

Arterial Tortuosity and Its Clinical Impact Assessed Through Medical Imaging: A Systematic Review

Tortuosidad Arterial y Su Impacto Clínico Evaluado Mediante Imágenes Médicas: Una Revisión Sistemática

Francisco Pérez-Rojas¹; Juan José Cabezas¹ & José A. Vega^{2,3}

PÉREZ-ROJAS, F.; CABEZAS, J. J. & VEGA, J. A. Arterial tortuosity and its clinical impact assessed through medical imaging: A systematic review. *Int. J. Morphol.*, 43(5):1779-1784, 2025.

SUMMARY: Arterial tortuosity is a morphological variation characterized by abnormal curvatures, twists, or elongations along the course of arteries, with potential clinical implications due to its impact on hemodynamics and tissue perfusion. Although in some cases it may be considered a benign anatomical variant, multiple studies associate arterial tortuosity with cardiovascular, neurological, and microvascular diseases. The aim of this study was to systematically review and update the scientific evidence on the clinical impact of arterial tortuosity, as assessed through medical imaging, and to analyze the structural and functional mechanisms that may explain its association with cardiovascular risk factors. A systematic search was conducted in PubMed, Scopus, and Web of Science up to February 2025, following PRISMA guidelines. A total of 42 studies met the inclusion criteria. The vascular territories most frequently evaluated were coronary, cerebral, femoral, and retinal arteries, and the imaging techniques included conventional and CT angiography, MR angiography, Doppler ultrasound, and digital fundus photography. Significant associations were found between arterial tortuosity and systemic hypertension, non-obstructive coronary artery disease, ischemic cerebrovascular events, intermittent claudication, and diabetic or hypertensive retinopathies. In addition, a growing use of artificial intelligence-based strategies for the automated detection and quantification of arterial tortuosity was observed. Taken together, these findings highlight the clinical relevance of arterial tortuosity and underscore the urgent need to establish standardized criteria for its measurement, classification, and longitudinal follow-up, in order to integrate tortuosity into diagnostic and prognostic algorithms in vascular medicine.

KEY WORDS: Arterial tortuosity; Coronary arteries; Vascular imaging; Hemodynamics; Cerebral Arteries; Femoral Artery; Artificial intelligence.

INTRODUCTION

The morphology of blood vessels, particularly arteries, plays a key role in cardiovascular physiology. In some individuals, arteries display abnormal curvatures, elongations, or winding courses that are collectively referred to as arterial tortuosity (AT). These irregularities may compromise blood flow dynamics and tissue perfusion. While AT may be regarded as a benign anatomical variant in certain cases, excessive tortuosity can reflect or contribute to underlying pathological processes. AT has been documented in multiple vascular territories, including coronary, cerebral, retinal, and femoral arteries, and its association with systemic hypertension, atherosclerosis, ischemic events, and retinopathies is increasingly recognized (Luta *et al.*, 2024).

The growing interest in AT is closely linked to advances in vascular imaging and image analysis. High-resolution techniques such as conventional and CT angiography, MR angiography, Doppler ultrasound, and digital fundus photography allow a more precise characterization of arterial geometry. This progress has been reinforced by the development of computational and artificial intelligence (AI) tools that enable objective and automated quantification of tortuosity. For example, Cobo *et al.* (2023) demonstrated that deep learning models can detect coronary tortuosity with high accuracy in conventional angiographic images, opening the possibility for large-scale, reproducible, and clinically useful analyses. In the context of coronary heart disease, which remains one of the leading causes of death

¹ Facultad de Medicina, Departamento Ciencias Preclínicas, Universidad Católica del Maule, Chile.

² Departamento de Morfología y Biología Celular, Grupo SINPOS, Universidad de Oviedo, Oviedo, Spain.

³ Facultad de Ciencias de la Salud, Universidad Autónoma de Chile, Región Metropolitana, Chile.

worldwide (National Heart, Lung, and Blood Institute, 2025), it is essential to investigate anatomical determinants such as AT that may influence risk stratification and therapeutic decision-making.

Interest in this topic has also been driven by morphometric studies in specific populations. Pérez-Rojas *et al.* (2020), through an angiographic analysis in Chilean subjects, characterized the normal dimensions of coronary arteries and provided reference parameters essential for interpreting pathological deviations. Likewise, detailed recognition of complex anatomical variants (Adam *et al.*, 2021; Fuenzalida *et al.*, 2024), such as the anomalous origin of the left coronary artery from the right coronary sinus with an interarterial course (Pérez-Rojas *et al.*, 2023), underscores the importance of precise coronary anatomy for avoiding diagnostic errors and therapeutic complications. In more extreme scenarios, such as arterial tortuosity syndrome described by the National Organization for Rare Disorders (NORD, n.d.), generalized vascular alterations are associated with severe systemic manifestations (Ekhtor *et al.*, 2023). Beyond the coronary circulation, AT has also been described in cerebral (Ha *et al.*, 2023) and pulmonary arteries (Alshair *et al.*, 2024), suggesting a potentially systemic vascular phenotype.

Despite the growing body of evidence, several key questions remain unresolved. Increasing data link AT to various vascular diseases, but its independent clinical relevance is not yet fully established. Furthermore, there is no consensus on the definition, classification, or measurement of AT, which hampers comparisons between studies and limits its integration into routine clinical practice. Standardized evaluation of tortuosity could provide additional tools for risk stratification, monitoring chronic vascular disease, and planning surgical or endovascular interventions. Clinical guidelines, such as those published by Erbel *et al.* (2015) for the diagnosis and treatment of aortic disease, explicitly recognize arterial tortuosity as a relevant anatomical factor in both surgical planning and vascular risk assessment. Similarly, the guidelines of the Spanish Society of Arteriosclerosis (Lahoz *et al.*, 2016) on acute aortic syndrome emphasize the importance of assessing structural arterial abnormalities, including AT, in emergency cardiovascular settings.

In this context, the present systematic review aims to synthesize and update the available evidence on the clinical impact of AT in different vascular territories, as assessed exclusively through imaging techniques. Specifically, we sought to address the following question: What is the relationship between AT and clinically relevant conditions, and what structural or hemodynamic mechanisms could explain this association?

MATERIAL AND METHOD

A systematic review was conducted following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The review was not registered in PROSPERO or other databases.

Search Strategy

A comprehensive search of PubMed, Scopus, and Web of Science was performed for studies published up to February 28, 2025. The search strategy combined controlled vocabulary (MeSH/EMTREE) and free-text terms using Boolean operators as follows: (“arterial tortuosity” OR “vascular tortuosity”) AND (“angiography” OR “MRI” OR “CT scan” OR “fundus photography” OR “vascular imaging”). No restrictions were applied regarding geographical region or publication type, except for language (English or Spanish). All references were exported and screened for duplicates.

Study Selection

The selection process was completed in two phases. First, two independent reviewers screened titles and abstracts to identify potentially relevant articles. In the second phase, full-text articles were reviewed to determine eligibility. Discrepancies were resolved by consensus or by consulting a third reviewer. Reasons for exclusion during full-text assessment were documented.

Inclusion and Exclusion Criteria

Inclusion criteria:

- Quantitative or qualitative evaluation of arterial tortuosity in relation to clinical outcomes in coronary, cerebral, femoral, or retinal arteries.
- Observational, retrospective, prospective, cross-sectional, or cohort studies with clear methodological description and appropriate statistical analysis.
- Articles published in English or Spanish.

Exclusion criteria:

- Studies focused exclusively on venous, capillary, or non-arterial vessels.
- Single case reports without statistical analysis.
- Narrative reviews, editorials, and letters to the editor lacking primary data.

Quality Assessment

Methodological quality was evaluated independently

by two reviewers using the QUADAS-2 tool (Whiting *et al.*, 2011). The domains assessed included patient selection, index test, reference standard, and flow/timing. Disagreements were resolved by consensus. No automation tools were used for bias assessment.

RESULTS

A total of 412 records were initially identified across all databases. After removal of duplicates and screening of titles and abstracts, 86 articles were selected for full-text review. Of these, 42 studies met the inclusion criteria and were incorporated into the final synthesis. Inter-reviewer agreement was high (kappa = 0.89).

Vascular Territories.

Among the included studies, coronary arteries were the most frequently analyzed (n=15, 36 %), followed by cerebral arteries (n=10, 24 %), retinal arteries (n=7, 17 %), and femoral arteries (n=5, 12 %). Five additional studies evaluated tortuosity in other arterial territories such as radial, iliac, or systemic arteries, (Fig 1).

Imaging Modalities.

Conventional angiography and CT angiography were the most commonly used techniques (n=17, 40 %), followed by MR angiography (n=11, 26 %), fundus photography (n=8, 19 %), and Doppler ultrasound (n=6, 15%). (Fig 2)

Main Clinical Associations.

Across the included studies, five consistent clinical associations were identified: (Table I)

Table I. Summary of the most consistent clinical associations reported between arterial tortuosity (AT) and pathological conditions across different arterial territories. The table synthesizes the strength of evidence and the nature of association measures reported in the literature, highlighting the systemic and localized vascular implications of AT.

Arterial Territory	Main Clinical Finding	Evidence (No. of Studies)	Association Measure
Retina and Brain	Strong association between AT and systemic hypertension	12 studies	r = 0.67; p < 0.01
Coronary	AT linked to myocardial ischemia in the absence of significant obstruction	≥6 studies	Observational
Cerebral	Increased risk of ischemic stroke	8 studies	Mean OR = 3.2 (95% CI: 2.4–4.1)
Femoral	Intermittent claudication associated with femoral AT in adults over 60 years	4 studies	_ lower limb perfusion
Retinal	AT as an early marker of microvascular damage in diabetes and hypertension	5 studies	Consistent evidence

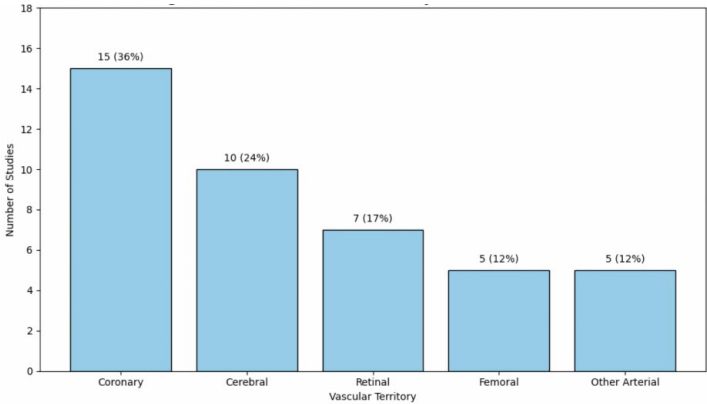


Fig. 1. Distribution of the studies included in the systematic review according to vascular territory. The bar chart illustrates the number and proportion of studies evaluating arterial tortuosity in each vascular territory. Coronary arteries were the most frequently analyzed (n = 15; 36%), followed by cerebral (n = 10; 24 %), retinal (n = 7; 17 %), femoral (n = 5; 12 %), and other arterial territories such as radial or iliac arteries (n = 5; 12 %).

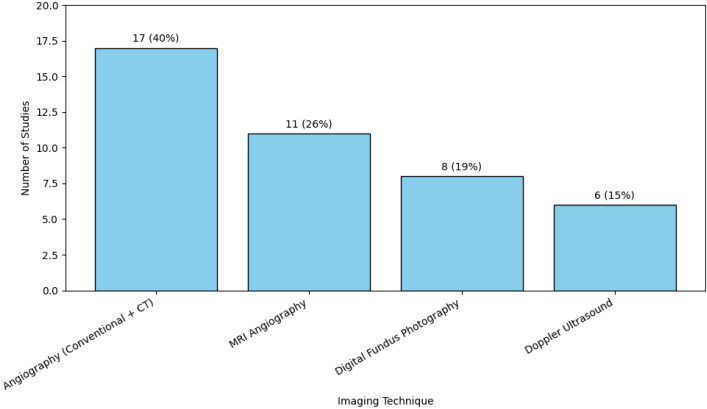


Fig. 2. Distribution of imaging techniques used in the studies included in the systematic review. The bar chart shows the number and percentage of studies employing each imaging modality for the assessment of arterial tortuosity. Conventional and CT angiography were the most frequently used techniques (n = 17; 40 %), followed by MR angiography (n = 11; 26%), digital fundus photography (n = 8; 19 %), and Doppler ultrasound (n = 6; 15 %).

1. Systemic Hypertension: 12 studies demonstrated a strong positive association, particularly in retinal and cerebral territories ($r = 0.67$; $p < 0.01$).
2. Coronary Artery Disease: At least six studies reported that coronary arterial tortuosity was associated with myocardial ischemia in the absence of significant coronary obstruction.
3. Ischemic Stroke: Eight studies found an increased risk of ischemic stroke associated with cerebral arterial tortuosity (mean OR = 3.2; 95 % CI: 2.4–4.1).
4. Intermittent Claudication: Four studies in older adults (>60 years) identified femoral tortuosity as a contributor to impaired lower-limb perfusion.
5. Retinal Microvascular Damage: Five studies identified retinal arterial tortuosity as an early marker of microvascular injury in patients with diabetes or hypertension.

Use of tortuosity indices. Several studies applied quantitative tortuosity indices (e.g., total curvature index, elongation index), and in multiple cases these indices were independent predictors in multivariate models. Overall methodological quality was high, with a minimal risk of bias in QUADAS-2 assessments.

DISCUSSION

The findings of this systematic review confirm that arterial tortuosity (AT) is a clinically relevant anatomical phenomenon with significant pathophysiological implications across multiple vascular territories. Although historically regarded as a benign morphological variant, the evidence synthesized here supports a consistent association between AT and a broad range of cardiovascular, cerebrovascular, and microvascular disorders (Ciurica *et al.*, 2019; Luta *et al.*, 2024).

Clinical Interpretation of Findings

The association between AT and systemic hypertension was among the most consistently reported observations, particularly in retinal and cerebral arteries. Hypertension contributes to arterial wall remodeling, increased stiffness, and altered hemodynamic forces, all of which may promote tortuous vascular geometry (Ciurica *et al.*, 2019; Luta *et al.*, 2024). Conversely, AT itself may modify flow resistance and perfusion pressure, suggesting a bidirectional relationship that warrants further mechanistic investigation.

In the coronary circulation, AT was frequently associated with myocardial ischemia in the absence of significant luminal obstruction. This supports the concept

that vascular geometry may influence coronary blood flow independently of atherosclerotic burden. Such associations have been previously reported in angiographic and clinical studies (Zebic Mihic *et al.*, 2023; Konigstein *et al.*, 2021). Although the present evidence does not justify redefining non-obstructive coronary artery disease, these findings underscore the importance of considering AT during diagnostic evaluation. Moreover, recent advancements in artificial intelligence—such as the deep learning model proposed by Cobo *et al.* (2023)—enable automated and reproducible detection of AT in coronary angiography, offering promising applications in interventional cardiology and risk stratification.

In the cerebral territory, AT demonstrated a notable association with ischemic stroke. Recent work by Ha *et al.* (2023) highlights that tortuosity in perforating or small-caliber arteries may contribute to early neurological deterioration. Plausible mechanisms include altered flow patterns, increased vascular resistance, and reduced cerebrovascular reserve.

Retinal AT, readily assessable through non-invasive imaging, emerged as an early marker of microvascular injury in individuals with hypertension or diabetes. This is consistent with the recognition that the retina reflects systemic microvascular health (Ciurica *et al.*, 2019; Luta *et al.*, 2024). Thus, retinal tortuosity may serve as a practical surrogate indicator of more widespread microvascular pathology.

Although fewer studies evaluated the femoral territory, the available evidence suggests a relationship between femoral AT and peripheral arterial disease, particularly in older adults. Wood *et al.* (2006) demonstrated that femoral artery tortuosity is associated with impaired lower-limb perfusion and intermittent claudication, reinforcing the functional and clinical relevance of this arterial segment.

Methodological Considerations and Limitations

The studies included in this review exhibited substantial heterogeneity in the definition, measurement, and classification of AT, complicating direct comparison across investigations. Such methodological variability has been previously emphasized in the literature on arterial tortuosity and vascular morphology (Ciurica *et al.*, 2019). Furthermore, differences in imaging modalities and computational indices (Brummer *et al.*, 2019) represent additional barriers to standardization.

Most included studies were observational, limiting

causal inference. Publication bias is also possible, as studies reporting positive associations are more likely to be published. Additionally, several investigations did not adjust for important confounders such as age, smoking, diabetes, and dyslipidemia.

Future Directions

Future research should prioritize the development and validation of standardized quantitative indices of arterial tortuosity across multiple vascular territories (Brummer *et al.*, 2019; Zebic Mihic *et al.*, 2023). Prospective longitudinal studies are required to clarify whether AT represents a marker, mediator, or consequence of vascular disease. Integration of artificial intelligence into vascular imaging analysis—as suggested by Cobo *et al.* (2023)—offers promising opportunities for automated detection and risk prediction. Harmonizing imaging protocols and classification systems will be essential to facilitate meta-analyses and strengthen the current evidence base.

Clinical Implications

The synthesis of current evidence indicates that AT should not be regarded as an anatomical curiosity. Rather, it represents a structural marker with potential diagnostic and prognostic value in cardiovascular, neurological, and microvascular medicine. Incorporating AT into clinical evaluation algorithms may enhance risk stratification and guide therapeutic decision-making, particularly in non-obstructive coronary ischemia (Zebic Mihic *et al.*, 2023), stroke prevention (Ha *et al.*, 2023), and microvascular disease assessment (Luta *et al.*, 2024).

CONCLUSIONS

Arterial tortuosity (AT) is a relevant anatomical feature consistently associated with several clinical conditions, particularly systemic hypertension, non-obstructive coronary ischemia, ischemic cerebrovascular events, peripheral arterial disease, and retinal microvascular injury. Its evaluation through imaging techniques allows the recognition of vascular risk patterns and may complement traditional diagnostic and prognostic assessments.

Given the heterogeneity in current definitions and measurement approaches, the development of standardized criteria for the evaluation, classification, and follow-up of AT is essential. Future longitudinal studies are required to clarify whether AT acts as a marker, mediator, or consequence of vascular disease and to determine its potential integration into clinical prediction algorithms.

PÉREZ-ROJAS, F.; CABEZAS, J. J. & VEGA, J. A. Tortuosidad arterial y su impacto clínico evaluado mediante imágenes médicas: una revisión sistemática. *Int. J. Morphol.*, 43(5):1779-1784, 2025.

RESUMEN: La tortuosidad arterial es una variación morfológica caracterizada por curvaturas, torsiones o elongaciones anormales a lo largo del trayecto de las arterias, con posibles implicaciones clínicas debido a su impacto en la hemodinámica y la perfusión tisular. Aunque en algunos casos puede considerarse una variante anatómica benigna, múltiples estudios asocian la tortuosidad arterial con enfermedades cardiovasculares, neurológicas y microvasculares. El objetivo de este estudio fue revisar sistemáticamente y actualizar la evidencia científica sobre el impacto clínico de la tortuosidad arterial, evaluada mediante técnicas de imagen médica, y analizar los mecanismos estructurales y funcionales que podrían explicar su asociación con los factores de riesgo cardiovascular. Se realizó una búsqueda sistemática en PubMed, Scopus y Web of Science hasta febrero de 2025, siguiendo las directrices PRISMA. Un total de 42 estudios cumplió los criterios de inclusión. Los territorios vasculares evaluados con mayor frecuencia fueron las arterias coronarias, cerebrales, femorales y retinianas, y las técnicas de imagen incluyeron angiografía convencional y por tomografía computarizada, angiografía por resonancia magnética, ecografía Doppler y retinografía digital. Se encontraron asociaciones significativas entre la tortuosidad arterial y la hipertensión arterial sistémica, la enfermedad coronaria no obstructiva, los eventos cerebrovasculares isquémicos, la claudicación intermitente y las retinopatías diabéticas o hipertensivas. Además, se observó un creciente uso de estrategias basadas en inteligencia artificial para la detección y cuantificación automatizada de la tortuosidad arterial. En conjunto, estos hallazgos resaltan la relevancia clínica de la tortuosidad arterial y subrayan la necesidad urgente de establecer criterios estandarizados para su medición, clasificación y seguimiento longitudinal, con el fin de integrar la tortuosidad en los algoritmos diagnósticos y pronósticos de la medicina vascular.

PALABRAS CLAVE: Tortuosidad arterial; Arterias coronarias; Imagen vascular; Hemodinámica; Arterias cerebrales; Arteria femoral; Inteligencia artificial.

REFERENCES

- Adam, E. L.; Generoso, G. & Bittencourt, M. S. Anomalous coronary arteries: when to follow-up, risk stratify, and plan intervention. *Curr. Cardiol. Rep.*, 23(8):102, 2021.
- Alshair, F. M.; Alsulami, A. S.; Shihata, M. S.; Alradi, O. O.; Debis, R. S.; Baghaffar, A. H. & Fatani, M. A. Total pulmonary arterial reconstruction in a patient with arterial tortuosity syndrome affecting the pulmonary artery: a case report and review of the literature. *J. Cardiothorac. Surg.*, 19(1):432, 2024.
- Brummer, A.; Hunt, D. & Savage, V. Improving blood vessel tortuosity measurements via numerical integration of the Frenet–Serret equations. *arXiv*, 1911.12316, 2019.
- Ciurica, S.; Lopez Sublet, M.; Loeys, B. L.; Radhouani, I.; Natarajan, N.; Vikkula, M.; Maas, A. H. E. M.; Adlam, D. & Persu, A. Arterial tortuosity. *Hypertension*, 73(5):951-60, 2019.
- Cobo, M.; Pérez-Rojas, F.; Gutiérrez-Rodríguez, C.; Heredia, I.; Maragaño-Lizama, P.; Yung-Manriquez, F.; Lloret Iglesias, L. & Vega, J. A. Novel deep learning method for coronary artery tortuosity detection through coronary angiography. *Sci. Rep.*, 13(1):11137, 2023.

- Ekhtor, C.; Devi, M.; Barker, C.; Safdar, S.; Irfan, R.; Malineni, J.; Hussain, I.; Bisharat, P.; Ramadhan, A.; Abdelaziz, A. M.; *et al.* Arterial tortuosity syndrome: unraveling a rare vascular disorder. *Cureus*, 15(9):e44906, 2023.
- Erbel, R.; Aboyans, V.; Boileau, C.; Bossone, E.; Di Bartolomeo, R.; Eggebrecht, H.; Evangelista, A.; Falk, V.; Frank, H.; Gaemperl, O.; *et al.* Guía ESC 2014 sobre diagnóstico y tratamiento de la patología de la aorta. *Rev. Esp. Cardiol.*, 68(3):242.e1-e69, 2015.
- Fuenzalida, J. J. V.; Becerra-Rodríguez, E. S.; Quivira Muñoz, A. S.; Báez Flores, B.; Escalona Manzo, C.; Orellana-Donoso, M.; Nova-Baeza, P.; Suazo-Santibáñez, A.; Bruna-Mejías, A.; Sanchis-Gimeno, J.; *et al.* Anatomical variants of the origin of the coronary arteries: a systematic review and meta-analysis of prevalence. *Diagnostics (Basel)*, 14(13):1458, 2024.
- Ha, S. H.; Jeong, S.; Park, J. Y.; Chang, J. Y.; Kang, D. W.; Kwon, S. U.; Kim, J. S. & Kim, B. J. Association between arterial tortuosity and early neurological deterioration in lenticulostriate artery infarction. *Sci. Rep.*, 13(1):19865, 2023.
- Konigstein, M.; Ben-Yehuda, O.; Redfors, B.; Mintz, G. S.; Madhavan, M. V.; Golomb, M.; McAndrew, T.; Zhang, Z.; Kandzari, D. E.; Hermiller, J. B.; *et al.* Impact of coronary artery tortuosity on outcomes following stenting: a pooled analysis from six trials. *JACC Cardiovasc Interv.*, 14(9):1009-18, 2021.
- Lahoz, C.; Esteban Gracia, C.; Reinares García, L.; Bellmunt Montoya, S.; Brea Hernando, Á.; Fernández Heredero, Á.; Suárez Tembra, M.; Botas Velasco, M.; Guijarro Herráiz, C.; Bravo Ruiz, E.; Pintó Sala, X.; Vega de Céniga, M.; Moñux Ducajú, G. Guía SEA-SEACV 2015: Guía para el diagnóstico y tratamiento del aneurisma de aorta abdominal. *Clin. Investig. Arterioscler.*, 28(Supl 1):1-49, 2016.
- Luta, X.; Zanchi, F.; Fresa, M.; Porceddu, E.; Keller, S.; Bouchardy, J.; Déglise, S.; Qanadli, S. D.; Kirsch, M.; Wuerzner, G.; *et al.* Tortuosity in non-atherosclerotic vascular diseases is associated with age, arterial aneurysms, and hypertension. *Orphanet J. Rare Dis.*, 19(1):227, 2024.
- National Heart, Lung, and Blood Institute (NHLBI). *Coronary Heart Disease*. National Institutes of Health, U.S. Department of Health and Human Services, 2025. Available at: <https://www.nhlbi.nih.gov/health-topics/coronary-heart-disease>
- Pérez-Rojas, F. J.; Maragaño Lizama, P.; Maragaño, M. I.; Sepulveda Opazo, F.; Tapia Osorio, C.; Castro, T. Z.; Vega, J. A. Atypical origin of the left coronary artery originating from the right coronary sinus with interarterial course: a case report. *Transl. Res. Anat.*, 31:100242, 2023.
- Pérez-Rojas, F.; Vega, J. A.; Gambeta-Tessini, K.; Puebla-Wuth, R.; Olavarría-Solís, E. F.; Maragaño-Lizama, P. & Olave, E. Biometric analysis of healthy coronary arteries in a Chilean population: an angiographic study. *Int. J. Morphol.*, 38(6):1797-802, 2020.
- Whiting, P. F.; Rutjes, A. W.; Westwood, M. E.; Mallett, S.; Deeks, J. J.; Reitsma, J. B.; Leeflang, M. M.; Sterne, J. A.; Bossuyt, P. M.; QUADAS-2 Group. QUADAS-2: A revised tool for the quality assessment of diagnostic accuracy studies. *Ann. Intern. Med.*, 155(8):529-36, 2011.
- Wood, N. B.; Zhao, S. Z.; Zambanini, A.; Jackson, M.; Gedroyc, W.; Thom, S. A.; Hughes, A. D.; Xu, X. Y. Curvature and tortuosity of the superficial femoral artery: a possible risk factor for peripheral arterial disease. *J. Appl. Physiol.* (1985), 101(5):1412-8, 2006.
- Yoo, B. S.; Yoon, J.; Ko, J. Y.; Kim, J. Y.; Lee, S. H.; Hwang, S. O.; Choe, K. H. Anatomical consideration of the radial artery for transradial coronary procedures: arterial diameter, branching anomaly and vessel tortuosity. *Int. J. Cardiol.*, 101(3):421-7, 2005.
- Zebic Mihic, P.; Arambasic, J.; Mlinarevic, D.; Saric, S.; Labor, M.; Bosnjak, I.; Mihaljevic, I.; Bilic Curcic, I.; Juric, I. Coronary Tortuosity Index vs. Angle Measurement Method for the Quantification of the Tortuosity of Coronary Arteries in Non-Obstructive Coronary Disease. *Diagnostics (Basel)*, 14(1):35, 2023.

Corresponding author:
Francisco Javier Pérez Rojas
Av. San Miguel 3605
Talca
CHILE

E-mail: fjperez@ucm.cl