Biometric Analysis of Healthy Coronary Arteries in a Chilean Population: An Angiographic Study

Análisis Biométrico de Arterias Coronarias Sanas en Población Chilena: Un Estudio Angiográfico

Francisco Pérez-Rojas1,2; José A. Vega2; Karla Gambeta-Tessini2; Ricardo Puebla-Wuth5; Eduardo F. Olavarriá-Solís6; Patricio Maragaño-Lizama6 & Enrique Olave7

SUMMARY: Thorough knowledge and understanding of coronary arteries and their anatomy is essential when performing cardiac surgery such as a coronary bypass. Coronary angiography is a minimally invasive method used to evaluate the anatomy and obtain different measurements of the coronary arteries. This study was designed to evaluate the endoluminal diameter, trunk length and anatomical distribution of coronary arteries in Chilean subjects without apparent angiographic lesions. Measurements were carried out by 3 trained examiners using Leonardo® software program in 238 Chilean subjects of both sexes with an age-range of 45 to 78 years. Ostium and the distal luminal segments diameters were measured, as well as trunk length of both right and left coronary arteries. Ostium of the anterior interventricular artery, dominance and tortuosity were also registered. In the right coronary artery, the diameters (3.8 ± 1.2 mm and 3.6 ± 1.0 mm) differed according to sex and dominance, and the length (35.2 ± 12.5 mm) differed according to age. In the left coronary artery, the diameters (4.9 ± 1.1 mm and 4.7 ± 1.0 mm) were greater in males than in females. The left coronary artery showed greater diameters and length than the right coronary artery. The prevalence of right arterial dominance was 88.0 %. Patients with right arterial dominance presented greater distal caliber in the right coronary artery than those with left arterial dominance (p<0.05), especially in older patients. Significant arterial tortuosity was observed in seven subjects.

KEY WORDS: Angiography; coronary arteries; biometry; Chilean population.

INTRODUCTION

Globally, coronary heart disease is one of the most common causes of premature death (GBD 2015 Eastern Mediterranean Region Cardiovascular Disease Collaborators, 2018). The disease also has a significant impact in developing countries (Zhu et al., 2015). In Chile’s Maule Region, located in the central area of the country, mortality rates due to coronary heart disease were 10 points higher in comparison than the national average (51.8 x 100,000) and (41.7 x 100,000) respectively (Ministerio de Salud, 2018). This unique disparity with the rest of the country has not been researched, although specific aspects of coronary artery anatomy may play a role.

Information about the morphology, length and lumen diameters in normal healthy coronary arteries is scarce. Nevertheless, thorough knowledge and understanding of these parameters is critical. Indeed, coronary artery dimensions may vary based on sex, age, and ethnicity as well as body surface area and body weight (Leung et al., 1991; Dodge et al., 1992). Thus, interventional cardiac procedures and factors adjusted for age, sex, body surface area and ethnicity, in small populations as is the case of this study, may be useful for comparison with other populations. (Skowronski et al., 2018). In recent years, the biometric characteristics of coronary arteries in particular countries or ethnic groups, have been studied and compared with other populations i.e. India, Turkey or Iraq (Shukri et al., 2014; Turamanlar et al., 2016; Özdemir & Sökmen, 2020). However, to our knowledge there are no studies regarding normal anatomical characteristics of coronary arteries in the Chilean population.

1 Facultad de Ciencias de la Salud, Universidad Autónoma de Chile, Talca, Chile.
2 Departamento de Morfología y Biología Celular, Grupo SINPOS, Universidad de Oviedo, Spain.
3 Magister en Ciencias, Mención Morfología, Universidad de La Frontera, Temuco, Chile.
4 Departamento de Rehabilitación Bucomaxilofacial, Escuela de Odontología, Universidad de Talca, Talca, Chile.
5 Facultad de Educación, Escuela de Postgrado, Universidad Mayor, Temuco, Chile.
6 Departamento de Hemodinamia, Hospital Regional de Talca, Talca, Chile.
7 Facultad de Medicina, Universidad de la Frontera, Temuco, Chile.
Currently, coronary angiography (CA) is considered the gold standard and an essential technique to evaluate these arteries, despite the potential risks such as ionizing radiation, invasiveness and a small associated risk of morbidity (Wielopolski et al., 2000). On the other hand, since visual estimation of arterial stenosis may vary between operators, automated measurement systems have been introduced. In a recent study Sen et al. (2018), analyzed both inter-observer variability and consistency between operator estimation and quantitative coronary analysis measurements. They concluded that visual assessment may overestimate a coronary lesion and thus lead to unnecessary interventions. Therefore, automated systems have been developed to accurately evaluate normal and pathologic morphology in coronary arteries and avert needless procedures.

The present study was designed to evaluate length and endoluminal diameter of selected segments of coronary arteries and their main branches. The analysis was carried out in a sample of Chilean subjects without coronary angiographic lesions, residing in an area with high rates of coronary disease. It is proposed that the study may serve as a baseline for comparison with other populations, and establish clinical standards for procedures in accordance with the characteristics of local patients.

MATERIAL AND METHOD

This is a retrospective clinical study in a sample of 402 patients who were referred to the hospital with symptoms of coronary heart disease, between 2015 and 2018. Subjects underwent coronary angiography at the Haemodynamic Unit of the Regional Hospital in Talca, Chile. Diagnosis revealed no significant angiographic lesions. This research was approved by the Ethics Committee on Human Research of the Maule Health Service, Chile (2018).

Respecting their anonymity, baseline clinical status of patients, socio demographic information and other data were obtained for participating subjects. Clinical records were retrieved from the Talca Regional Hospital through FileMaker Pro Advanced 8.5v2 pProgram® for Windows. The selection of patients did not consider co-morbidity. The inclusion criteria were as follows: subjects without significant angiographic lesions, angiographic projections not exceeding 3° of dispersion in the angulation, and imaging examination always performed by the same operator. The exclusion criteria were those proposed by Leung et al. After applying inclusion and exclusion criteria the final sample consisted of 238 patients.

Selection of images and Measurement: The measurements on left coronary artery were carried out in a 45° left/25° caudal projection (Spider). Since measurements were concentrated in the proximal portion of the trunk, measurements for the right coronary artery were in a 45° left/0° projection.

Clinical Procedure: Coronary artery images were captured with an angiograph Axiom Artis® (Siemens AG, München, Germany) following Seldinger's radial access technique (Seldinger, 1953; Campeau, 1989). Data were collected in IMA format, and the images analyzed with Leonardo® program (Siemens, München, Germany) (U. S. Food & Drug Administration, 2020).

Parameters for measurement design. The following parameters were considered:

a) demographic variables, sex and age of patients.
b) Coronary dominance is defined as the emerging side of posterior interventricular branch and is classified as, a) right dominance, b) left dominance and c) co-dominance (Saikrishna et al., 2006);
c) Coronary artery tortuosity is classified as normal and sinuous. Sinuosity was identified by presence of three or more folds (defined as a change of 45° in the direction of the vessel) along the main trunk, of at least one coronary artery (Davutoglu et al., 2013);
d) Internal diameter of the vessels was measured using a 6 French catheter.
e) Biometric analysis that includes three measurement for right coronary artery (RCA) and four measurements for left coronary artery (LCA) at different points in the coronary arteries (Fig. 1a). At RCA the following measurements were performed: e.1) ostium diameter (R1): endoluminal diameter (mm) of the emerging point of the coronary artery; e.2) arterial trunk length (R2): distance (mm) between the ostium of the artery and the emerging point of the first marginal artery; e.3) end-trunk diameter (R3): endoluminal diameter (mm) of the end segment of the trunk just before the emerging point of the first marginal artery. At LRA the measurements were: e.4) ostium diameter (L1): endoluminal diameter (mm) of at the emerging point of the artery; e.5) artery trunk length (L2): distance (mm) between the artery ostium and bifurcation; e.6) end-trunk diameter (L3): endoluminal diameter (mm) of the final segment of the common LCA; e.7) diameter of the anterior interventricular artery (L4): endoluminal diameter (mm) estimated at 2 mm distal to its emerging point.
Angiographic images meeting the pre-established inclusion and exclusion criteria were used for calibration, and results obtained by an expert were considered as reference values. Reliability of biometric analyses was calculated for inter- and intra-examiner values using infraclass correlations (ICC) giving an average value of 98.0 %.

Thereafter, a descriptive analysis of the sample obtained was performed according to sex, age (over 61 years and under 62 years) and dominance (right: left, excluding the codominance of bivariate analysis, since it occurred in two subjects only). Central trend and dispersion measures were obtained from all measurements.

**Statistical analysis.** To compare the average measurements t-test were performed for independent samples, and Mann-Whitney U test, selected according to the normality obtained in the data distribution. Wilcoxon signed rank (W) test was used to compare paired samples. Furthermore, the ostium diameters and end-trunk diameter of both arteries were related visually related by point graph and statistically by Pearson correlation test. Values of p ≤ 0.05 were considered as significant.

**RESULTS**

A total of 402 subjects were initially recorded, however 162 patients were excluded for not meeting the inclusion criteria, and 2 were excluded for showing statistically extreme values. Therefore, the final number of subjects studied was 238 individuals. Figures 1b to 1f illustrate several cases in which measurement points chosen in the Leonardo ® program are identified. Most of the patients were male (55.9 %; n =133), under 62 years of age (51.7 %; n =123) and in nearly 90 % (n = 211) of cases there was right dominance (Table I).

For right coronary arteries (Table I) the average value at R1 was 3.8 mm (SD 1.2). Moreover, statistically significant differences were observed between sexes, with higher average values in males (3.9 mm vs 3.5 mm; U = 5243; p = 0.001). For the right trunk length (R2) average value was 35.2 mm (SD 12.5) and showed statistically significant differences between age groups: values from younger subjects were higher than subjects over 62 years (36.9 mm vs 33.3 mm); t (236) -2.23; p = 0.03). The end-trunk diameter (R3) averaged 3.6 mm (SD 1.0) showing statistically significant differences by sex and dominance. Males had a thicker caliber relative to women (3.7 mm vs 3.3 mm; U = 5125, p = 0.001), and subjects with right dominance showed a higher diameter than those with left dominance (3.6 mm vs 3.1 mm; U = 1827, p = 0.01) (Table I).

**Fig. 1.** (A) Coronary angiography scheme showing the measurement points chosen (R: right, L: left) AIA: anterior interventricular artery. CA: circumflex artery, LCA: left coronary artery, RCA: right coronary artery. (B) Measurement in RCA, the right marginal branch (main) is observed originates in the middle third of the right coronary artery right at the measurement endpoint. There are also some marginal vessels that emerge from the main trunk regarded as minor marginals vessels. (C) Measurements in right coronary artery (45°/0°) at R1, R2 and R3. The absence of minor marginal branches makes measurement easier (end-to-end pointed lines define arterial trunk length). (D) Measurement at L1 in a left coronary artery with a slight angulation deviation (note the visibly decreased gauges). (E) Measurement at L3, where the pointed line is observed to detect a diameter of 5.46 mm. (F) Measurement at L4. Note that there is a distance of 1.99 mm to detect the measuring point. In some cases, the exact distance 2 mm from the start of the anterior ventricular branch cannot be obtained. The discontinuous line shows a diameter of 2.35 mm.
For left coronary arteries, ostium diameter (L1) indicated an average value of 4.9 mm (SD 1.1) with statistically significant differences (U = 5631, p = 0.01) between male (5.1 mm; SD 1.1) and female (4.7 mm; DS 0.9). Length of the arterial trunk (L2) and lumen at the end of the trunk (L3) showed on average, values of 7.9 mm (SD 3.1) and 4.7 mm (SD 1.0), respectively. Lumen diameter at the end-trunk of the artery (L3) was 4.7 mm, and statistically significant differences were observed between for sex (4.9 mm in male vs 4.5 mm in female; U = 5551, p = 0.007). The same was true for the diameter of the anterior interventricular artery (L4) which had an average value of 3.4 mm (SD 0.8) in males and 3.2 mm (SD 0.8) in females (U = 5355, p = 0.003), with an average values of 3.3 mm (SD 0.8) (Table I).

Regarding tortuosity factor, 7 subjects were considered sinuous, and the average values of end-trunk diameters statistically differed between right and left arteries (3.6 vs 4.7; W = 11.23; p < 0.001) (Table I). Figure 2a shows the scatter plot between the left and right ostium, showing a positive and statistically significant linear relationship (r = 0.21; p = 0.001). Finally, the diameter of the ending of both arteries showed positive and statistically significant relationship (r = 0.21; p = 0.001; Fig. 2b).

For left coronary arteries, ostium diameter (L1) indicated an average value of 4.9 mm (SD 1.1) with statistically significant differences (U = 5631, p = 0.01) between male (5.1 mm; SD 1.1) and female (4.7 mm; DS 0.9). Length of the arterial trunk (L2) and lumen at the end of the trunk (L3) showed on average, values of 7.9 mm (SD 3.1) and 4.7 mm (SD 1.0), respectively. Lumen diameter at the end-trunk of the artery (L3) was 4.7 mm, and statistically significant differences were observed between for sex (4.9 mm in male vs 4.5 mm in female; U = 5551, p = 0.007). The same was true for the diameter of the anterior interventricular artery (L4) which had an average value of 3.4 mm (SD 0.8) in males and 3.2 mm (SD 0.8) in females (U = 5355, p = 0.003), with an average values of 3.3 mm (SD 0.8) (Table I).

Regarding tortuosity factor, 7 subjects were considered sinuous, and the average values of end-trunk diameters statistically differed between right and left arteries (3.6 vs 4.7; W = 11.23; p < 0.001) (Table I). Figure 2a shows the scatter plot between the left and right ostium, showing a positive and statistically significant linear relationship (r = 0.21; p = 0.001). Finally, the diameter of the ending of both arteries showed positive and statistically significant relationship (r = 0.21; p = 0.001; Fig. 2b).

DISCUSSION

A retrospective imaging study was conducted through coronary angiography, using Seldinger’s radial technique in a sample of 238 patients that meet the inclusion and exclusion criteria. To our knowledge no similar studies have been carried out locally in a Chilean population. The size of the sample and internal characteristics of the group (age and sex distribution) give rise for comparison of these results with previous studies. These may be considered...
showed an average caliber at end-trunk greater than those respectively. Interestingly, subjects with right dominance (Vasheghani-Farahani et al., 2008; He et al., 2017). These studies demonstrate significantly reduced caliber of the left main trunk, anterior ventricular branch, circumflex branch and right trunk in Asian-Indian subjects compared to the North American Caucasian population (Makaryus et al., 2005).

The present study shows that there is a significant difference (p = 0.001) for average caliber between the right and left coronary trunks (3.6 mm and 4.7 mm, respectively). These results coincide with Vieweg et al. (1976), in reference to normal measurement values of human coronary arteries. Our results on the other hand, are in contrast with data reported by Latarjet & Ruiz Liard (2006) who considered the average coronary trunk diameter similar to (3 to 4 mm). It should be noted however, that they did not take into consideration demographic factors. For instance, ethnicity, dominance, tortuosity or cardiovascular risk, all of which can influence the biometric values of coronary arteries (Makaryus et al.; Vasheghani-Farahani et al., 2008).

An interesting finding in our study was that the endoluminal measurement of both coronary arteries varies parallelly. To our knowledge, this observation is being reported for the first time. Further studies are necessary to elucidate the relevance of these findings. Also, ostium caliber for the right and left coronary arteries, end-trunks’ caliber in both coronary arteries, and the anterior interventricular branch were significantly higher in males. This lends support to the studies by Vaccarino et al. (1995) and Shukri et al. that report significantly smaller dimensions in women compared to men.

In their study Özdemir & Sökmen (2020) contradict the general belief that women have narrower coronary arteries than men. Though this may be the result of ungrouped data from various ethnic populations, and the evidence presented involving scarce number of studies that compare white and Asian-Indian subjects. It is worthwhile mentioning the limitation between the various ethnic population comparison studies, since they use different measurement points in each arterial branch.

With respect to coronary dominance 88.0 % displayed right dominance, 11 % left dominance 11.0 % and 1.0 % co-dominance similarly to Vasheghani-Farahani et al. who found values of 84.2 %, 10.9 % and 4.8 %, respectively. Interestingly, subjects with right dominance showed an average caliber at end-trunk greater than those with left dominance. It has also been reported that the ending lumen of the left coronary trunk and the anterior interventricular branch are not affected by dominance (Dodge et al.; Vasheghani-Farahani et al.).

Right trunk length was significantly longer (3.6 mm) in younger subjects, suggesting that the length of the trunk of the RCA decreases with age. Nevertheless, the length of the left arterial trunk did not change in relation to sex, age or dominance. Since it was present in 3.0 % of subjects in the sample, we consider that tortuosity should be analyzed during future evaluations. Furthermore, 42 subjects were excluded from this study because they presented tortuosity that interfered with the measurement.

As noted by Zhu et al., coronary heart disease, has become a primary health concern for the world population in recent decades. Thorough knowledge of the dimensions of the coronary arteries in patients is critical, especially during coronary interventions such as stent placement, sizing of endoprosthesis or decisions regarding these procedures (Manjappa et al., 2016). The endoluminal diameter is an important predictor of the results, following coronary artery bypass graft surgery (CABG) and for percutaneous coronary intervention (PCI). Undoubtedly, dominance is an important factor for surgeons and radiologists, and should be considered prior to any such interventions. It is noteworthy that a dominant left coronary artery is associated with worse outcome and prognosis following extensive myocardial infarction (STEMI) when compared to right dominance or a balanced system (He et al.; Veltman et al., 2014).

As in Davutoglu et al., it has been proposed that recording coronary tortuosity for follow-up studies is an important variable to consider. Coronary tortuosity has been shown to be associated with subclinical atherosclerosis even in normal coronary angiography, and could also be an indicator of systemic tortuosity of the retinal artery. Moreover, it is a factor that makes measurements difficult for this type of biometric study. Coronary tortuosity is generally not recorded during coronary angiography procedures.

Since variations exist in populations between different countries, this study is an important means to accurately determine population measurements. This research presents several working lines that may be applied in clinical studies of systemic tortuosity. These may include comorbidities, study of the circumflex branch or other branches, incorporating additional angiographic projections to choose different points of the coronary arteries and population comparisons among others.
RESUMEN: Un factor clave durante los procedimientos quirúrgicos cardíacos tal como el bypass coronario, es el conocimiento exhaustivo de las arterias coronarias y su anatomía. La angiografía coronaria es un método mínimamente invasivo que se utiliza para evaluar la anatomía y obtener diferentes medidas. El presente estudio fue diseñado para evaluar el diámetro endoluminal, la longitud del tronco y la distribución anatómica de las arterias coronarias en sujetos chilenos. Se midieron los ostios y los diámetros luminales distales de los troncos coronarios derecha e izquierda, así como también las longitudes del tronco de las arterias coronarias derecha e izquierda. Además, se identificaron los ostios de la arteria interventricular anterior, dominancia y tortuosidad. En la arteria coronaria derecha, los diámetros (3.8 ± 1.2 mm y 3.6 ± 1.0 mm) se observaron variaciones según el sexo y la dominancia, y la longitud (35.2 ± 12.5 mm) difirió según la edad. En la arteria coronaria izquierda, los diámetros (4.9 ± 1.1 mm y 4.7 ± 1.0 mm) fueron mayores en los hombres que en las mujeres. La arteria coronaria izquierda mostró mayor diámetro y longitud que la arteria coronaria derecha. La prevalencia de dominancia arterial derecha fue del 88.0 %. Los pacientes con dominancia arterial derecha presentaron mayor calibre distal en la arteria coronaria derecha que aquellos con dominancia arterial izquierda (p < 0.05), especialmente en pacientes mayores. En siete sujetos se observó una tortuosidad arterial significativa.

PALABRAS CLAVE Arterias Coronarias, Angiografía; Biometría; Población chilena.

REFERENCES

Campeau, L. Percutaneous radial artery approach for coronary angiography. Catheter. Cardiovasc. Diagn., 10(1):3-7, 1989.
Davutoglu, V.; Dogan, A.; Okumus, S.; Demir, T.; Tatar, G.; Gurler, B.; Erkan, S.; Sari, I.; Alici, H. & Altunbas, G. Coronary artery tortuosity: comparison with retinal arteries and carotid intima-media thickness. Kardiol. Pol., 71(11):1121-8, 2013.
Dodge, J. T. Jr.; Brown, B. G.; Bolson, E. L. & Dodge, H. T. Lumen diameter of normal human coronary arteries. Influence of age, sex, anatomic variation, and left ventricular hypertrophy or dilatation. Circulation, 86(1):232-46, 1992.

GBD 2015 Eastern Mediterranean Region Cardiovascular Disease Collaborators. Burden of cardiovascular diseases in the Eastern Mediterranean Region, 1990-2015: findings from the Global Burden of Disease 2015 study. Int. J. Public Health, 63(Suppl. 1):1-77, 2018.
He, C.; Ma, Y. L.; Wang, C. S.; Song, Y.; Tang, X. F.; Zhao, X. Y.; Gao, R. L.; Yuan, Y. J.; Xu, B. & Yuan, J. Q. Effects of coronary dominance on 2-year outcomes after percutaneous coronary intervention in patients with acute coronary syndrome. Catheter. Cardiovasc. Interv., 89(1):54-60, 2017.
Latarjet, M. & Ruiz Liard, A. Anatomía Humana. 4ª ed. Buenos Aires, Médica Panamericana, 2006.
Leung, W. H.; Stadius, M. L. & Alderman, E. L. Determinants of normal coronary artery dimensions in humans. Circulation, 84(6):1294-1306, 1991.
Makaryus, A. N.; Dhamma, B.; Raince, J.; Raince, A.; Garayali, S.; Labana, S. S.; Kaplan, B. M.; Park, C. & Jauhar R. Coronary artery diameter as a risk factor for acute coronary syndromes in Asian-Indians. Am. J. Cardiol., 96(6):778-80, 2005.
Manjappa, M.; Hegde, M. & Math, R. Normal proximal coronary artery diameters in adults from India as assessed by computed tomography angiography. J. Clin. Diagn. Res., 10(5):10-3, 2016.
Ministerio de Salud (MINSA). DEIS. Defunciones y Mortalidad por Causas. Santiago de Chile, Ministerio de Salud, Gobierno de Chile, 2018. Available from: http://www.deis.cl/defunciones-y-mortalidad-por-causas/ Ozdemir, L. & Sökmen, E. Normal coronary diameters in Turkish population. Turk Cerrahisi J., 28(1):188-193, 2013.
Raut, B. K.; Patil, V. N. & Cherian, G. Coronary artery diameters in normal Indians. Indian Heart J., 69(4):512-4, 2017.
Saikrishna, C.; Talwar, S.; Gulati, G. & Kumar, A. S. Normal coronary artery diameters in Indians. J. Thorac. Cardiovasc. Surg., 22(5):159-64, 2006.
Seldinger, S. Catheter replacement of the needle in percutaneous arteriography: a new technique. Acta Radiol., 39(5):368-76, 1953.
Sen, T.; Kilit, C.; Astarcıoğlu, M. A.; Asarcıklı, L. D.; Aksu, T.; Kafes, H.; Paşpar, A.; Gozعبayık, G. & Amasyali, B. Comparison of quantitative and qualitative coronary angiography: computer versus the eye. Cardiovasc. J. Afr., 29(5):278-82, 2018.
Shukri, I. G.; Hawas, J. M.; Karim, S. H. & Ali, I. Angiographic study of the normal coronary artery in patients attending ulaimani center for heart diseases. Eur. Sci. J., 10(4):384-415, 2014.
Skowronski, J.; Pregowski, J.; Mintz, G. S.; Kruk, M.; Kępka, C.; Tyczynski, P.; Michalowska, I.; Kalinczuk, L.; Opolski, M. P.; Ciszewski, M.; et al. Measurements of lumen areas and diameters of proximal and middle coronary artery segments in subjects without coronary atherosclerosis. Am. J. Cardiol., 121(8):917-23, 2018.
Turanmlar, O.; Adali, F.; Beker Acay, M.; Horata, E.; Tor, O.; Macar, O.; Kesö, H.; Keskin, H. & Abbasoglu, Y. Angiographic analysis of normal coronary artery lumen diameter in a Turkish population. Anatomy, 10(2):99-104, 2016.
U. S. Food & Drug Administration. Class 2 Device Recall Leonardo. Workstation. Website. Silver Spring, U.S. Food & Drug Administration, U. S. Department of Health & Human Service, 2020. Available from: https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfdocs.cfm?id=67280
Vaccarino, V.; Krumholz, H. M.; Berkman, L. F. & Horwitz, R. I. Sex differences in mortality after myocardial infarction. Is there evidence for an increased risk for women? Circulation, 91(6):1861-71, 1995.
Vasheghani-Farahani, A.; Kassaian, S. E.; Yaminisharif, A.; Davoodi, G.; Salari, M.; Amizadegan, A. & Hakki, E. The association between coronary arterial dominance and exterior of coronary artery disease in angiography and paraclinical studies. Clin. Anat., 21(6):519-23, 2008.
Veltman, C.; Hoogsag, G.; Kharbanda, R.; Graaf, M. A.; Zwet, E. W.; Hoeven, B. L. & Scholte, A. J. Relation between coronary arterial dominance and left ventricular ejection fraction after ST-segment elevation acute myocardial infarction in patients having percutaneous coronary intervention. Am. J. Cardiol., 114(11):1646-50, 2014.
Vieweg, W. V.; Alpert, J. S. & Hagan, A. D. Caliber and distribution of normal coronary arterial anatomy. Catheter. Cardiovasc. Diagn., 2(3):269-90, 1976.
Wielopolski, P.A.; van Geuns, R.J.; de Feyter, P.J. & Oudkerk, M. Coronary dimensions in humans. Catheter. Cardiovasc. Diagn., 2(3):137-49, 1992.
Zhu, K. F.; Wang, Y. M.; Zhu, J. Z.; Zhou, Q. Y. & Wang, N. F. National coronary diameters in adult Chinese. Eur. Sci. J., 10(24):384-415, 2014.

Corresponding author: Francisco Pérez Rojas Facultad de Ciencias de la Salud Universidad Autónoma de Chile Talca - CHILE

Email: fperrez@uautonoma.cl

Received: 27-05-2020
Accepted: 10-08-2020