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Coronary Dominance and Variation Associated with Acute Myocardial Infarction: a Literature Review

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ABSTRACT

Introduction: the dominance and anatomic variation in coronary circulation can be associated with acute coronary syndrome, such as acute myocardial infarction.

Review: The variation and dominance of coronary are related with the development of heart attack. An obstructive disease in the left coronary artery is able to cause more complications compared to the right coronary artery. This happens because the left coronary artery is the major source of blood supply to the heart and, consequently, is responsible for supplying a large portion of the ventricular myocardium. The majority of patients who suffered heart attack with ST-segment elevation showed right dominance, while the highest mortality was associated with left dominance. In addition, the dominance pattern may influence, significantly, the formation of a collateral circulation, which can help as an alternative way of blood flow to the myocardium when there is an obstruction in coronary arteries. Besides this, coronary dominance influences the progress of certain clinical conditions, such as pulmonary embolism, in which the right dominance allows more favorable hemodynamics conditions to patients.

Conclusion: The morphological pattern of the coronary arteries influences the development of acute coronary syndrome. The knowledge about this may help as a tool for a better stratification of infarction risk and long-term prognosis in order to provide an improvement in quality of life and reduce morbidity and mortality.

Keywords: Coronary; Dominance; Infarction; Variation

Introduction

The pattern of dominance of the myocardial circulation is established from the artery that emits the posterior interventricular branch. It may present as right, left or codominance due to the right, left coronary artery or both giving rise to this branch, respectively[1]. The coronary artery dominance can be associated with the occurrence of acute coronary syndrome, such as acute myocardial infarction (AMI), and with cardiovascular prognosis. In the general population, the right dominance is the most prevalent, found in approximately 70%-80% of the population, while left dominance occurs in about 5%-10% of cases and codominance is present in 1%-20% of cases[1,2].

The knowledge about variations, anomalies and anatomical patterns of coronary arteries and coronary collateral pathways could help in the management of cardiac patients. It is important in a scenario of increased cardiac procedures, such as coronary angiography[2,3]. Thus, the dominance and coronary variations influence the development of clinical conditions and it is relevant to embrace complementary exams to follow-up the patient in order to improve prognosis.

Therefore, the purpose of this study is to analyze recent studies regarding the relation between the coronary dominance pattern and their variations in the development of AMI, as well as the proportion of cardiac muscle involvement. In addition, it is relevant to study possible updates of complementary cardiac tests to assist the clinical management of infarcted patients.

Materials and Methods

An integrative review of literature that analyzed the dominance and possible anatomical variations of coronary artery system associated with the occurrence of acute coronary syndrome was performed. The following databases were included: PubMed, Excerpta Medica (Embase), Latin American and Caribbean Literature on Health Sciences (Lilacs), Cochrane Library and Scientific Electronic Library Online (SciELO) of studies published from 2015 to 2022. Then, a literature search was made for published articles with the filters for free access to full text, research in humans and the best match articles.

The descriptors used for the search followed the description of the Health Sciences Descriptors (DeCS)

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terms of the Virtual Health Library developed from the Medical Subject Headings (MeSH) of the United States National Library of Medicine. The keywords were combined using the Boolean operators OR and AND, without linguistic restriction using the following words: "Coronary", "Dominance", "Imaging", "Infarction", "Myocardial" and "Variation". All the articles obtained in the databases through the research suffered the application of inclusion and exclusion criteria.

First, the review consisted of analyzing the titles and abstracts of the studies related with the topic. Then, it included only those articles that met the eligibility criteria: date of publication between 2015 and 2022, title and/or abstract with some of the descriptors used in searching, studies in humans, no language restriction, cross-sectional, retrospective and prospective studies and case reports. Articles that presented repeated information, conventional concepts, duplicated or that the topic addressed was not associated to the research proposal, systematic reviews and meta-analysis were excluded. The studies that were selected as relevant and that generated doubts were retained for further analysis of the text in its entirety. Secondly, the review consisted of the extraction of data from the studies selected previously. All eligible records were read in full and data available in the text were extracted. We excluded those who, despite appearing in the search result, did not approach the subject adequately with the variables of interest in this study. Additionally, references and related citations were manually searched to identify any further relevant articles.

Results

By searching the databases cited, the search found 464 studies in the period, but 441 were rejected, as they did not meet the inclusion criteria. Thus, a total of 23 publications were selected on the subject (Figure 1), covering the association of coronary dominance and variation with AMI. All selected studies were accessed and read for subsequent selection of the characteristics that incorporated the research. The data were extracted and processed using a tool designed by the authors with the following fields: authors, year of publication, name of the journal, methodology and main results. The characteristics of each study are presented in Table 1.

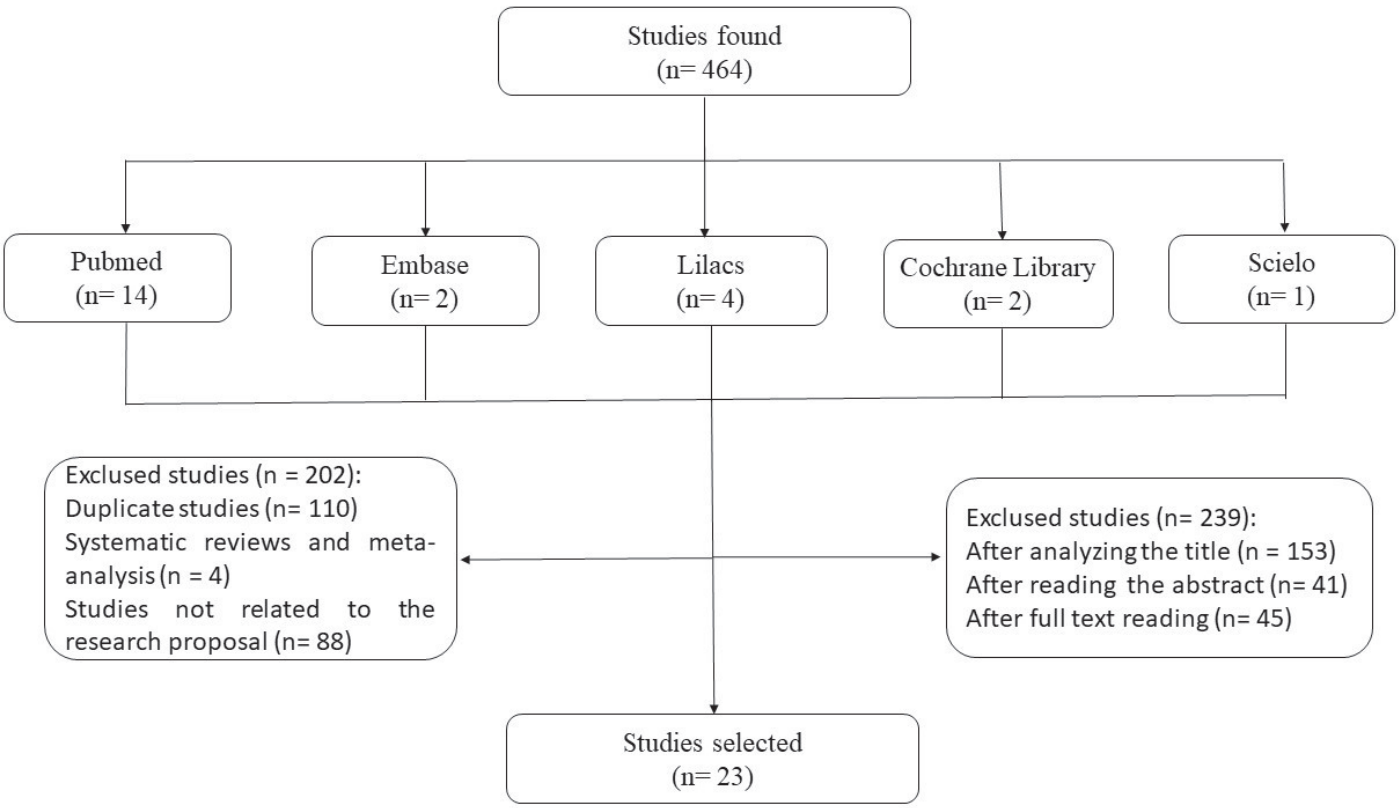

Figure 1. Search flowchart showing the study selection process of this literature review.

Table 1. Main aspects of anatomical variation and coronary dominance related with myocardial infarction, in chronological order, found in the literature review.

Author (s) (year)	Periodical	Methodology	Results
Ajahi *et al.*[3] (2015)	Folia Morphological	Cross-sectional study of 286 patients	The right dominance influenced the formation of coronary collateral pathways in LCx and RCA obstructions.
Altin *et al.*[2] (2015)	Singapore Medical Journal	Retrospective cohort study of 5548 patients	Coronary anatomical variations, such as anomalous pulmonary and aortic origins, congenital atresia, myocardial bridging, arteriovenous fistulas, aneurysms, stenosis, and anomalies of origin and distribution.
Gebhard *et al.*[32] (2015)	European Heart Journal	Retrospective cohort study of 6382 patients	The coronary computed tomographic angiography is a tool for non-invasive diagnosis of CAD and can assess coronary dominance.
Lam *et al.*[11] (2015)	EuroIntervention	Non-pre-specified post hoc analysis of a prospective randomized trial of 1387 patients	The left dominance was associated with a higher incidence of AMI.
Omerbasic *et al.*[5] (2015)	Medical Archives	Retrospective cohort study of 100 patients	In left coronary dominance, the left ventricle is almost completely vascularized by the LAD and LCx.
Veltman *et al.*[22] (2015)	European Heart Journal	Retrospective cohort study of 1131 patients	The coronary vessel dominance may influence long term prognosis of patients with STEMI.
Abu-Assi *et al.*[12] (2016)	Revista Española de Cardiología	Retrospective cohort study of 767 patients	It was found a larger caliber of LCx and a longer LAD in left dominance; higher rate of cardiogenic shock and in-hospital mortality after acute occlusion of the proximal LCx than in LAD.
Koenraadt *et al.*[2]8 (2016)	Heart	Cross-sectional study of 178 patients	The left dominant coronary artery system and separated ostia were associated with BAVs with left-right fusion without a raphe (type 1B), CAD and aortic coarctation.
Michatowska *et al.*[27] (2016)	Journal of Thoracic Imaging	Retrospective cohort study of 193 patients with a control group of 235 patients	Higher incidence of left dominance in patients with BAV compared to tricuspid aortic valve; patients with BAV had more absence of the left coronary trunk and when it was present had a shorter length and the presence of the intermediate branch.
Waziri *et al.*[14] (2016)	EuroIntervention	Retrospective cohort study of 7539 patients	Lesions in LCx were presented as ST elevation in patients with infarction and dominant left coronary arteries; while LCx lesions in non-ST elevation infarction were seen in the dominant right coronary arteries.
Attar *et al.*[34] (2017)	Indian Heart Journal	Retrospective cohort study of 720 patients	The left dominance decreases the specificity and accuracy of the exercise tolerance test; left dominance associated with higher mortality from acute coronary syndrome.
Gebhard *et al.*[10] (2017)	Catheter Cardiovascular Intervention	Cross-sectional study of 2002 patients	The left dominance is a predictor of increased death and major adverse cardiac events in patients with chronic total occlusions.
Hanboly *et al.*[9] (2018)	Journal of the Saudi Heart Association	Prospective observational study of 300 patients	The left coronary artery dominance confers a higher risk of various adverse clinical events after primary PCI.
Yan *et al.*[1] (2018)	BMJ Open	Cross-sectional study of 1654 patients	The right dominance was associated with higher occurrence of coronary stenosis and three-vessel disease.

Vasiltseva *et al.*[6] (2019)	Kardiologiia	Cross-sectional study of 893 patients	The left dominance and codominance with stenosis and atherosclerosis were associated with worse prognosis.
Wang *et al.*[16] (2019)	BMC Cardiovascular Disorders	Observational retrospective study of 795 patients	Higher long-term mortality in acute coronary syndrome and left dominance; right dominance is a predictor of inferior wall infarction.
Xu *et al.*[33] (2019)	Journal of Thoracic Disease	Cross-sectional study of 1006 patients	The coronary computed tomography angiography may help identify and observe coronary artery anatomical distributions.
Cabezas *et al.*[23] (2020)	Cardiovascular Revascularization Medicine	Cross-sectional study of 900 patients	The STEMI compromises coronary atrial branch flow and may cause atrial ischemia; anatomical variability of the atrial coronary branch, which may originate from the sinus node artery, the atrioventricular node, smaller branches of the RCA or the LCx.
Femia *et al.*[17] (2020)	Catheter Cardiovascular Intervention	Retrospective cohort study of 939 patients	Worse prognosis in culprit lesion location in dominant right coronary artery in patients with STEMI.
Mikaeilvand *et al.*[20] (2020)	Journal of Research in Medical Sciences	Retrospective cohort study of 491 patients	The coronary artery dominance may influence outcome in patients following primary PCI.
Alegria *et al.*[7] (2021)	Arquivos Brasileiros de Cardiologia	Observational retrospective study of 127 patients	The most affected arteries in AMI are the common trunk, anterior descending, LCx and RCA; higher prevalence of anterior wall AMI and involvement of three coronary vessels.
Leguizamón *et al.*[8] (2021)	Revista Argentina de Cardiologia	Retrospective cohort study of 95 patients	Higher mortality and hospital adverse events in cases of left coronary trunk involvement.
Liu *et al.*[35] (2021)	Chinese Medical Journal	Retrospective cohort study of 79 patients	There are several patterns of coronary circulation due to the variability of coronary anatomy analyzed from the dominance of RCA, the length of the LAD and the size of the diagonal branch.

LCx: left circumflex artery. RCA: right coronary artery. LAD: left anterior descending artery. AMI: acute myocardial infarction. CAD: coronary artery disease. PCI: percutaneous coronary intervention. STEMI: acute myocardial infarction with ST-segment elevation. BAV: bicuspid aortic valve.

Discussion

An obstructive disease in the left coronary artery (LCA) is capable of causing greater complications compared to the right coronary artery (RCA), because the LCA is the major source of blood supply to the heart and is responsible for supplying a large portion of ventricular myocardium[4-6]. The most affected arteries in AMI are the common trunk, anterior descending artery, LCA and RCA[7]. The cases of obstruction in the left coronary trunk are involved with higher mortality and hospital adverse events, such as reinfarction, heart failure, lower left ventricular ejection fraction, atrioventricular block, ventricular tachycardia, cardiorespiratory arrest, hemorrhage, stroke and longer hospital stay[8-10]. There is a higher occurrence of bifurcated and severely calcified coronary lesions in patients with left dominance. The presence of left trunk disease and proximal stenosis in left anterior descending artery (LAD) in this type of dominance pattern may induce more complications during surgical revascularization, requiring more aggressive pharmacological therapy[11].

The majority of patients who have suffered AMI with ST-segment elevation (STEMI) were right-dominant, while the highest mortality and reinfarctions in patients were associated with left dominance[12,13]. The right dominance is also related with greater severity in coronary artery disease (CAD), as they have a higher proportion of severe coronary stenosis than patients with left dominance and codominance[1]. In patients with non-ST elevation infarction (NSTEMI), lesions in the left circumflex artery (LCx) region are more frequent compared to patients with STEMI and have worse short-term mortality compared to LAD and RCA lesions. This occurs because LCx occlusions in the right dominance are not properly detected on the electrocardiogram (ECG)[14,15]. The right dominance acts as a predictor of occurrence of AMI of inferior hall due to increased shear stress on RCA endothelial cells along with increased stenosis and multivessel coronary vascular atherosclerosis[16]. In right coronary artery dominance with STEMI, proximal culprit lesions have higher rates of acute complications, such as bradycardia and cardiogenic shock and require intra-

aortic balloon pump and temporary cardiac pacing[17]. The presence of stenosis in left main coronary artery of the left dominance is related with increased mortality after coronary surgery, percutaneous coronary intervention (PCI) and higher length of hospitalization and incidence of major adverse cardiac events[5,18,19]. Patients with left coronary artery dominance had higher indicators of worse outcomes in primary PCI, such as lower left ventricular ejection fraction and increased occurrence of thrombolysis compared with right dominance[20]. The left dominant pattern along with the presence of myocardial bridges is associated with an increase in the incidence of arteriosclerosis and mortality by AMI[21]. And it is also related with a significantly risk of 30-day mortality, long term in 5 years of follow-up and early reinfarction after STEMI[22].

There are anatomical variations of the coronary arteries that emit branches to irrigate the atria and the existence of various phenotypes of atrial perfusion. This can affect the correct assessment of the clinical impact of atrial ischemia in patients with STEMI, which would impair the detection of atrial arrhythmias[23]. Moreover, the recognition of coronary artery abnormalities is important for the appropriate diagnosis and management of patients undergoing coronary angioplasty or cardiac surgery. Some are associated with angina, AMI and sudden death, and therefore have to be treated[2]. An anomalous left main coronary artery arising from the right aortic sinus was found in cases of STEMI, that caused difficulties in identification of coronary ostia during PCI[24]. The continuation of the LAD to form the posterior descending artery is a rare coronary anomaly known as "hyperdominant" or "superdominant". The stenosis of hyperdominant LAD can have catastrophic complications such as ruptures of ventricular septum, right ventricle and aneurysmal left ventricle following massive biventricular infarction[25]. And also an occlusion in a superdominant circumflex artery can cause posterior wall myocardial infarction[26].

In addition, the dominance pattern may significantly influence the formation of a coronary collateral circulation, which can serve as an alternative route of blood flow to the myocardium. The higher prevalence of collaterals found in the right dominant pattern may be related to the morphology of the obstructed vessel. With the RCA also supplying the left ventricle in the right dominant pattern, the development of collaterals could be amplified by this coronary arrangement[3]. The possibility of creating collaterals may be lower in patients with left coronary dominance. Since there is no posterior interventricular artery branch that starts from the RCA, there is no possibility of creating collaterals from the right coronary system when occurs severe stenosis in left coronary system[5]. Additionally, anatomical variations in the dominant circumflex artery and less formation of collateral circulation lead to an increased risk of thrombus formation secondary to turbulent blood flow and greater difficulty in PCI[17].

Beyond that, the coronary dominance may play a role in the progression of certain clinical conditions, such as pulmonary embolism. In this clinical condition, the right dominance, in the absence of stenosis or atherosclerosis in the right coronary artery, creates more favorable hemodynamic conditions of survival compared to left dominance and codominance[6]. The higher frequencies of left dominant coronary artery system are usually found in a bicuspid aortic valve (BAV) with left-right fusion without a raphe (type 1B) along with the absence of the left coronary trunk, besides of the association of aortic coarctation[27,28]. In addition, patients with type 1B BAVs also are at more risk of developing CAD and more often have separate ostia that could facilitate coronary angiography procedure[28]. Also it was found an interaction between coronary dominance and hypertension, in which right coronary arterial flow patterns were strongly influenced by dominance and systemic/pulmonary hypertension while the dominance had minor effects on LCA and all microvascular flow patterns[29].

It is essential to embrace imaging exams to evaluate the extension of cardiac damage and assist clinical management of infarcted patients. The extent of cardiac damage after an AMI can be determined by imaging tests generally using echocardiography, computed tomography and cardiac magnetic resonance[30]. The ECG allows detecting abnormalities of electrical signals in the heart and damage to blood supply to the heart muscle. It is used to differentiate between two types of myocardial infarctions, the STEMI and the NSTEMI, which will determine the type of treatment. Besides, a coronary angiography or X-ray of the heart and blood vessels can be performed to see narrowing of coronary arteries[4]. A computed tomography angiography has become the reference method for the evaluation of coronary anomalies. It detects not only the anomaly at the origin of these arteries and recognize coronary artery dominance, but also their path and relationship with other mediastinal structures[31-33]. This imaging method is important for therapeutic management and evaluation of prognosis in patients with CAD. Moreover, the electrocardiographic exercise test can be used to clarify the presence of cardiovascular disease that may be obscured during rest. However, this test can be affected by the coronary dominance pattern, in which the left dominance is responsible for generating false positives results, decreasing the specificity and accuracy of the test[34]. Furthermore, there is a coronary artery tree description and lesion evaluation (CatLet) score that is an angiographic scoring system performed in patients with AMI. It is a new tool to characterize and reflect the variability of the coronary anatomy based on the dominance of the RCA, the length of the LAD artery and the size of the diagonal branch[35]. This exam can accommodate the variability in the coronary anatomy and standardized

the collection of the coronary angiographic data. It could facilitate the comparison and exchange of these data between different catheter labs and would facilitate the predicting the clinical outcomes[36].

Among the limitations, the delimitation of the publication period stands out, which excludes relevant studies previously published. There was a lack of data on updates of cardiac complementary exams that could help in the investigation of the relationship between dominance and anatomic variations with acute coronary syndrome. It was found information already well-established in literature about the usual imaging cardiac exams. Furthermore, the context of the COVID-19 pandemic contributed to a greater number of recent studies approaching the effects of the infection on the cardiovascular system. However, the coronavirus scenario decreased drastically the emergency room visits for heart attack, so that the delay in seeking care and treating of this condition generated more complications and, consequently, higher morbidity and mortality[37]. Therefore, it is relevant to prepare and publish new studies that could contribute with more information about the relationship between dominance and anatomical variation of the coronary artery system in the development of acute coronary syndrome.

Conclusion

This study updates the literature about the impact that dominance and coronary variations may perform in acute coronary syndrome. The clinical manifestations of the coronary artery disease are different in relation to which the coronary arteries are affected and which type of arterial vascularization is present. It is essential to know the anatomy of the coronary circulation, dominance type and its variations in order to indicate appropriate diagnostic imaging techniques, contributing to the success of the treatment. Distinguishing between normal and varied structures can contribute to reduction of complications in invasive procedures and to plan different or additional strategies in order to have even better outcomes. Thus, the assessment of coronary morphology may serve as a tool to evaluate the risk stratification and long-term prognosis in order to improve quality of life and reduce morbidity and mortality from an acute coronary syndrome.

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Mini Curriculum and Author's Contribution

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