Review

NaCl: A Determinant Factor in the Pathophysiology of Arterial Hypertension

Jose Rodrigo Hernandez Avila *, Flor Ines Burgos Amador, Maria Fernanda Triviño-Burgos, Juan Manuel Benitez Diaz, Keinner Mandoza Algarín, Rosaura Gomez Garcia, Maria Jose Rodríguez Deluque

Posted Date: 1 July 2025

doi: 10.20944/preprints202506.2474.v1

Keywords: arterial hypertension; pathophysiology; sodium chloride

 doi:10.20944/preprints202506.2474.v1

Review

NaCl A Determinant Factor in the Pathophysiology of Arterial Hypertension

Juan Manuel Benitez Diaz *, Rosaura Gomez Garcia, Keinner Mandoza Algarín, Maria Jose Rodríguez Deluque, Maria Fernanda Triviño-Burgos, Flor Ines Burgos Amador and Jose Rodrigo Hernandez Avila

San Martín University Foundation and University of Sucre, Faculty of Health Sciences, Medicine Program

* Correspondence: jose.hernandez@unisucre.edu.co

Abstract

Arterial hypertension affects one in three adults worldwide, with a higher prevalence in low- and middle-income countries, where the incidence reaches approximately 20% of the population. This condition is closely associated with risk factors such as obesity and metabolic syndrome. The objective of this research was to identify the main risk factors related to arterial hypertension, establish its link with metabolic syndrome and obesity, and analyze effective strategies for its detection and prevention, with special emphasis on the role of sodium chloride (NaCl) in its pathophysiology. A systematic review of updated scientific literature was conducted to obtain accurate, evidence-based information. The results revealed that the prevalence of hypertension in Colombia is 40.3% in urban areas and 34.9% in rural areas. Diagnosis is based on repeated blood pressure measurements, considering hypertension when values are equal to or greater than 140/90 mm Hg. One of the most relevant findings was the direct implication of excessive NaCl consumption in the development and worsening of arterial hypertension. Various studies indicate that a high intake of sodium chloride contributes to fluid retention and increased vascular resistance, factors that sustainably raise blood pressure. In this regard, reducing salt intake in the diet is positioned as an essential preventive strategy, along with proper weight management and the adoption of healthy habits such as regular physical activity. This study highlights the need to strengthen primary prevention measures focused on community education about the impact of NaCl on cardiovascular health, promoting sustainable changes in consumption patterns and lifestyle.

Keywords: arterial hypertension; pathophysiology; sodium chloride

Introduction

Blood Pressure (BP) is the force exerted by the blood against the walls of the arteries, determined by two essential factors: the blood flow generated by the heart and systemic vascular resistance [1]. When this pressure rises sustainably, arterial hypertension occurs—a chronic condition that constitutes one of the main preventable causes of cardiovascular disease, strokes, and mortality worldwide [2]. Among the multiple factors contributing to hypertension development, excessive sodium chloride intake occupies a central place. High sodium intake disrupts mechanisms regulating plasma volume and vascular resistance, favoring water retention and increased blood pressure. The World Health Organization has warned that the average salt consumption worldwide far exceeds recommendations, which is reflected in the sustained increase in hypertension prevalence: it is estimated that the number of affected individuals doubled between 1990 and 2019, currently reaching 1.3 billion [21]. In Colombia, this issue is also significant, with a hypertension prevalence of 40.3% in urban areas and 34.9% in rural areas [24]. Excess dietary NaCl is not only directly related to arterial hypertension but also associated with metabolic conditions such as obesity and metabolic syndrome due to its role in disrupting the body's homeostatic mechanisms. These factors are interrelated and amplify the risk of cardiovascular disease, requiring an integral approach for prevention and control

 doi:10.20944/preprints202506.2474.v1

[3]. Understanding the implication of sodium chloride in the pathophysiology of arterial hypertension is essential in health, both to establish primary prevention strategies and to improve timely diagnosis and treatment of this condition [2]. The objectives of this research were to identify the main risk factors related to arterial hypertension, establish their relationship with metabolic syndrome and obesity, and analyze effective strategies for detection and prevention of associated diseases, with special emphasis on the impact of NaCl. For this purpose, a systematic review of recent scientific literature was conducted, applying rigorous search, analysis, inclusion, and exclusion criteria to obtain solid evidence supporting public health interventions and raising awareness in the academic community about the influence of sodium chloride on the development of arterial hypertension as a foundational factor of metabolic syndrome.

3. Methodology

A systematic review of the scientific literature was conducted to thoroughly analyze the available evidence on arterial hypertension, its prevalence, pathophysiology, risk factors, prevention and diagnostic methods, as well as its close relationship with metabolic syndrome, obesity, and particularly, excessive sodium chloride consumption. The central focus of the search was to identify studies specifically addressing the impact of NaCl on blood pressure regulation, its role as a modifiable cardiovascular risk factor, and its relation to essential hypertension development. Structured search criteria, a systematic analysis method, and rigorous inclusion and exclusion filters were applied. Source selection was limited to original scientific articles and reviews published between 2010 and 2023, in Spanish and English. Literature available in academic databases and reliable virtual libraries was prioritized, including Google Scholar, San Martín University Foundation database, SciELO, PubMed, and Elsevier. Keywords and specific descriptors were combined using Boolean operators to optimize information retrieval. Some of the terms used were: “arterial hypertension,” “sodium chloride,” “NaCl,” “blood pressure,” “hypertension pathophysiology,” “salt intake,” “metabolic syndrome,” “obesity,” and “cardiovascular disease prevention.” Inclusion criteria encompassed observational studies, clinical trials, and systematic reviews directly addressing the relationship between salt intake and the onset or progression of arterial hypertension. Duplicated articles, non-peer-reviewed publications, studies with non-human populations, or those lacking relevant quantitative data on NaCl exposure were excluded. Finally, selected articles were organized and analyzed based on thematic relevance, methodological quality, and clinical applicability to integrate solid evidence supporting relevant conclusions on sodium chloride’s influence in the genesis, diagnosis, and prevention of arterial hypertension.

4. Results and Analysis

4.1. Prevalence and Current Status

In September 2023, the World Health Organization published a report on global hypertension prevalence, stating it affects one in three adults worldwide. The number of people with hypertension doubled between 1990 and 2019, rising from 650 million to 1.3 billion. The report highlights the importance of understanding hypertension’s silent nature, noting that nearly half of those affected are unaware of their condition. Similarly, higher prevalence exists in low- and middle-income countries due to inadequate treatment and prevention [21]. Incidence among people over 18 years exceeds 20%, being more frequent in older adults. Prevalence in women is lower than men before menopause [2].

A study by the Integral Information System of Social Protection (SISPRO) indicated that hypertension prevalence in Colombia is 40.3% in urban areas and 34.9% in rural zones. The Atlantic coast departments of Sucre and Atlántico reported prevalence above 9%, La Guajira between 3% and 6%, and other coastal departments between 6% and 9% [24].

 doi:10.20944/preprints202506.2474.v1

4.2. Diagnosis and Pathophysiology of Arterial Hypertension

Blood Pressure (BP) corresponds to the tension the blood generates within arterial walls and is determined by myocardial contractility, circulating intrathoracic volume, and arterial wall structural characteristics [1]. BP is measured in millimeters of mercury (mmHg), defined by systolic pressure (SBP) from left ventricular contractions and diastolic pressure (DBP) dependent on arterial resistance [2]. Hypertension diagnosis is based on BP measurements during medical consultation. A patient presenting repeatedly with readings ≥140/90 mm Hg (SBP/DBP) is considered hypertensive, though the number of visits for diagnosis varies among institutions [1]. Dr. Casado Pérez suggests hypertension diagnosis after four visits with sustained elevated readings. BP is a variable parameter influenced by the autonomic nervous system and affected by physical and mental stimuli [2].

The pathophysiology of arterial hypertension involves the (pro)renin receptor (PRR) and the renin-angiotensin-aldosterone system (RAAS), where angiotensin II modulates BP through vasoconstriction, sympathetic nervous system activation, among other mechanisms [12]. An in-depth analysis of the pathophysiology proposed by Patrick Garner in 2018 concluded that hypertension is characterized by endothelial dysfunction due to an imbalance between vasodilatory and vasoconstrictive factors. Endothelin is a potent local vasoconstrictor, undergoing transformations to ET-1 responsible for systemic vasoconstriction, with angiotensin II being the second most potent vasoconstrictor [5]. The RAAS raises BP when the body detects decreased blood flow or pressure, necessary to maintain adequate organ perfusion. However, hyperactivation contributes to hypertension development [4].

4.3. Classification: Prehypertension, Primary and Secondary Hypertension

Hypertension classification is consistent across youth, middle-aged adults, and the elderly [25]. A patient is normotensive or has optimal BP when values are below 120/80 mmHg. Prehypertension or high-normal BP refers to systolic 130-139 mmHg and diastolic 85-89 mmHg. Primary hypertension ranges from 140-159 mmHg systolic and 90-99 mmHg diastolic. Secondary hypertension applies when BP reaches 160-179 mmHg systolic and 100-109 mmHg diastolic; grade 3 hypertension is ≥180/110 mmHg. Table 1 details these classifications [23]. Regarding age, most affected individuals are 40-49 years, with 36.1% men and 32.5% women; young men have higher hypertension prevalence than women, while women have higher prevalence after age 39 [22].

Table 1. Classification of SBP and DBP Values in Different Conditions.

Category	Systolic Pressure (SBP)	Diastolic Pressure (DBP)
Optimal	<120	<80
Normal	120-129	80-84
High-normal (Prehypertension)	130-139	85-89
Grade 1 Hypertension	140-159	90-99
Grade 2 Hypertension	160-179	100-109
Grade 3 Hypertension	≥180	≥110

 doi:10.20944/preprints202506.2474.v1

Category	Systolic Pressure (SBP)	Diastolic Pressure (DBP)
Optimal	<120	<80
Normal	120-129	80-84
High-normal (Prehypertension)	130-139	85-89
Grade 1 Hypertension	140-159	90-99
Isolated Systolic Hypertension	≥140	<90

Note: Adapted from the 2013 ESH/ESC Clinical Practice Guidelines for Hypertension Management by the European Society of Hypertension (ESH) and the European Society of Cardiology (ESC).

4.4. Risk Factors

BP varies throughout life, progressively increasing with age. A 2020 study by Regino et al. indicates advanced age as a risk factor for hypertension and cardiovascular diseases, along with smoking, physical inactivity, poor diet, dyslipidemia, insulin resistance, and obesity [3]. Studies show hypertension relates to central obesity, which is linked to metabolic syndrome. Physiologically, increased subcutaneous fat leads to more free fatty acid release, increased reactive oxygen species production, and impaired oxidative stress response, reducing vascular endothelial function and ultimately raising BP [8].

Different fat distributions in the body associate with hypertension and metabolic risks [8]. Salt consumption is an important factor in hypertension development and high prevalence, as are sedentary lifestyles and diets high in saturated fats and low in vegetables, contributing to overweight [2]. Bates suggests that hypertension within metabolic syndrome can cause cardiovascular diseases (CVDs) preventable by lifestyle changes [14].

4.6. Preventive Measures

Non-pharmacological preventive measures include awareness campaigns encouraging BP monitoring, especially in individuals with hypertensive relatives, since early detection prevents complications. Dr. Casado Pérez recommends the measures summarized in Table 2 [2].

Table 2. General Measures to Control Arterial Hypertension.

Initiative	Goal	Reduction in SBP (mmHg)
Salt restriction	Consume less than 4g of salt/day	6-8
Weight control	Maintain ideal body weight	5-20
Regular exercise	30 min, 3-5 days/week	4-9
Smoking cessation	Avoid tobacco use	4-10

Note: Taken from Santos Casado Pérez, *Book of the Heart*, Chapter 12: Arterial Hypertension.

The reduction of salt intake remains one of the most effective interventions to reduce hypertension prevalence. The American Heart Association recommends less than 2.3 grams of sodium per day (approx. 5.8 grams of salt), with an ideal limit of 1.5 grams per day for most adults,

 doi:10.20944/preprints202506.2474.v1

especially hypertensive individuals [20]. High sodium diets contribute to fluid retention, increasing blood volume and cardiac output, causing sustained elevated BP [7]. Education on dietary habits, promoting fruit and vegetable consumption rich in potassium, is also essential, as potassium intake counters sodium's effects on blood pressure.

5. Conclusions

Arterial hypertension is a prevalent condition worldwide, significantly influenced by excessive sodium chloride consumption. This condition increases cardiovascular disease risk and is closely linked to obesity and metabolic syndrome. Its diagnosis relies on repeated blood pressure measurements, with values ≥140/90 mmHg indicating hypertension. Preventive strategies focusing on reducing salt intake, weight control, and lifestyle modifications are essential to curb its prevalence and complications. Education and awareness programs targeting populations at risk should be prioritized to promote sustainable behavioral changes.

References

1. R. Tagle, "Diagnóstico de Hipertensión Arterial," *Revista médica clínica las condes*, 2018. [En línea]. Disponible: https://www.sciencedirect.com/science/article/pii/S0716864018300099
2. S. Casado Pérez, *Libro del corazón*, capítulo 12: Hipertensión Arterial, 2002. [En línea]. Disponible: https://www.fbbva.es/microsites/salud_cardio/mult/fbbva_libroCorazon_cap12.pdf
3. R. Regino-Ruenes *et al.*, "La hipertensión arterial no controlada y sus factores asociados en un programa de hipertensión," *Revista Colombiana de Cardiología*, vol. 28, no. 6, pp. 648–655, 2021, Epub 7 ene. 2022, doi:10.24875/rccar.m21000108.
4. P. Wagner Grau, "Pathophysiology of hypertension: New concepts," *Revista Peruana de Ginecología y Obstetricia*, vol. 64, no. 2, pp. 175–184, 2018. doi:10.31403/rpgo.v64i2075.
5. P. Wagner-Grau, "Pathophysiology of arterial hypertension," *Anales de la Facultad de Medicina*, vol. 71, no. 4, pp. 225–229, 2010. [En línea]. Disponible: http://www.scielo.org.pe/scielo.php?script=sci_arttext&pid=S1025-55832010000400003&lng=es&tlng=en
6. K. J. Bao *et al.*, "Diverse association between components of metabolic syndrome and chronic kidney disease in hypertension of different low-density lipoprotein cholesterol levels," *Cardiol Plus*, vol. 5, pp. 89–96, 2020. [En línea]. Disponible: https://journals.lww.com/cardioplus/fulltext/2020/04000/diverse_association_between_components_of.5.aspx
7. "Programa Nacional de Prevención…," *Revista Cubana de Medicina General Integral*, vol. 15, no. 1, pp. 46–87, 1999. [En línea]. Disponible: http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S0864-21251999000100009
8. Y. Zhang *et al.*, "The correlation between neck circumference and risk factors in patients with hypertension: what matters," *Medicine*, vol. 99, no. 47, Art. e22998, 2020. [En línea]. Disponible: https://pubmed.ncbi.nlm.nih.gov/33217801/
9. S. Ono *et al.*, "Effect of Metabolic Syndrome on Blood Pressure Changes During Cataract Surgery," *Asia-Pacific Journal of Ophthalmology*, vol. 9, no. 1, pp. 14–19, 2020. doi:10.1097/01.APO.0000617932.60445.77.
10. F. J. Fassler *et al.*, "Components of Metabolic Syndrome as Significant Risk Factors for Postoperative Complications Following Total Shoulder Arthroplasty: Hypertension, Diabetes, and Obesity," *JSES International*, 2023. doi:10.1016/j.jseint.2023.08.019.
11. M. Yilmaz *et al.*, "Síndrome metabólico, hipertensión e hiperlipidemia en madres, padres, hermanas y hermanos de mujeres con síndrome de ovario poliquístico: una revisión sistemática y un metanálisis," Departamento de Obstetricia y Ginecología, Facultad de Medicina de la Universidad Izmir Katip Celebi, Turquía, 2018. doi:10.1016/j.fertnstert.2017.10.018.
12. N. Ramkumar y D. E. Kohan, "El receptor de (pro)renina: un actor emergente en la hipertensión y el síndrome metabólico," *Circulation Research*, 2019. doi:10.1161/CIRCRESAHA.120.317532.

 doi:10.20944/preprints202506.2474.v1

13. R. Ortega Anta *et al.*, "Pautas nutricionales en prevención y control de la hipertensión arterial," *Nutrición Hospitalaria*, vol. 33, Supl. 4, pp. 53–58, 2016. doi:10.20960/nh.347.
14. BATES, *Guía de exploración física e historia clínica*, 13ª ed., 2021. [En línea]. Disponible: https://cienciasbasicas-lwwhealthlibrary com.proxy.sanmartin.edu.co/content.aspx?bookId=3176&sectionId=252215656&resultClick=1#252216318
15. L. C. Mefford, "Alteraciones del flujo sanguíneo y la regulación de la presión arterial," en *Porth. Fisiopatología: Alteraciones de la salud. Conceptos básicos*, 10ª ed., 2019. [En línea]. Disponible: https://cienciasbasicas-lwwhealthlibrary-com.proxy.sanmartin.edu.co/content.aspx?bookId=2908&sectionId=243777832
16. E. Ferat Osorio y M. Molina Ayala, "Respuesta Inmunológica en Enfermedades Metabólicas," *Inmunología Molecular, Celular y Traslacional*, 2ª ed. [En línea]. Disponible: https://cienciasbasicas-lwwhealthlibrary-com.proxy.sanmartin.edu.co/content.aspx?bookId=3080&sectionId=250381503
17. M. R. Hernández, "La actividad física en la prevención y tratamiento de la hipertensión arterial," *Intersedes*, vol. 13, no. 26, 2012. [En línea]. Disponible: https://www.redalyc.org/articulo.oa?id=66624662008
18. J. C. Fernández-Travieso, "Síndrome metabólico y riesgo cardiovascular," *Revista CENIC Ciencias Biológicas*, vol. 47, no. 2, pp. 106–119, 2016.
19. L. B. García y O. A. Centurión, "Medidas preventivas y manejo diagnóstico y terapéutico de la hipertensión arterial y las crisis hipertensivas," *Revista de Salud Pública del Paraguay*, vol. 10, no. 2, pp. 59–66, 2020. doi:10.18004/rspp.2020.diciembre.59.
20. L. J. Berenguer Guarnaluses, "Algunas consideraciones sobre la hipertensión arterial," *MEDISAN*, vol. 20, no. 11, pp. 2434–2438, 2016. [En línea]. Disponible: https://www.redalyc.org/articulo.oa?id=368448441015
21. M. R. Bloomberg, "Primer informe sobre la hipertensión arterial, los devastadores efectos de esta afección y maneras de ponerle coto," *OMS*, 2023. [En línea]. Disponible: https://www.who.int/es/news/item/19-09-2023-first-who-report-details-devastating-impact-of-hypertension-and-ways-to-stop-it#:~:text=El%20n%C3%BAmero%20de%20personas%20con,650%20millones%20a%201300%20millones.
22. É. Navarro Lechuga y R. Vargas Moranth, "Características epidemiológicas relacionadas con el género en hipertensos de raza negra," *Revista Científica Salud Uninorte*, 2009. [En línea]. Disponible: https://www.redalyc.org/pdf/817/81711840009.pdf
23. R. de la Fuente Crespo, R. G. Carballo, J. Fernández-Britto, S. Guilarte y M. J. Albert, "Circunferencia de la cintura con sobrepeso e hipertensión arterial en adultos," *Revista Habanera de Ciencias Médicas*, 2012. [En línea]. Disponible: https://www.redalyc.org/articulo.oa?id=180425059011
24. Á. A. García-Peña *et al.*, "Prevalencia de hipertensión arterial en Colombia según información del Sistema Integral de Información de la Protección Social (SISPRO)," *Revista Colombiana de Cardiología*, 2022. doi:10.24875/rccar.m22000114.
25. Grupo de Trabajo para el manejo de la hipertensión arterial de la Sociedad Europea de Hipertensión (ESH) y la Sociedad Europea de Cardiología (ESC), "Guía de práctica clínica de la ESH/ESC 2013 para el manejo de la hipertensión arterial."