Received: 17 February 2025 / Accepted: 02 October 2025 / Published online: 30 October 2025

DOI 10.34689/SH.2025.27.5.008

UDC 616.98:579.876.1

ASSESSMENT OF ANTHROPOMETRIC CHARACTERISTICS IN PATIENTS WITH CORONARY ARTERY DISEASE IN KAZAKHSTAN: DATA FROM A PROSPECTIVE CROSS-SECTIONAL STUDY, SINGLE-CENTER EXPERIENCE

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Abstract

Objective: Coronary artery disease (CAD) remains one of the leading causes of mortality and disability worldwide. In patients with CAD, the lumen of the coronary arteries gradually narrows due to atherosclerosis, leading to an imbalance between myocardial oxygen supply and demand. Non-invasive methods such as scintigraphy and positron emission tomography (PET) are widely used for the diagnosis of CAD. Invasive coronary angiography (ICA) has long been considered the "gold standard" for diagnosing CAD. However, studies have shown that the degree of stenosis determined by ICA does not always correlate with the functional significance of the lesion. **The aim of our study** was to investigate the correlations between the volume, length, and diameter of coronary arteries, myocardial mass (MM), and anthropometric indicators such as height, weight, body mass index, body surface area, age, and sex.

Methods: We analyzed 654 medical records of patients who underwent inpatient treatment at the Pavlodar Regional Cardiology Center from November 2024 to January 2025. The patients, aged 18 years and older, were hospitalized with coronary artery pathology, received conservative treatment, and underwent diagnostic coronary angiography (D-CAG).

Results: Our study revealed a significant positive correlation between the volume of coronary arteries and myocardial mass, myocardial mass and patient weight, patient height and the length of coronary arteries ($p < 0.05$). However, no association was found between the volume of coronary arteries, their diameter, and other anthropometric indicators (body mass index, body surface area) ($p > 0.05$).

Conclusion: Thus, our study demonstrates that the dimensions of coronary arteries are closely related to the anthropometric characteristics of the patient.

Keywords: *coronary artery volume, myocardial mass, coronary artery disease.*

For citation: *Antikeev A.M., Abiltayev. A.M., Abiltayeva A.A., Tleuova A.K., Izguttinov D.E.* Assessment of Anthropometric Characteristics in Patients with Coronary Artery Disease in Kazakhstan: Data from a Prospective Cross-Sectional Study, Single-Center Experience // *Nauka i Zdravookhranenie* [Science & Healthcare]. 2025. Vol.27 (5), C.63-69. *doi 10.34689/SH.2025.27.5.008*

Резюме

ОЦЕНКА АНТРОПОМЕТРИЧЕСКИХ ХАРАКТЕРИСТИК У ПАЦИЕНТОВ С ИШЕМИЧЕСКОЙ БОЛЕЗНЬЮ СЕРДЦА В КАЗАХСТАНЕ: ДАННЫЕ ПРОСПЕКТИВНОГО ПОПЕРЕЧНОГО ИССЛЕДОВАНИЯ, ОПЫТ ОДНОГО ЦЕНТРА

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Актуальность: Ишемическая болезнь сердца (ИБС) остается одной из ведущих причин смертности и инвалидности во всем мире. У пациентов с ИБС просвет коронарных артерий постепенно сужается из-за атеросклероза, что приводит к дисбалансу между кровоснабжением сердца и потребностью миокарда в кислороде. Для диагностики ИБС широко используются неинвазивные методы, такие как сцинтиграфия и позитронно-эмиссионная томография (ПЭТ). Инвазивная

коронарная ангиография (ИКА) долгое время считалась "золотым стандартом" диагностики ИБС. Однако исследования показали, что степень стеноза, определяемая с помощью ИКА, не всегда коррелирует с функциональной значимостью поражения. **Целью исследования** стало изучение корреляционных связей между объемом, длиной и диаметром коронарных артерий, массой миокарда (ММ) и антропометрическими показателями, такими как рост, вес, индекс массы тела, площадь поверхности тела, возраст и пол.

Методы: Нами был проведен анализ 654 историй болезни пациентов проходивших стационарного лечения в условиях Павлодарского Областного Кардиологического центра, госпитализированных с патологией коронарных артерий с ноября 2024 года по январь 2025 года. В возрасте от 18 лет, которые получали консервативное лечение, а также была проведена Д-КАГ.

Результаты: В нашем исследовании была выявлена значимая положительная корреляция между объемом коронарных артерий и массой миокарда, массой миокарда и массой пациента, ростом пациента и длиной коронарных артерий, а так же между (p <0,05). Однако связи между объемом коронарных артерий, их диаметром и другими антропометрическими показателями (индекс массы тела, площадь поверхности тела) не обнаружена (p> 0,05).

Выводы: Таким образом, наше исследование демонстрирует, что размеры коронарных артерий тесно связаны с антропометрическими показателями пациента.

***Ключевые слова**: объем коронарных артерий, масса миокарда, ишемическая болезнь сердца.*

***Для цитирования:** Антикеев А.М., Абильтаев А.М., Абильтаева А.А., Тлеуова А.К., Изгуттинов Д.Е.* Оценка антропометрических характеристик у пациентов с ишемической болезнью сердца в Казахстане: данные проспективного поперечного исследования, опыт одного центра // Наука и Здравоохранение. 2025. Vol.27 (5), С.63-69. *doi 10.34689/SH.2025.27.5.008*

Түйіндеме

ҚАЗАҚСТАНДАҒЫ ИШЕМИЯЛЫҚ ЖҮРЕК АУРУЫ БАР НАУҚАСТАРДЫҢ АНТРОПОМЕТРИЯЛЫҚ СИПАТТАМАЛАРЫН БАҒАЛАУ: БІР ОРТАЛЫҚТЫҢ ТӘЖІРИБЕСІ, ПРОСПЕКТИВТЫ КӨЛДЕНЕҢ ЗЕРТТЕУ ДЕРЕКТЕРІ

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Актуальность: Ишемиялық жүрек ауруы (ИЖА) әлем бойынша өлім мен мүгедектіктің негізгі себептерінің бірі болып қала береді. ИЖА-сы бар науқастарда атеросклероздың әсерінен тамырлардың кеңістігі бірте-бірте тарылып, жүрекке қан жеткізу мен миокардтың оттегіге деген қажеттілігі арасында теңсіздік пайда болады. ИЖА-ны диагностикалау үшін сцинтиграфия және позитрон-эмиссионды томография (ПЭТ) сияқты инвазивті емес әдістер кеңінен қолданылады. Инвазивті коронарлы ангиография (ИКА) ұзақ уақыт бойы ИЖА диагностикасының "алтын стандарты" болып саналды. Дегенмен, зерттеулер ИКА арқылы анықталатын стеноз дәрежесі әрдайым зақымданудың функционалды маңыздылығымен сәйкес келмейтінін көрсетті. **Зерттеуіміздің мақсаты** – коронарлы тамырлардың көлемі, ұзындығы және диаметрі, миокардтың массасы (ММ) және бой, салмақ, дене массасы индексі, дене бетінің ауданы, жасы және жыныс сияқты антропометриялық көрсеткіштер арасындағы корреляциялық байланыстарды зерттеу болды.

Әдістері: 2024 жылдың қарашасынан 2025 жылдың қаңтарына дейін «Павлодар облыстық кардиология орталығында» стационарлық емдеу алған 18 жастан асқан 654 науқастың медициналық тарихтары талданды. Барлық науқастарға консервативті ем берілді және Д-КАГ жүргізілді.

Нәтижесі: Зерттеу барысында коронарлы тамырлардың көлемі мен миокардтың массасы, миокардтың массасы мен науқастың салмағы, науқастың бойы мен коронарлы тамырлардың ұзындығы арасында айтарлықтай оң корреляция байқалды (p <0,05). Дегенмен, коронарлы тамырлардың көлемі, диаметрі мен басқа антропометриялық көрсеткіштер (дене массасы индексі, дене бетінің ауданы) арасында байланыс анықталған жоқ (p> 0,05).

Қорытынды: Осылайша, біздің зерттеуіміз коронарлы тамырлардың өлшемдері науқастың антропометриялық көрсеткіштерімен тығыз байланысты екенін көрсетті.

***Түйін сөздер:** коронарлы тамырлардың көлемі, миокардтың массасы, ишемиялық жүрек ауруы.*

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Introduction

The Problem and the Limitations of Modern Diagnostic Methods

Ischemic heart disease (IHD) remains one of the leading causes of mortality and disability worldwide. In patients with IHD, the lumen of the coronary arteries gradually narrows due to atherosclerosis, leading to an imbalance between myocardial blood supply and oxygen demand. This imbalance manifests with clinical symptoms such as angina pectoris and significantly impairs a patient's quality of life [1].

To diagnose IHD, clinicians rely on a range of tools, each with its own strengths and weaknesses. Non-invasive methods, such as scintigraphy and positron emission tomography (PET), are widely used and allow assessment of myocardial perfusion and identification of ischemic areas. However, a significant limitation is that these techniques do not provide accurate information on coronary artery anatomy [2]. To overcome this, cardiac magnetic resonance imaging (MRI) offers a more comprehensive approach, allowing visualization of both coronary artery anatomy and myocardial perfusion. Despite this advantage, MRI has its own limitations: it cannot always distinguish between blood flow impairments in large epicardial vessels (that can be solved by revascularization) and microcirculation impairments. Furthermore, its lengthy procedure time limits its widespread use in clinical practice [3].

For decades, invasive coronary angiography (ICA) has been the undisputed "gold standard" for anatomical assessment. Yet, a critical flaw has been recognized: the degree of stenosis determined by ICA does not always correlate with the functional significance of the lesion. This realization is supported by data on the advisability of using invasive fractional flow reserve (FFR) measurement to assess the physiological significance of stenoses [4]. Moreover, a fundamental diagnostic challenge persists, as modern methods often fail to account for the impact of diffuse atherosclerosis on the vasodilatory capacity of vessels. Diagnosing microvascular dysfunction also remains difficult, as it can cause angina symptoms even in the absence of significant stenoses in the major coronary arteries [5].

Bridging the Diagnostic Gap: The Role of Anatomy and Anthropometry

This diagnostic complexity highlights a critical, yet understudied aspect of IHD: the relationship between coronary artery dimensions and basic patient anthropometric indicators such as height, weight, body mass index (BMI), and body surface area (BSA). Although fundamental principles of biology and cardiac physiology suggest that coronary artery volume should match myocardial mass to ensure adequate blood supply [6], it remains unclear exactly how anthropometric parameters influence coronary artery size.

Existing research has begun to explore this relationship, with studies using ICA and computed tomography coronary angiography (CTCA) demonstrating the importance of the coronary artery lumen volume to myocardial mass ratio (V/M) for assessing ischemia risk [6, 7, 8]. However, these findings are primarily based on Western populations, and do not account for ethnic and geographical characteristics that may significantly influence coronary artery anatomy.

Research Objective, Significance, and Our Study

In Kazakhstan, where ethnic diversity and specific climatic conditions may impact the cardiovascular system, such studies are virtually absent. This creates a significant knowledge gap that may limit opportunities for personalized diagnosis and treatment of CAD in the local population.

Therefore, the aim of our study was to investigate the correlations between the volume, length, and diameter of coronary arteries, myocardial mass (MM), and anthropometric indicators such as height, weight, BMI, BSA, age, and sex. We hypothesize that the obtained data will not only deepen the understanding of anatomical features of coronary arteries in this population but also help develop more accurate diagnostic criteria for identifying patients at increased risk of ischemia.

Our study is unique in that it combines data from diagnostic coronary angiographies (D-CAG) with anthropometric measurements, allowing for a direct assessment of the relationship between coronary artery size and individual patient characteristics. This is particularly important for developing personalized approaches to CAD treatment that consider not only the degree of stenosis but also the anatomical features of the coronary arteries.

To achieve this goal, we conducted a prospective single-center study analyzing the results of D-CAG of patients treated at the Pavlodar Regional Cardiology Center from November 2024 to January 2025.

Materials and Methods

Study Design and Population

This prospective single-center study was conducted at the Pavlodar Regional Cardiology Center (PRCC), a tertiary referral hospital providing a full range of specialized care for patients with circulatory system diseases. We analyzed medical records of 654 patients hospitalized with suspected coronary artery pathology who underwent D-CAG from November 2024 to January 2025.

From this initial cohort, 137 patients were selected for the final analysis based on the following inclusion criteria: (1) age 18 years or older, (2) hospitalization with a preliminary diagnosis of unstable angina (ICD-10 code I20.0), and (3) the absence of hemodynamically significant coronary artery disease, defined as no coronary lesions or stenoses < 30% as confirmed by D-CAG. Exclusion criteria included a history of prior percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG), poor angiographic image quality, and severe valvular heart disease.

Data Collection and Measurements

Demographic and anthropometric data, including sex, age, weight, and height, were extracted from the electronic medical record system (EMIS). BMI and BSA were calculated from these measurements. Echocardiographic data were used to calculate MM according to the American Society of Echocardiography (ASE) formula [9], where PWT is the posterior wall thickness, IVS is the interventricular septum thickness, and LVEDD is the left ventricular end-diastolic dimension.

$$MM = 0.8 * (1.04 * [(PWT + IVS + LVEDD)^3 – LVEDD^3]) + 0.6$$

Coronary artery analysis was performed using D-CAG images acquired on a GE Innova system. The length, diameter, and volume of the left and right coronary arteries were assessed in standard projections for each artery.

Measurements were performed offline using dedicated software (2D viewer and VolumeViewer), with the size of the diagnostic catheter used as a reference for calibration. The presence or absence of coronary pathology was assessed based on the D-CAG results.

Ethical Considerations

This study was conducted within the scientific program of the Department of Surgery of the Pavlodar Branch, Semey Medical University. The institutional ethics committee reviewed and approved the study protocol, waiving the requirement for informed consent due to the prospective, anonymized nature of the data analysis and the study's compliance with local regulations permitting the use of de-identified clinical records for research purposes. The institutional leadership raised no objections to the publication of anonymized data. Patients participating in the study were included only after voluntarily signing a written informed consent form.

Statistical Analysis. Continuous variables are presented as mean ± standard deviation (SD), and categorical variables are presented as absolute numbers and percentages. The normality of the distribution of continuous variables was assessed using the Shapiro-Wilk test. Comparisons of continuous variables between groups were performed using the Student's t-test or the Mann-Whitney U test, as appropriate. Correlation analyses between continuous variables were assessed using Pearson or Spearman correlation coefficients, depending on the data distribution.

All statistical analyses were performed using R software version 4.1.1 (The R Foundation for Statistical Computing, Vienna, Austria). A two-sided p-value < 0.05 was considered statistically significant.

Results

Study Population and Baseline Characteristics

A total of 137 patients met the inclusion criteria and constituted the study population. The baseline characteristics of the patients are summarized in Table 1. The mean age of the cohort was 67.7 ± 10.6 years, and 50.4% (n=69) were male. Significant differences were observed between genders: women were significantly older than men (64.6 ± 10.8 vs. 58.8 ± 9.7 years, $p < 0.05$). As expected, men had significantly greater height (172.1 ± 7.1 vs. 161.8 ± 6.5 cm, $p < 0.05$) and BSA (1.97 ± 0.18 vs. 1.86 ± 0.19 m², $p < 0.05$) compared to women. Although women had a lower mean weight than men (82.2 ± 16.1 vs. 84.6 ± 15.2 kg, $p > 0.05$), this difference was not statistically significant. However, BMI was significantly higher in women (31.3 ± 5.9 vs. 28.5 ± 4.6 kg/m², $p < 0.05$).

Analysis of Coronary Artery Dimensions

The detailed measurements of coronary artery dimensions are presented in Table 1. Overall, the mean volume of the coronary arteries was 1585 ± 564 mm³. While descriptive trends showed larger absolute dimensions (length and diameter) in men compared to women for both the left anterior descending (LAD) and right coronary arteries (RCA), these differences did not reach statistical significance ($p > 0.05$ for all comparisons).

The mean length and diameter of the LAD were 102.0 ± 25.4 mm and 2.87 ± 0.75 mm, respectively (Men: 105.9 mm / 2.79 mm; Women: 99.0 mm / 2.94 mm). For the RCA, the mean length and diameter were 94.4 ± 26.5 mm and 2.95 ± 0.70 mm, respectively (Men: 98.3 mm / 2.96 mm; Women: 90.5 mm / 2.96 mm). Similarly, the volume of the left coronary artery (LCA) was greater in men (982.2 mm³ vs. 943.9 mm³), as was the volume of the RCA (659.2 mm³ vs. 582.9 mm³), but these differences were also not statistically significant.

Table 1.

General characteristics of patients

Characteristics	Mean (SD)
Age, years	67,7 (10,6)
Height, sm	167,0 (8,57)
Weight, kg	83,4 (16,9)
BMI, kg/m^2	29,9 (5,56)
BSA, m^2	1,92 (0,201)
Mass of myocardium (gr)	252 (120)
Volume of coronary artery (mm^3)	1585 (564)
Length of LAD, mm	102,0 (25,4)
Diameter of LAD, mm	2,87 (0,75)
Volume of LCA, mm^3	963,0 (338,0)
Length of RCA, mm	94,4 (26,5)
Diameter of RCA, mm	2,95 (0,70)
Volume of RCA, mm^3	621,0 (35,0)

Notes: BMI - body mass index; BSA - body surface area; LAD - left anterior descending artery; LCA - left coronary artery; RCA - right coronary artery.

Correlation Analyses

The distribution of key variables was assessed for normality (Figure 1). Height, LCA length, and RCA length followed a normal distribution (Shapiro-Wilk $p > 0.05$). In contrast, MM, coronary artery volume, and patient weight showed distributions significantly different from normal (Shapiro-Wilk $p < 0.05$), which informed the choice of correlation methods (Pearson or Spearman).

We identified several significant correlations (Figure 2): A moderate positive correlation was found between total coronary artery volume and myocardial mass ($r = 0.48$, $p < 0.05$; Figure 2A). Weak positive correlations were observed between: Myocardial mass and patient weight ($r = 0.32$, $p < 0.05$; Figure 2B). RCA length and patient height (r = 0.33, $p = 0.00063$; Figure 2C). LCA length and patient height ($r = 0.26$, $p < 0.05$; Figure 2D). No significant association was found between coronary artery volume or diameter and other anthropometric indicators such as BMI or BSA ($p > 0.05$).

Discussion

Key findings in our research were: We identified a moderate positive correlation ($r = 0.48$, $p < 0.05$) between total coronary artery volume and myocardial mass, supporting the fundamental allometric principle of a matching blood supply to muscle mass. The absolute dimensions (length, diameter, volume) of the coronary arteries in our cohort were generally lower than those reported in studies of other populations, suggesting potential ethnic or geographical variations in coronary anatomy. We found a weak but significant positive correlation between patient height and the length of both the LAD and RCA, confirming that overall body size is a determinant of coronary artery anatomy. However, no significant association was found between coronary dimensions and BMI or BSA.

The principle of allometric scaling and the volume-to-mass (V/M) ratio, established over 40 years ago by Gould et al. [10],

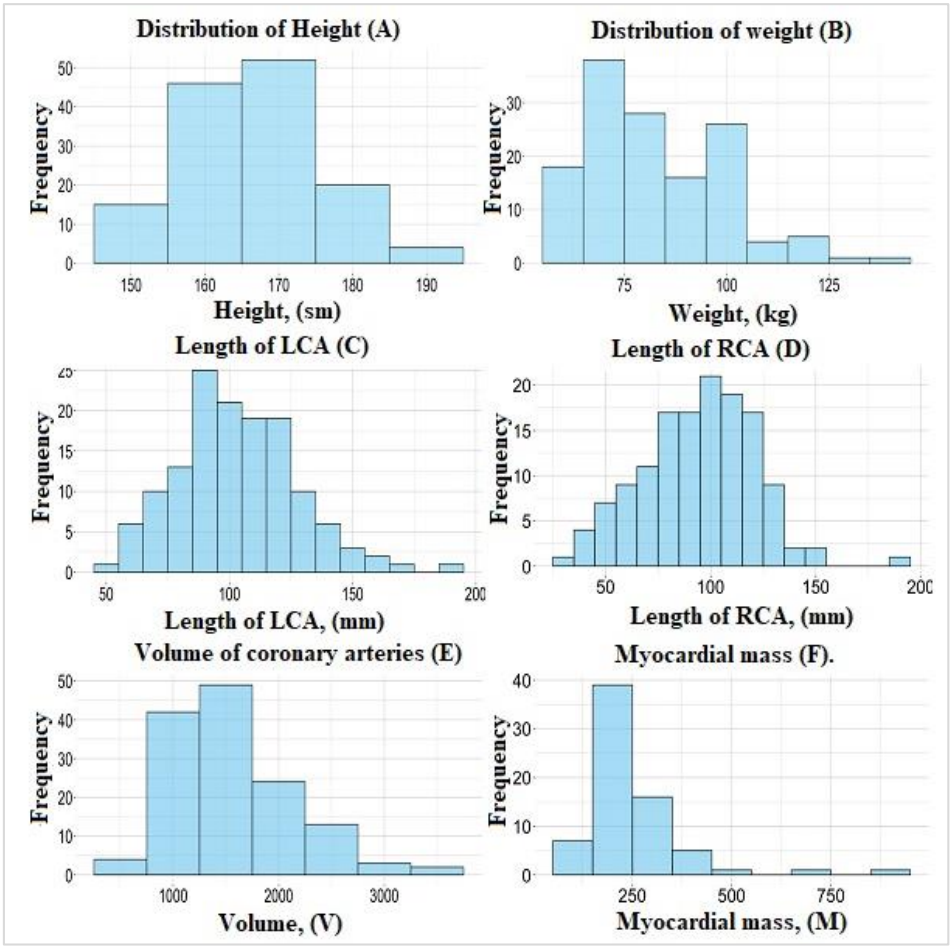

Figure 1. Distribution of Height (Figure 1A), weight (Figure 1B), length of Left Coronary Artery (LCA) (Figure 1C) and Right Coronary Artery (RCA) (Figure 1D), volume of coronary arteries (V) (Figure 1E), myocardial mass (M) (Figure 1F).

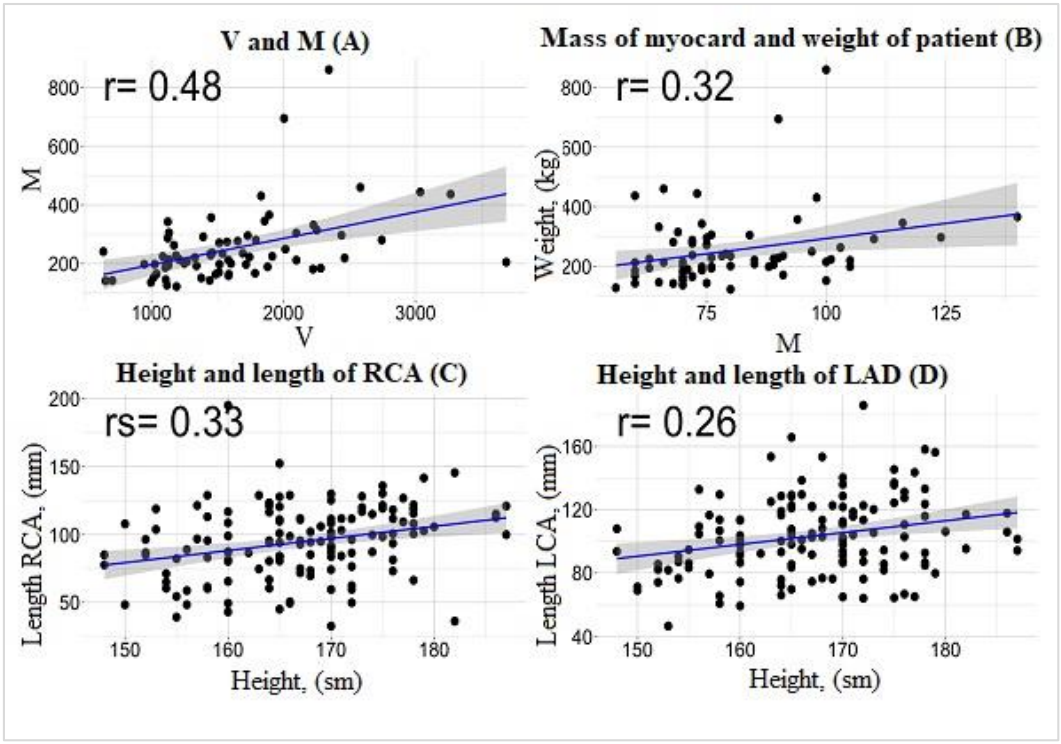

Figure 2. Correlation between volume of coronary artery (V) and mass of myocard (M) (Figure 2A), mass of myocard and weight of patient (Figure 2B), height and length of right coronary artery (RCA) (Figure 2C) and height and length of left coronary artery (LCA) (Figure 2D). Trends line and Pearson's (Figure 2A, 2B, 2C) and Spearman's (Figure 2D) correlation coefficient.

provides a crucial framework for understanding the relationship between coronary anatomy and cardiac function. Our finding of a moderate correlation between coronary volume and myocardial mass confirms that this relationship holds true in our specific population, indicating a statistically significant and non-random dependence despite the sample size.

An intriguing result of our study is that the mean absolute values for coronary artery volume (1585 ± 564 mm³), length (102.0 ± 25.4 mm), and diameter (2.87 ± 0.75 mm) were lower than those reported in similar studies on other populations (diameter (mean±SD) of the left main coronary was 3.5±0.8 mm and the length 105.0±53.0 mm) [11]. This discrepancy may be related to the unique ethnic and geographical characteristics of the Kazakhstani population, a factor that warrants further investigation in larger, multi-ethnic studies. Furthermore, the correlation we observed between patient height and coronary artery length is consistent with the established principles of allometric scaling described in the literature [1, 12], reinforcing the idea that overall body size is a key determinant of vascular anatomy.

In contrast, the lack of a significant association between coronary artery dimensions and BMI or BSA is notable. This may be because these composite indices do not fully capture key aspects of body composition, such as lean muscle mass volume or specific fat distribution patterns [13]. Our results also showed a weak correlation between myocardial mass and body weight. This weak association could be attributed to the influence of obesity, where increased body size is not necessarily accompanied by a proportional, functional increase in heart mass and coronary artery dimensions. This mismatch can place additional strain on the cardiovascular system, potentially exacerbating the course of IHD.

This leads to a discussion of the complex "obesity paradox," where patients with overweight and obesity often present with more pronounced clinical manifestations of IHD, leading to more frequent hospitalization and higher detection rates. While this may seem contradictory, one explanation is that obesity not only increases the risk of IHD but also makes its symptoms more apparent, potentially promoting earlier diagnosis and intervention [14, 15]. Consequently, current statistics on the impact of obesity on CAD might be incomplete or distorted if they fail to account for underlying anatomical variations. Our study emphasizes the importance of considering precise anthropometric parameters beyond BMI to achieve a more accurate assessment of the relationship between body size and CAD.

Collectively, our findings argue for the development of a more nuanced "coronary body index" that integrates coronary artery volume, myocardial mass, cardiac output, and key anthropometric data (e.g., height). Such an index could refine risk stratification, answer questions about coronary insufficiency in patients without overt IHD, and ultimately inform more personalized treatment tactics, improve diagnostic algorithms, and enhance long-term survival outcomes [16].

Study Uniqueness and Clinical Significance

Our study is among the first to investigate the relationship between coronary artery dimensions and anthropometric indicators in a population from Kazakhstan. This is particularly important given the region's ethnic diversity and specific climatic conditions, which may influence cardiovascular physiology. The data obtained can be used to develop more accurate, population-specific diagnostic criteria for identifying patients at increased risk of ischemia, fostering a personalized approach to CAD treatment that considers not only the degree of stenosis but also the patient's unique coronary anatomy.

Limitations

Several limitations of our study must be acknowledged. First, the assessment of coronary parameters was based on 2D invasive coronary angiography (D-CAG). While widely available, this method is susceptible to projection distortions, which can lead to an underestimation or overestimation of artery length and diameter [17, 18]. Future studies would benefit from employing 3D imaging techniques, such as CT coronary angiography, for more precise anatomical reconstruction.

Second, myocardial mass was estimated using echocardiography, a method known to potentially underestimate values by 10–30% compared to the gold standard of cardiac MRI [19]. This inaccuracy may have affected the strength of the correlation we observed between myocardial mass and body weight.

Finally, the measurements were conducted without controlling for the administration of nitrates, which can cause vasodilation and temporarily alter coronary artery diameter, potentially leading to an underestimation of their true size. The inclusion of patients with various stages of coronary atherosclerosis might have also influenced the results, as plaque burden can distort native anatomical parameters.

Conclusions

Our study confirms the fundamental allometric principle of a positive correlation between coronary artery volume and myocardial mass in a specific population of Kazakhstan. These findings underscore the potential clinical value of developing a personalized "coronary body index" that integrates coronary anatomy, myocardial mass, and key anthropometric data. Such an index could refine diagnostic accuracy, improve risk stratification for ischemia, and inform more tailored treatment strategies for patients with coronary artery disease. Despite limitations related to 2D angiographic measurements and echocardiographic mass estimation, this study provides a foundational insight into the anatomical relationships of the coronary system in the Kazakhstani population. Future research utilizing advanced 3D imaging and larger, multi-ethnic cohorts is essential to validate these findings and explore the impact of ethnic and geographical factors on coronary anatomy, ultimately working towards more personalized and effective cardiovascular care.

Conflict of interest: *The authors declare that they have no conflicts of interest.*

Contribution of the authors: *Each of the authors made an equal contribution.*

Funding: *This research has not been funded.*

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