

Original Article

The impacts of armed conflict on outcomes of coronary angiography: report from Sudan's hot war zone 2023-2024

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Abstract: Objectives: Coronary angiography and emergency coronary revascularizations are critical for decreasing morbidity and mortality linked to coronary artery disease. Establishing and maintaining this service in armed conflict and on the battlefield poses challenges; however, it remains achievable. This study aimed to evaluate the results of coronary angiography in Sudan amid the armed conflict of 2023-2024. Methods: This study utilized a retrospective descriptive analysis conducted at El-Obeid International Hospital (Aldaman) in North Kordofan State, Sudan. Patient data was obtained from the hospital for the period spanning April 15, 2023, to April 30, 2024. Results: Out of 314 diagnostic coronary angiograms, 32% had PCI with DES implantation, 18% showed normal coronary arteries, and the other 50% were treated with medication and advice from heart surgeons (CTC). Among the 100 patients who underwent PCI, 64% were male and 36% were female. The predominant age group was 50-59 years, succeeded by 60-69 years, under 50 years, and over 60 years, with incidence rates of 30%, 29.9%, 20.3%, and 18.2%, respectively. Conclusions: The offering of cardiac catheterization laboratory services amid armed conflict poses challenges but is nonetheless feasible. Despite the tragedy, constrained resources, and the impact of wartime conditions, our findings were consistent with prior reports both locally and globally.

Keywords: Coronary artery disease, catheterization laboratory, coronary angiography, Sudan, percutaneous coronary interventions, drug-eluting stent

Introduction

Coronary artery disease (CAD) is the leading cause of death for both men and women globally [1]. The level of atherosclerosis and how far it has progressed, along with the severity of risk factors for the disease, mainly influence the long-term results for patients with CAD [2-5]. Cardiogenic shock is a serious problem that can occur with CAD, especially during acute coronary syndrome, and it has a high chance of causing death and requires complex treatment. Emergency coronary revascularization and circulatory assistance are critical interventions that can preserve life [2]. Men over 45

and women over 55 represent non-modifiable risk factors for the condition, along with a family history of early CAD. Modifiable risk factors include hypertension, diabetes, tobacco use, dyslipidemia, obesity, and inactivity [6]. The cardiac catheterization laboratory (Cath Lab) serves to diagnose and treat cardiovascular diseases, ultimately improving patient survival rates. Patients experiencing out-of-hospital cardiac arrest in the US have a survival rate of 6-8%, indicating a critical need for intervention [7].

Coronary angiography utilizes X-rays to assess the arteries and blood supply of the heart, making it a widely performed procedure worldwide.

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The femoral artery has been the predominant vascular access site for this surgery for decades. Radial access is increasingly preferred due to its enhanced safety and practicality as a vascular access method. The distal transradial technique has shown promise as a safer way to access blood vessels for both testing and treatment in heart-related and other medical situations [8, 9].

Primary angioplasty is the top treatment for patients with ST-elevation acute coronary syndrome (STE-ACS), which is a major cause of death and increasing heart issues around the world. Cardiac catheterization is a common procedure, with over one million diagnostic coronary angiograms conducted in the United States in 2011 [10].

In Sudan, cardiovascular disease represents the leading cause of mortality in hospitals and demonstrates a significant prevalence within the community [11].

Despite the negative impact of the Sudan conflict on the community and resources, especially the healthcare system, specialized medical teams continue to save the lives of numerous patients in critical conditions. Delivering catheterization laboratory services post-calamity presents significant challenges due to a lack of operational supplies and qualified personnel. This study sought to investigate the results of coronary angiography in Western Sudan from 2023 to 2024, corresponding with the peak of the conflict.

Materials and methods

Study design

A retrospective descriptive analysis was conducted at El-Obeid International Hospital in Aldaman, North Kordofan State, Sudan. Data were collected pertaining to patients who underwent procedures at the El-Obeid International Hospital catheterization laboratory from April 15, 2023, to April 30, 2024.

Inclusion and exclusion criteria

Data regarding patients who received diagnostic coronary angiography and drug-eluting stent (DES) implantation during the designated time frame were incorporated into the study.

Patients with heart conditions who presented during the designated time frame but did not undergo the recommended procedure were excluded from the study.

Procedure

A catheter, which is a thin and flexible tube, is carefully threaded into the heart via an artery in the arm. Contrast media is injected via the catheter to examine cardiac blood channels. Blood flow is assessed using rapid X-ray imaging techniques, specifically fluoroscopy. A minor skin incision is required for the test. Angioplasty and stenting effectively restore patency in obstructed arteries during coronary angiography.

Data collection

The sample size represents the total number of patients who underwent the procedure within the specified time frame, approximately one year after the onset of the Sudan conflict in 2023-2024. A total of 314 patients who underwent diagnostic coronary angiography and drug-eluting stent (DES) implantations were evaluated. All patient records were reviewed to obtain the necessary information, including age, sex, education, occupation, residence, and other diagnostic investigations.

Statistical analysis

All acquired data were organized into data sheets prior to entry into the Chicago-based statistical package for social science (SPSS) version 24. The data were analyzed to ascertain frequencies, percentages, and cross-tabulations.

Results

This study included 314 patients, aged 25 to 89 years, with a mean age of 57.97 years and a standard deviation of 12.1 years. Of the 314 patients, 189 (60.2%) were male and 125 (39.8%) were female. Most cases are observed in the 50-59 age group, followed by the 60-69, under 50, and over 70 age categories, with respective rates of 99/314 (30%), 94/314 (29.9%), 64/314 (20.3%), and 57/314 (18.2%). Most patients were illiterate, with subsequent educational levels represented as follows: university (186/314, 59.2%), basic (56/314,

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Table 1. Shows the distribution of the study population in terms of demographic characteristics

Variable	Males		Females		Total	
	N = 189	%	N = 125	%	N = 314	%
Age						
≤ 50 years	36	56	28	44	64	20
50-59	56	57	43	43	99	32
60-69	65	69	29	31	94	30
≥ 70	32	56	25	44	57	18
Education						
Illiterate	96	52	90	48	186	59
Basic	25	74	9	26	34	11
Secondary	22	76	7	24	29	9
University	40	71	16	29	56	18
Postgraduates	6	67	3	33	9	3
Occupation						
Farmers	33	79	9	21	42	13
Employees	18	69	8	31	26	8
Armed forces	7	58	5	42	12	4
Teachers	13	54	11	46	24	8
Students	2	100	0	0	2	0.6
Health workers	4	80	1	20	5	1.6
Jobless	16	17	77	83	93	30
Retired	13	81	3	19	16	5
Labors	64	88	9	12	73	23
Businessmen	19	90	2	10	21	7

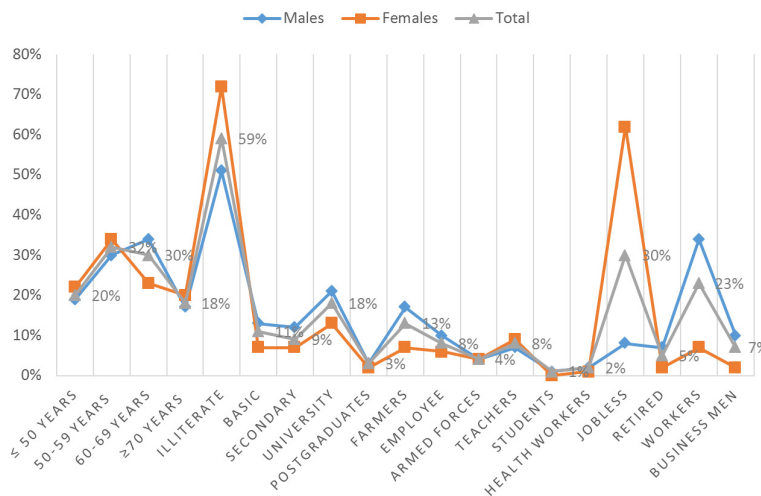


Figure 1. The image shows the distribution of the study populations according to demographic features.

17.8%), secondary (34/314, 10.8%), postgraduate (29/314, 9%), and illiterate (9/314, 2%).

The majority of patients were unemployed, followed by laborers, farmers, and employees,

with respective representations of 93 (29.6%), 73 (23.2%), 42 (13.4%), and 26 (8.3%), as illustrated in **Table 1** and **Figure 1**.

Table 2 and **Figure 2** present the demographic distribution of the study population. Approximately 300 individuals (95.5%) were classified within the low socioeconomic class. A majority of patients, 272 (86.6%) out of 314, were married, whereas 22 (7%) identified as single. A total of 161 individuals (51.3%) lived in rural areas, while 153 individuals (48.7%) were urban residents.

Figure 3 illustrates that out of 314 patients undergoing diagnostic coronary angiographies, 115 (36.62%) received medication, 100 (31.84%) underwent percutaneous coronary intervention (PCI) with drug-eluting stent (DES) implantation, 57 (18.15%) exhibited normal epicardial coronary vessels, and 42 (13.37%) were referred to a cardiothoracic conference (CTC).

Of the 57 patients with normal epicardial coronary vessels, 26 (45.6%) were male and 31 (54.4%) were female. The relative risk (RR) and the 95% confidence interval (CI) indicate the level of risk associated with epicardial coronary vessels in women. The relative risk (95% confidence interval) is 1.8471 (1.1557 to 2.9521), with a *p*-value of 0.0103. Of the 115 patients scheduled for medical therapy, 68 (59.1%) were male and 47 (40.9%) were female. Fe-

males exhibited greater susceptibility to medical therapy compared to males; the relative risk (95% confidence interval) was 1.0451 (0.7779 to 1.4040), with a *p*-value of 0.7698. In the PCI group, male representation constituted 64 indi-

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Table 2. Summarizes the distribution of the study population in terms of demographic characteristics

Variable	Males		Females		Total	
	N = 189	%	N = 125	%	N = 314	%
Socioeconomic class						
Low	177	59	123	41	300	96
Middle	12	86	2	14	14	4.5
Marital Status						
Single	12	55	10	45	22	7
Married	164	60	108	40	272	87
Divorced	5	56	4	44	9	3
Widowed	8	73	3	27	11	4
Residence						
Rural	99	62	62	38	161	51
Urban	90	59	63	41	153	49

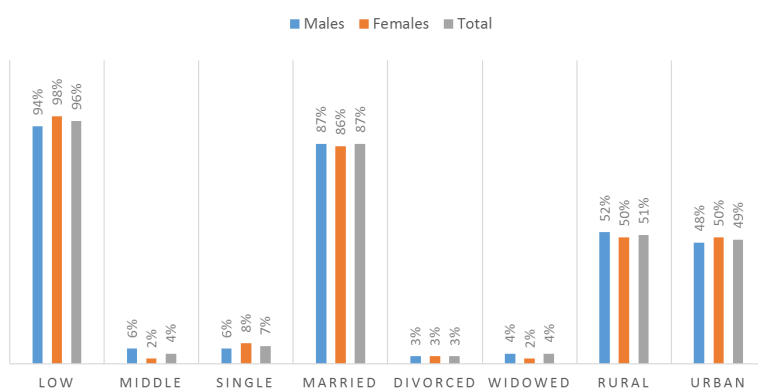


Figure 2. The image depicts the distributions of the study populations according to demographic factors.

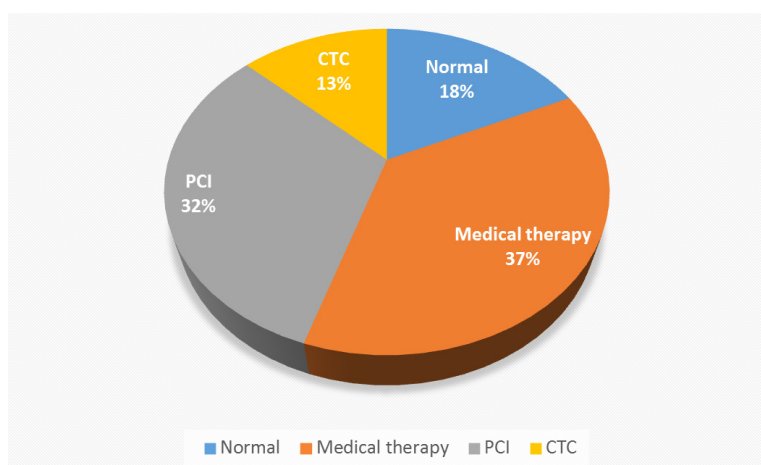


Figure 3. The image illustrates the results of coronary angiography.

viduals (64%) out of 100, whereas female representation comprised 36 individuals (36%)

out of 100. Males exhibit a higher likelihood of necessitating PCI (RR = 1.1758, 95% CI = 0.8368-1.6521, P = 0.3507). The CTC group consisted of 31 males (73.8%) and 11 females (26.2%) out of a total of 42 participants. Males exhibit a notably higher CTC uptake (RR = 1.8639, 95% CI = 0.9733-3.5692), P = 0.0603, z statistic = 1.878.

The majority of patients with normal epicardial coronary vessels were aged 50 to 59 years. The subsequent prevalent age groups included those under 50 years, over 70 years, and those aged 60 to 69 years, comprising 22/57 (38.56%), 13/57 (22.8%), 12/57 (21%), and 10/57 (17.5%) of the patients, respectively. The primary age group receiving medical care was 60-69 years, accounting for 38 out of 115 cases (33%), followed by the 50-59 years group, which represented 29 out of 115 cases (25.2%). Most PCI patients were aged 60-69 years, representing 31% (31/100), followed by the 50-59 years group at 30% (30/100), those under 50 years at 22% (22/100), and patients aged 70 years and above at 17% (17/100). **Table 3** and **Figure 4** indicate that most individuals in the CTC group were aged 50 to 59, with 18 participants (42.9%) in this category, while 15 participants (35.7%) were aged 60 to 69.

Table 4 and **Figure 5** present the results of coronary angiography. The data encompass education level, socioeconomic status, marital status, and residence. All variables yielded comparable results, with no significant differences identified.

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Table 3. The distribution of coronary angiography results by sex, age group, and education

Variable	Normal		Medical therapy		PCI		CTC		Total	
	N	%	N	%	N	%	N	%	N	%
Sex										
Males	26	14	68	36	64	34	31	16	189	60
Females	31	25	47	38	36	29	11	9	125	40
Total	57	18	115	37	100	32	42	13	314	100
Age group										
≤ 50 years	13	20	24	38	22	34	5	8	64	20
50-59	22	22	29	29	30	31	18	18	99	32
60-69	10	11	38	40	31	33	15	16	94	30
≥ 70	12	21	24	42	17	30	4	7	57	18
Education										
Illiterate	37	20	64	34	60	32	25	13	186	59
Basic	5	15	18	53	8	24	3	9	34	11
Secondary	7	24	15	52	3	10	4	14	29	9
University	6	11	15	27	25	45	10	18	56	18
Postgraduate	2	22	3	33	4	44	0	0	9	3

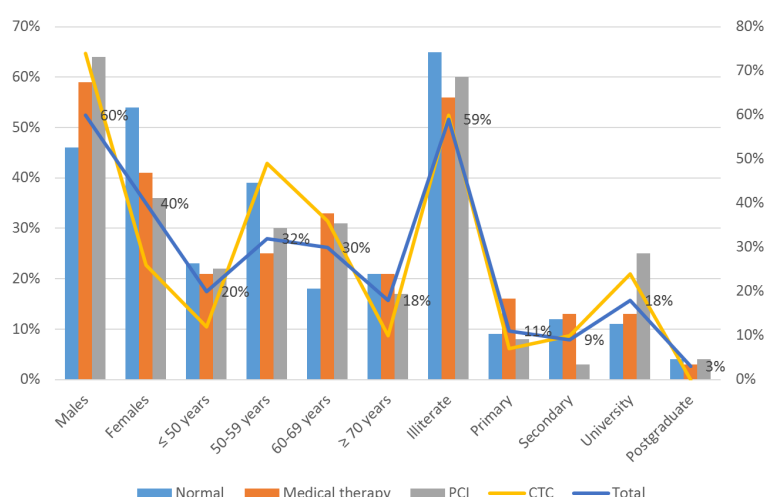


Figure 4. The image depicts a description of the outcomes of coronary angiography, including sex, age group, and education.

Discussion

Cardiovascular problems are a serious ailment that generally requires immediate intervention, bolstered by sufficient hospital facilities, skilled personnel, and availability of suitable therapies. During conflicts, numerous aspects generally deteriorate, leading to reduced service quality and negative patient outcomes. This study presents a group of patients admitted to our center during the tumultuous era of the Sudan war. Throughout this period, several patients could not access the hospital promptly

due to safety apprehensions, and several staff members were likewise unable to attend to deliver services. Consequently, we aimed to examine the outcomes of these patients during these arduous periods.

Notwithstanding progress in the management of cardiovascular diseases, including cardiac catheterizations and various laboratory services, morbidity and mortality rates persistently remain alarmingly elevated, especially among patients with acute coronary syndromes. In Sudan, the most prevalent cardiac catheterization operations include diagnostic coronary angiograms, left and right heart catheterizations, percutaneous coronary interventions, and permanent pacemaker implantations [11].

The international society acknowledges the catastrophe of Sudan's 2023 conflict and its resulting destruction of the healthcare industry, especially in interventional cardiology services. Given the substantial challenges related to staff safety, equipment availability, operational supply chains, and financial limitations, we conducted this study to evaluate the results

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Table 4. The distribution of coronary angiography results by demographic characteristics

Variable	Normal		Medical Therapy		PCI		CTC		Total	
	N	%	N	%	N	%	N	%	N	%
Socioeconomic										
Low	56	19	108	36	97	32	39	13	300	96
Middle	1	7	7	50	3	21	3	21	14	5
Total	57	18	115	37	100	32	42	13	314	100
Marital status										
Single	3	14	10	45	9	41	0	0	22	7
Married	48	18	96	35	89	33	39	14	272	87
Divorced	3	33	4	45	1	11	1	11	9	3
Widowed	3	27	5	45	1	9	2	18	11	4
Residence										
Rural	27	17	61	38	51	31	22	14	161	51
Urban	30	20	54	35	49	32	20	13	153	49

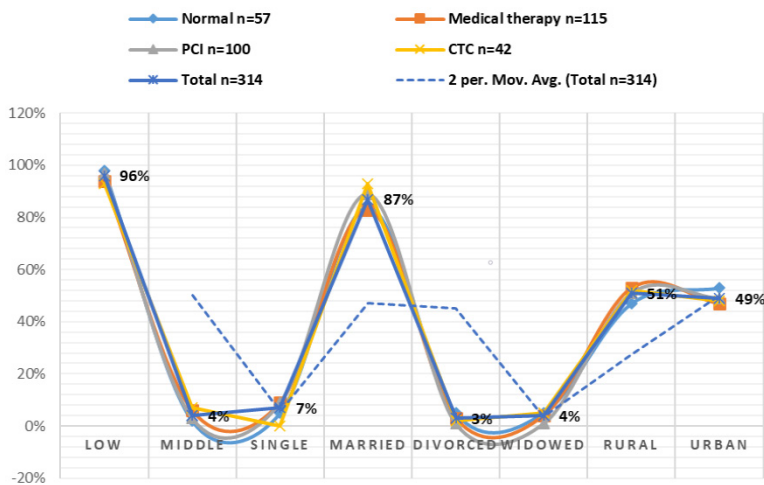


Figure 5. The image presents the results of coronary angiography categorized by demographic characteristics.

of coronary angiography during this turbulent period in our nation's history, characterized by a significant disruption of the healthcare system, especially impacting interventional cardiology services.

Given the geographical setting of our center, situated in a combat zone, we encounter a significant shortage of operational supplies, and our foremost concern does not relate to ammunition or guns. Thus, the execution of 314 coronary angiography procedures within a single year appears quite insignificant in comparison to our previous accomplishments before to the disaster. Notwithstanding these constraints, we welcomed patients from many regions across the nation.

The current study indicated a higher male population, with a percentage slightly below the previously documented figure of 65.7% from Sudan, as well as several other international publications [12]. The participants' mean age in this study was closely correlated with previously reported data from Sudan [13].

In our study, 32% of patients underwent PCI with DES implantation, resulting in a PCI:CAG (coronary angiogram) ratio of 0.32. This value surpasses the findings of earlier national studies, which reported a rate of 23% from a

total of 12,256 diagnostic coronary angiograms, resulting in a PCI:CAG ratio of 0.23 [11]. The restricted sample size of our study, compared to previous research, along with the availability of noninvasive assessments at certain facilities in Sudan, may clarify this conclusion.

A close correlation was identified between the normal epicardial coronary vessels observed in this study and those recorded in the existing medical literature [14]. The ratio demonstrates variability, with certain studies showing elevated rates [15] and others indicating diminished rates [16]. This study's results indicate that normal coronary outcomes are more prevalent in females, aligning with

previous national [17] and worldwide [18] findings.

Prior to undergoing invasive coronary angiography, individuals with chronic coronary syndromes, particularly those with low to moderate cardiac risk, should undergo a noninvasive cardiac evaluation utilizing established methodologies such as cardiac magnetic resonance, dobutamine stress echocardiography, and myocardial perfusion imaging. However, these investigative techniques are not widely available in the country [19].

Although our center lacks these noninvasive investigations, our results about normal coronary arteries are consistent with those reported both nationally and globally, demonstrating effective patient selection and comprehensive clinical evaluation [20].

While the present study provides a significant addition to the little literature on cardiology in Sudan, it is not devoid of limitations, particularly its retrospective approach. This design is mostly dependent on the information available in the patient's file. Future investigations in this context are considered highly important.

Conclusion

Delivering cardiac catheterization laboratory services in conflict situations, including wartime, presents challenges; nonetheless, it remains feasible. In spite of the tragedy, our findings aligned with previous reports at both local and global levels. The main strategies employed in the management of patients during wartime include medical therapy, PCI, and CTC. In western Sudan, men are more prone to heart issues compared to women. Most patients come from rural areas.

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Disclosure of conflict of interest

None.

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References

- [1] Ehrenberger R, Németh BT, Kulyassa P, Fülöp GA, Becker D, Kiss B, Zima E, Merkely B and Édes IF. Acute coronary syndrome associated cardiogenic shock in the catheterization laboratory: peripheral veno-arterial extracorporeal membrane oxygenator management and recommendations. *Front Med (Lausanne)* 2023; 10: 1277504.
- [2] Amsterdam EA, Wenger NK, Brindis RG, Casey DE Jr, Ganiats TG, Holmes DR Jr, Jaffe AS, Jneid H, Kelly RF, Kontos MC, Levine GN, Liebson PR, Mukherjee D, Peterson ED, Sabatine MS, Smalling RW and Zieman SJ; ACC/AHA Task Force Members; Society for Cardiovascular Angiography and Interventions and the Society of Thoracic Surgeons. 2014 AHA/ACC guideline for the management of patients with non-ST-elevation acute coronary syndromes: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Circulation* 2014; 130: 2354-94. Erratum in: *Circulation* 2014; 130: e431-2.
- [3] Ambrose JA, Tannenbaum MA, Alexopoulos D, Hjelm Dahl-Monsen CE, Leavy J, Weiss M, Borricco S, Gorlin R and Fuster V. Angiographic progression of coronary artery disease and the development of myocardial infarction. *J Am Coll Cardiol* 1988; 12: 56-62.
- [4] Glaser R, Selzer F, Faxon DP, Laskey WK, Cohen HA, Slater J, Detre KM and Wilensky RL. Clinical progression of incidental, asymptomatic lesions discovered during culprit vessel coronary intervention. *Circulation* 2005; 111: 143-9.
- [5] Levine GN, Bates ER, Bittl JA, Brindis RG, Fihn SD, Fleisher LA, Granger CB, Lange RA, Mack MJ, Mauri L, Mehran R, Mukherjee D, Newby LK, O'Gara PT, Sabatine MS, Smith PK and Smith SC Jr. 2016 ACC/AHA Guideline Focused Update on Duration of Dual Antiplatelet Therapy in Patients with Coronary Artery Disease: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *J Am Coll Cardiol* 2016; 68: 1082-115.

- [6] Tsao CW, Aday AW, Almarzooq ZI, Alonso A, Beaton AZ, Bittencourt MS, Boehme AK, Buxton AE, Carson AP, Commodore-Mensah Y, Elkind MSV, Evenson KR, Eze-Nliam C, Ferguson JF, Generoso G, Ho JE, Kalani R, Khan SS, Kissela BM, Knutson KL, Levine DA, Lewis TT, Liu J, Loop MS, Ma J, Mussolino ME, Navaneethan SD, Perak AM, Poudel R, Rezk-Hanna M, Roth GA, Schroeder EB, Shah SH, Thacker EL, VanWagner LB, Virani SS, Voecks JH, Wang NY, Yaffe K and Martin SS. Heart Disease and Stroke Statistics-2022 Update: a report From the American Heart Association. *Circulation* 2022; 145: e153-e639. Erratum in: *Circulation* 2022; 146: e141.
- [7] Byrne RA, Rossello X, Coughlan JJ, Barbato E, Berry C, Chieffo A, Claeys MJ, Dan GA, Dweck MR, Galbraith M, Gilard M, Hinterbuchner L, Jankowska EA, Jüni P, Kimura T, Kunadian V, Leosdottir M, Lorusso R, Pedretti RFE, Rigopoulos AG, Rubini Gimenez M, Thiele H, Vranckx P, Wassmann S, Wenger NK and Ibanez B; ESC Scientific Document Group. 2023 ESC Guidelines for the management of acute coronary syndromes. *Eur Heart J Acute Cardiovasc Care* 2024; 13: 55-161. Erratum in: *Eur Heart J Acute Cardiovasc Care* 2024; 13: 455.
- [8] Rubio M, Shirwany HAK, Monnin SR and Khouzam RN. Distal transradial access for coronary angiography and interventions. *Curr Probl Cardiol* 2021; 46: 100714.
- [9] Teoh Z, Rathod KS, Comer K, Tyrllis A, Choudry FA, Ozkor M, Archbold RA, Guttman O, Wragg A, Baumbach A, Jain AK, Mathur A and Jones DA. The safety of deferred coronary angiography in COVID-19 patients with acute coronary syndrome: the Barts COVID recovered pathway. *Am J Cardiovasc Dis* 2023; 13: 168-176.
- [10] Ibanez B, James S, Agewall S, Antunes MJ, Bucciarelli-Ducci C, Bueno H, Caforio ALP, Crea F, Goudevenos JA, Halvorsen S, Hindricks G, Kastrati A, Lenzen MJ, Prescott E, Roffi M, Valgimigli M, Varenhorst C, Vranckx P and Widimský P; ESC Scientific Document Group. 2017 ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation: the Task Force for the management of acute myocardial infarction in patients presenting with ST-segment elevation of the European Society of Cardiology (ESC). *Eur Heart J* 2018; 39: 119-177.
- [11] Suliman A. The state of heart disease in Sudan. *Cardiovasc J Afr* 2011; 22: 191-6.
- [12] Roger VL, Go AS, Lloyd-Jones DM, Benjamin EJ, Berry JD, Borden WB, Bravata DM, Dai S, Ford ES, Fox CS, Fullerton HJ, Gillespie C, Hailpern SM, Heit JA, Howard VJ, Kissela BM, Kittner SJ, Lackland DT, Lichtman JH, Lisabeth LD, Makuc DM, Marcus GM, Marelli A, Matchar DB, Moy CS, Mozaffarian D, Mussolino ME, Nichol G, Paynter NP, Soliman EZ, Sorlie PD, Sotodehnia N, Turan TN, Virani SS, Wong ND, Wood D and Turner MB; American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Executive summary: heart disease and stroke statistics-2012 update: a report from the American Heart Association. *Circulation* 2012; 125: 188-97. Erratum in: *Circulation* 2012; 125: e1001.
- [13] Hasabo EA, Mustafa GE, Jabir AM, Omer MH, Abdalla MA, Mohammed WH and Suliman AA. Clinical characteristics and treatment of patients with ischemic heart disease underwent Percutaneous Coronary Intervention (PCI): an African Experience from a tertiary hospital. *Am Heart J* 2022; 254: 255-256.
- [14] Drabaa Z and Majed M. The incidence of normal coronary angiography on cardiac catheterization in Jordanians. *The Egyptian Journal of Hospital Medicine* 2011; 42: 85-89.
- [15] McMullan JT, Lindsell CJ and Blomkalns AL. Five-year mortality and coronary heart disease development after normal coronary angiogram. *World J Emerg Med* 2011; 2: 24-9.
- [16] Cortell A, Sanchis J, Bodí V, Núñez J, Mainar L, Pellicer M, Miñana G, Santas E, Domínguez E, Palau P and Llacer A. Non-ST-elevation acute myocardial infarction with normal coronary arteries: predictors and prognosis. *Rev Esp Cardiol* 2009; 62: 1260-6.
- [17] Sullivan AK, Holdright DR, Wright CA, Sparrow JL, Cunningham D and Fox KM. Chest pain in women: clinical, investigative, and prognostic features. *BMJ* 1994; 308: 883-6.
- [18] Abdellah AA, Elsayed AS and Hassan MAA. Angiographic coronary artery anatomy in the Sudan Heart Centre. *Khartoum Medical Journal* 2009; 2: 162-164.
- [19] Becker LM, Peper J, van Nes SH, van Es HW, Sjaauw KD, van de Hoef TP, Leiner T and Swaans MJ. Non-invasive physiological assessment of coronary artery obstruction on coronary computed tomography angiography. *Neth Heart J* 2024; 32: 397-404.
- [20] Caldonazo T, Kirov H, Dochev I, Fischer J, Runkel A, Dewey M, Cardoso R, Teichgräber U, Mukharyamov M, Gräber S and Doenst T. Invasive coronary angiography versus noninvasive computed tomography coronary angiography as preoperative coronary imaging for valve surgery. *Am J Cardiol* 2025; 237: 1-5.