -      |
| **Contrast volume (mL)**                 | 135.65±44.28 | 134.3±42.97 | 137.66±46.18 | 0.375  |
| **Fluro time (min)**                     | 13.2±6.69       | 12.83±6.53     | 13.75±6.91   | 0.107  |
| **Number of stents deployed**            | 1.09±0.66       | 1.01±0.44      | 1.21±0.87    | <0.001 |
| **Post-procedure TIMI flow grade**       |       |                 |           |         |
| TIMI - 0                                 | 3 (0.5) | 2 (0.6)      | 1 (0.4)    | 0.426  |
| TIMI - 1                                 | 3 (0.5) | 2 (0.6)      | 1 (0.4)    |         |
| TIMI - 2                                 | 9 (1.6) | 3 (0.9)      | 6 (2.6)    |         |
| TIMI - 3                                 | 556 (97.4) | 335 (98)    | 221 (96.5) |         |
| **Post-procedure in-hospital outcomes**  |       |                 |           |         |
| Composite adverse events                 | 11 (1.9) | 6 (1.8)       | 5 (2.2)    | 0.715  |
| Re-infarction                            | 3 (0.5) | 3 (0.9)      | 0 (0)      | 0.155  |
| Cardiogenic shock                        | 2 (0.4) | 0 (0)        | 2 (0.9)    | 0.083  |
| Heart failure                            | 2 (0.4) | 0 (0)        | 2 (0.9)    | 0.083  |
| Dialysis                                 | 1 (0.2) | 0 (0)        | 1 (0.4)    | 0.221  |
| Mortality                                | 7 (1.2) | 3 (0.9)      | 4 (1.7)    | 0.355  |

TIMI: Thrombolysis in myocardial infarction.

effective strategies in reducing the burden of premature CAD.

### ARTICLE HIGHLIGHTS

#### Research background
Even though percutaneous coronary intervention (PCI) improved the survival of patients with acute myocardial infarction, the multivessel coronary artery disease remains an important factor burdening prognosis, and it is being associated with a worse prognosis compared to single-vessel disease (SVD).

#### Research motivation
Despite its prognostic importance, there is a paucity of data regarding the role of the number of vessels diseased in determining the outcome of management in young patients presenting with ST-elevation myocardial infarction (STEMI).

#### Research objectives
This study was conducted to carry out the comparative assessment of clinical profile and outcomes after the primary PCI in young patients with SVD vs multivessel disease (MVD).

#### Research methods
Patients were divided into SVD and MVD group. The study population consisted of both male and female young (≤ 45 years) patients presented with STEMI and undergone primary PCI from 1st July 2017 to 31st March 2018. Pre and post-procedure management of the patients was as per the guidelines and institutional protocols.

#### Research results
A total of 571 patients with STEMI (≤ 45 years) were stratified into two groups by the number of vessels involved. The average age of these patients was 39.04 ± 4.86 years. A lower prevalence of hypertension and diabetes was observed in SVD as compa to MVD group. Smoking was more prevalent among the SVD group as compared to MVD group. The high-C Lesion was observed in a significantly higher number of younger patients with MVD as compared to SVD group. Post-procedure thrombolysis in myocardial infarction flow grade was found to be not associated with the number of diseased vessels and thrombolysis in myocardial infarction flow grade III was observed in 98% vs 96.5% of the patients (SVD vs MVD group).

#### Research conclusions
The MVD comprised of around 40% of the young patients presented with STEMI. Also, this study shows that diabetes mellitus and hypertension have a certain role in the pathogenesis of MVD in young patients, preventive measures for diabetes mellitus and hypertension can be effective strategies in reducing the burden of premature coronary artery disease.
Muhammad AS et al. Multivessel disease in young patients

ACKNOWLEDGEMENTS

The authors wish to acknowledge the support of the staff members of the Clinical Research Department of the National Institute of Cardiovascular Diseases (NICVD) Karachi, Pakistan.

REFERENCES

1. Ahuja YR, Sharma S, Mohan V. Cardiovascular diseases: Interplay of epigenetics. Clin Exp Hypertens 2017; 39: 1-7 [PMID: 28055289 DOI: 10.1080/10641963.2016.1210627]

2. Egred M, Viswanathan G, Davis GK. Myocardial infarction in young adults. Postgrad Med J 2005; 81: 741-745 [PMID: 16344295 DOI: 10.1136/pgmj.2004.027532]

3. Konishi H, Miyauuchi K, Kasai T, Tsuboi S, Ogita M, Naito R, Kato H, Okai I, Tamura H, Okazaki S, Daida H. Long-term prognosis and clinical characteristics of young adults (<40 years old) who underwent percutaneous coronary intervention. J Cardiol 2014; 64: 171-174 [PMID: 24495504 DOI: 10.1016/j.jjcc.2013.12.005]

4. van Loon JE, de Matti MP, Deckers JW, van Domburg RT, Leebeek FW. Prognostic markers in young patients with premature coronary heart disease. Atherosclerosis 2012; 224: 213-217 [PMID: 22818563 DOI: 10.1016/j.atherosclerosis.2012.06.067]

5. Aggarwal A, Srivastava S, Velmurugan M. Newer perspectives of coronary artery disease in young. World J Cardiol 2016; 8: 728-734 [PMID: 28070240 DOI: 10.4236/wjcn.2016.85072]

6. Feit JP, Schmidt MM, David RH, Martinis JM, Schmidt KE, Gottschall CA, de Quadros AS. Clinical profile and outcomes of primary percutaneous coronary artery intervention in young patients. Rev Bras Cardiol Invasiva 2015; 23: 48-51 [DOI: 10.1691/j.rbci.2015.01.007]

7. Jebed H, Addisson D, Bhatt DL, Fonarow GC, Gokak S, Grady KL, Green LA, Heidenreich PA, Ho PM, Jurgens CG, King ML, Kumbhani DJ, Pancholy S. 2017 AHA/ACC Clinical Practice Guidelines and Quality Measures for Adults With ST-Elevation and Non-ST-Elevation Myocardial Infarction: A Report of the American College of Cardiology/American Heart Association Task Force on Performance Measures. J Am Coll Cardiol 2017; 70: 2048-2090 [PMID: 28943066 DOI: 10.1016/j.jacc.2017.06.032]

8. Weisssler-Suir A, Gurevitz C, Assali A, Vaknin-Assha H, Bental T, Lador A, Yavin H, Perl L, Kornowski R, Lev E. Prognosis of STEMI Patients with Multi-Vessel Disease Undergoing Culprit-Only PCI without Significant Residual Ischemia on Non-Invasive Stress Testing. PLoS One 2015; 10: e0138474 [PMID: 26406235 DOI: 10.1371/journal.pone.0138474]

9. Deharo P, Strange JW, Mozid A. Primary percutaneous coronary intervention of native chronic total occlusions to treat ST elevation myocardial infarction secondary to acute vein graft occlusion. Catheter Cardiovasc Interv 2017; 90: 251-256 [PMID: 28315396 DOI: 10.1002/ccd.26972]

10. Soraja P, Gersh BJ, Cox DA, McLaughlin MG, Zimbaumen P, Costantini C, Stuckey T, Tcheng JE, Mehran R, Lansky AJ, Grines CL, Stone GW. Impact of multivessel disease on reperfusion success and clinical outcomes in patients undergoing primary percutaneous coronary intervention for acute myocardial infarction. Eur Heart J 2007; 28: 1709-1716 [PMID: 17556348 DOI: 10.1093/eurheartj/ehm184]

11. Batra MK, Rasool SI, Solangi BA, Khan N, Karim M, Hassan Rizvi SN. Multivessel Disease As A Prognostic Marker In Patients Presenting For Primary Percutaneous Coronary Intervention. J Ayub Med Coll Abbottabad 2018; 30: 534-538 [PMID: 3062331]

12. Gjibberts CM, Santenba BT, Asselbergs FW, de Kleijn DP, Voskuil M, Agostoni P, Cramer MJ, Vaartjes I, Hoefer IE, Pasterkamp G, den Ruijter HM. Women Undergoing Coronary Angiography for Myocardial Infarction or Who Present With Multivessel Disease Have a Poorer Prognosis Than Men. Angiology 2016; 67: 571-581 [PMID: 26351280 DOI: 10.1016/j.atherosclerosis.2016.05.072]

13. Batra MK, Rizvi NI, Sial JA, Saghir T, Karim M. Angiographic characteristics and in hospital outcome of young patients, age up to 40 versus more than 40 years undergoing primary percutaneous coronary intervention. J Pak Med Assoc 2019; 69: 1308-1312 [PMID: 31517116]

14. Noor L, Adnan Y, Dar MH, Ali U, Ahmad F, Awan ZA. Characteristics of the coronary arterial lesions in young patients with acute myocardial infarction. Khyber Med Univ J 2018; 10: 81-85

15. Anjum M, Zaman M, Ullah F. Are Their Young Coronaries Old Enough? Angiographic Findings In Young Patients With Acute Myocardial Infarction. J Ayub Med Coll Abbottabad 2019; 31: 151-155 [PMID: 31094106]

16. Soeiro Ade M, Fernandes FL, Soeiro MC, Serrano CV, Oliveira MCT. Clinical characteristics and long-term progression of young patients with acute coronary syndrome in Brazil. Einstein (Sao Paulo) 2015; 13: 370-375 [PMID: 26466059 DOI: 10.1590/S1679-4508201500330381]

17. Deora S, Kumar T, Ramalingam R, Nanjappa Manjunath C. Demographic and angiographic profile in premature cases of acute coronary syndrome: analysis of 820 young patients from South India. Cardiovasc Diagn Ther 2016; 6: 193-198 [PMID: 27280082 DOI: 10.21037/cdt.2016.03.05]

18. Anello AL, Moscouo I, Tófano RJ, Salman AA, Cristóvão SA, Mauro MF, Batista de O Neto J, Mangione JA. Comparison of immediate results and follow-up of patients with single-vessel and multivessel coronary artery disease younger than 50 years of age undergoing coronary stent implantation. Arq Bras Cardiol 2003; 81: 494-505 [PMID: 14606055 DOI: 10.1590/s0004-27302003000600015]

19. Ge J, Li J, Yu H, Hou B. Hypertension Is an Independent Predictor of Multivessel Coronary Artery Disease in Young Adults With Acute Coronary Syndrome. Int J Hypertens 2018; 2018: 7623639 [PMID: 30538861 DOI: 10.1155/2018/7623639]

20. Esteban MR, Monterro SM, Sánchez JJ, Hernández HP, Pérez JJ, Afonso JH, Pérez del CR, Díaz BB, de León AC. Acute coronary syndrome in the young: clinical characteristics, risk factors and prognosis. Open Cardiovasc Med J 2014; 8: 61-67 [PMID: 25152777 DOI: 10.2174/1874192401408010061]

21. Waziri H, Jørgensen E, Kelbæk H, Stagmo M, Pedersen F, Lagerqvist B, James S, Køber L, Wachtell K. Short-and-long-term survival after primary percutaneous coronary intervention in young patients with ST-elevation myocardial infarction. J Hypertens 2016; 34: 697-701 [PMID: 26533834 DOI: 10.1016/j.jhyp.2015.09.012]

22. Mehta SR, Wood DA, Storey RF, Mehran R, Bainey KR, Nguyen H, Meeks B, Di Pasquale G, López-Sendón J, Faxon DP, Mauri L, Rao SV, Feldman L, Steg PG, Avezum A, Sheth T, Pinilla-Echeverri N, Moreno R, Campo G, Wrigley B, Kedev S, Sutton A, Oliver R, Rodés-Cabau J, Stančíković G, Welsh R,
Lavi S, Cantor WJ, Wang J, Nakamya J, Bangdiwala SI, Cairns JA; COMPLETE Trial Steering Committee and Investigators. Complete Revascularization with Multivessel PCI for Myocardial Infarction. *N Engl J Med* 2019; 381: 1411-1421 [PMID: 31475795 DOI: 10.1056/NEJMoa1907775]
