

Screening for Obstructive Sleep Apnea in Patients with Arterial Hypertension: Development and Internal Validation of an Exploratory Model Based on Clinical and Echocardiographic Variables

Cribado de apnea obstructiva del sueño en pacientes con hipertensión arterial: desarrollo y validación interna de un modelo exploratorio basado en variables clínicas y ecocardiográficas

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ABSTRACT

Background: Obstructive sleep apnea (OSA) is a recognized cause of secondary hypertension and a factor contributing to the progression of cardiovascular damage. Although its prevalence in hypertensive patients is high, it is often underdiagnosed.

Objective: To develop and validate a clinical predictive model based on routine variables to estimate the risk of OSA in patients with hypertension (HTN).

Methods: A retrospective cohort of patients with hypertension treated in an outpatient cardiology clinic was analyzed. Patients with complete data and diagnostic polysomnography were included. Polysomnography was indicated based on clinical criteria, according to the suspicion of OSA. Clinical and echocardiographic variables were evaluated, with age categorized into clinically relevant ranges. Predictors were selected using two methods: LASSO and AIC stepwise. Predictor robustness was assessed using bootstrap validation (n=1000). Model performance was evaluated using the area under the ROC curve (AUC), performance metrics, and calibration with the Hosmer-Lemeshow test.

Results: A total of 1795 patients were included, 88 of whom (4.9%) had OSA. The independent predictors were diastolic dysfunction (OR 2.39; 95% CI 1.54-3.74), male sex (OR 2.12; 95% CI 1.35-3.38), age between 45 and 65 years (OR 1.71; 95% CI 1.10-2.66), and body mass index (OR per 1 kg/m² 1.08; 95% CI: 1.05-1.11). The model showed an AUC of 0.70 (95% CI 0.59-0.81), 71% sensitivity, 55% specificity, 98% negative predictive value, and 56% overall accuracy, with good calibration.

Conclusions: The clinical model developed, based on simple variables that are easily obtained in outpatient practice, showed moderate discriminatory power and a high negative predictive value, which suggests its utility as a screening tool to rule out OSA in hypertensive patients. Its implementation could help optimize the indication for polysomnography, although it requires external validation in different settings before widespread clinical adoption.

Key words: Obstructive sleep apnea – Arterial hypertension – Predictive models – Screening – Echocardiography

RESUMEN

Introducción: La insuficiencia cardíaca (IC) aguda continúa siendo una de las principales causas de hospitalización y morbimortalidad a nivel mundial. La implementación de unidades especializadas en IC ha demostrado mejorar la calidad asistencial y los resultados clínicos; sin embargo, la evidencia sobre su impacto sostenido en América Latina es limitada.

Objetivo: Evaluar el impacto de una unidad especializada en IC sobre métricas de calidad asistencial en pacientes hospitalizados por IC aguda.

Material y métodos: Se realizó un análisis retrospectivo de una cohorte consecutiva de pacientes hospitalizados con diagnóstico principal de IC aguda entre enero de 2014 y diciembre de 2024. El programa de IC incluyó manejo basado en caminos críticos, checklist estructurado al alta, médicos con dedicación exclusiva, enfermeros especializados, personal administrativo dedicado, educación al alta con indicaciones escritas, seguimiento posalta estructurado, consultas prioritarias, presentación periódica de indicadores, ateneos para decisiones de manejo avanzado, descongestión guiada por ultrasonido, telemonitoreo y hospital de día. En los últimos dos años, pacientes seleccionados de bajo riesgo tratados exclusivamente en hospital de día no fueron incluidos. Los puntos finales analizados anualmente fueron mortalidad intrahospitalaria, rehospitalización por IC a 30 días y duración de la estadía hospitalaria.

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Se compararon dos períodos: etapa inicial (2014–2019) y etapa de consolidación (2020–2024).

Resultados: Se analizaron 3368 hospitalizaciones por IC aguda. El volumen anual de internaciones aumentó de 260 en 2014 a 463 en 2024, con una tendencia creciente significativa ($p=0,002$). La mortalidad intrahospitalaria mostró una leve tendencia descendente (5,0% a 3,9%), sin significación estadística. La rehospitalización a 30 días se mantuvo estable, con menor variabilidad en los años más recientes. La duración de la estadía hospitalaria se redujo progresivamente de 9,3 a 2,8 días ($p<0,001$), siendo significativamente menor en la etapa de consolidación (mediana 3,6 vs. 6,8 días; $p=0,004$).

Conclusión: La implementación y consolidación de una unidad especializada en IC se asoció con un aumento del volumen asistencial y mejoras sostenidas en la eficiencia hospitalaria, reflejadas en una reducción significativa de la duración de la estadía. La mayor estabilidad de la mortalidad y la rehospitalización durante la etapa de consolidación sugiere una mejora sostenida en la calidad de la atención, apoyando el desarrollo de modelos estructurados de atención en sistemas de salud de Latinoamérica.

Palabras clave: Insuficiencia cardíaca aguda - Insuficiencia cardíaca descompensada - Unidades de insuficiencia cardíaca - Calidad de atención médica

INTRODUCTION

Obstructive sleep apnea (OSA) is a respiratory disorder characterized by recurrent episodes of partial or complete obstruction of the upper airway during sleep, leading to intermittent hypoxemia, sleep fragmentation, and sustained sympathetic activation. (1,2) Its prevalence ranges from 9% to 38% in the general adult population, (3) with a higher incidence in men and in overweight or obese individuals. (4)

In the context of hypertension (HTN), OSA has gained particular relevance as it is a recognized cause of secondary hypertension and is associated with poorer blood pressure control, increased arterial stiffness, cardiac remodeling, and a higher risk of cardiovascular events. (5,6) Previous studies have shown that up to 30–50% of patients with HTN may have OSA, and this proportion is even higher in the subgroup with resistant hypertension. (7,8)

Despite its high prevalence, OSA remains an underdiagnosed condition, especially in the outpatient setting, where polysomnography, considered the gold standard for its diagnosis, is not always feasible due to limitations in availability, cost, or accessibility. (9) This highlights the need for specific screening tools for this population, capable of optimizing the selection of candidates for confirmatory studies and rationalizing the use of diagnostic resources.

In addition to polysomnography, ambulatory respiratory polygraphy has established itself as a valid diagnostic alternative in patients with high clinical suspicion, particularly in the outpatient setting. However, its performance may be limited in patients with cardiovascular comorbidities, such as hypertension, in whom clinical complexity may require more comprehensive studies.

Although validated screening scales exist for the general population, such as STOP-BANG or NoSAS, (6,7) their performance may vary in hypertensive patients, where the incorporation of echocardiographic parameters, such as diastolic dysfunction or cardiac morphological characteristics, could provide additional predictive value.

On this basis, the objective of this study was to develop and internally validate a clinical predictive screening model for OSA in patients with hyperten-

sion, using routine clinical and echocardiographic variables to generate a tool applicable in outpatient practice and adapted to this high-risk population.

OBJECTIVE

To develop and validate a clinical predictive model based on routine clinical and echocardiographic variables to estimate the risk of OSA in patients with hypertension.

METHODS

Study design and population

A retrospective observational study was conducted in a cohort of patients diagnosed with hypertension (HTN) treated in the outpatient Cardiology Department of a private institution in the Autonomous City of Buenos Aires, Argentina from 2017 to 2022. Adult patients over 18 years of age with a diagnosis of HTN who underwent a complete clinical evaluation and echocardiographic study were consecutively included. In the context of routine clinical practice, a subgroup of patients was evaluated for obstructive sleep apnea (OSA) using polysomnography based on clinical criteria and availability. Patients with incomplete data on the variables of interest were excluded, as were those with inconclusive or technically inadequate sleep studies. Additionally, patients with severe chronic respiratory diseases, advanced heart failure, or conditions that could interfere with the correct interpretation of sleep studies were excluded.

Definitions

Hypertension was defined according to current guidelines (10,11) and based on ambulatory blood pressure monitoring (ABPM) values: nighttime blood pressure (resting period) $\geq 120/70$ mmHg, daytime blood pressure (active period) $\geq 135/85$ mmHg, and mean 24-h blood pressure $\geq 130/80$ mmHg. A non-dipper pattern was considered present when the nocturnal reduction in systolic blood pressure was $<10\%$ compared to daytime values. Ambulatory blood pressure was measured with a validated oscillometric device (MED-ITECH® ABPM-04 model, Easy ABPM software version 1.1.2.3) (12). The cuff size was selected according to the patient's brachial circumference and the cuff was placed on the non-dominant arm. The active period was defined as the time between 8:00 a.m. and 10:00 p.m. in which measurements were taken every 20 minutes, and the passive period, as the time between 10:00 p.m. and 8:00 a.m. in which measurements were taken every 30 minutes. This information was supplemented with the patient's personal diary to corroborate the periods of activity and rest.

OSA, previously known as obstructive sleep apnea-hypopnea syndrome (OSAHS), was defined according to the current guidelines of the American Academy of Sleep Medicine (AASM) at the time of patient enrollment. (13) OSA was defined as the presence of repeated episodes of complete or partial upper airway obstruction during sleep detected by polysomnography and quantified by the apnea-hypopnea index (AHI). In the analyzed cohort, the diagnosis of OSA was exclusively determined by polysomnography, considered the gold standard for diagnostic confirmation. OSA was diagnosed with an AHI ≥ 5 events/hour, and its severity was classified as mild (5-14), moderate (15-29), or severe (≥ 30). Hypopnea was defined as a $\geq 30\%$ airflow reduction for at least 10 seconds, associated with $\geq 3\%$ oxygen desaturation and/or an arousal defined as a transient microarousal detected by polysomnography, which briefly interrupts the continuity of sleep.

Left ventricular (LV) diastolic dysfunction was defined according to current guidelines, (14,15) by applying the algorithm of the American Society of Echocardiography (ASE) and the European Association of Cardiovascular Imaging (EACVI), which integrates echocardiographic parameters to establish diastolic dysfunction and estimate LV filling pressure. In patients with sinus rhythm, diastolic dysfunction was considered when at least two of the following criteria were met: mean E/e' ratio > 14 , septal e' < 7 cm/s or lateral e' < 10 cm/s, left atrial volume index > 34 ml/m², or tricuspid regurgitation velocity > 2.8 m/s. Severity was categorized according to this algorithm as grade I (impaired relaxation with normal filling pressure), grade II (pseudonormal pattern with elevated filling pressure), or grade III (restrictive pattern with elevated filling pressure). For the predictive model, diastolic dysfunction was considered a dichotomous variable (presence/absence), regardless of the grade of severity, to facilitate its use as a rapid screening tool.

Outcome of interest

Our outcome of interest was the presence of OSA.

Statistical analysis Cohort description

Continuous variables were expressed as mean and standard deviation or median and interquartile range, depending on their distribution, and categorical variables as percentages. Comparisons between groups were performed using Student's t-test or the Mann-Whitney U test for continuous variables and the chi-square test for categorical variables. Quantitative variables were categorized according to clinically relevant cutoff points or explored using generalized additive models and visual analyses to determine potential clinically significant inflection points, which were then used for categorization. Body mass index (BMI) was calculated as weight in kilograms divided by height in square meters. Age was analyzed as both a continuous and a categorical variable (stratified into < 45 , 45–65, and > 65 years).

Selection of OSA predictors

Clinical and echocardiographic variables selected a priori based on their pathophysiological relevance and prior evidence were considered. Clinical variables included demographic characteristics, traditional cardiovascular risk factors (such as hypertension, diabetes, dyslipidemia, and smoking), and anthropometric parameters. Echocardiographic variables included structural and functional measures of the left ventricle, including assessment of diastolic and systolic function. To identify predictors, two comple-

mentary selection methods were used: the LASSO (Least Absolute Shrinkage and Selection Operator) penalized regression and the stepwise selection guided by the Akaike Information Criterion (AIC), which prioritized a parsimonious and clinically interpretable approach. Each method was run within a bootstrap resampling scheme with replacement (1000 iterations, with the frequency of variable inclusion recorded in each one, with the selection proportion and its 95% binomial confidence interval). Since both methods were applied with the same number of iterations, they were assigned equal weighting (1/2 each) in the calculation of a combined stability score. Predefined cutoff points ($\geq 75\%$ selection in each method) were established to define consensus, and those variables that simultaneously exceeded these thresholds in both methods were considered robust. This combined approach was adopted to improve robustness in predictor selection and reduce the risk of overfitting.

Multivariate analysis

The variables with the highest consistency (high frequency and/or agreement across methods) and those considered clinically relevant were included in multivariate logistic regression models to estimate the risk of OSA. Given the low number of events, a parsimonious approach was prioritized to avoid overfitting. Likewise, the inclusion of highly correlated or redundant variables was avoided to reduce model instability and improve its generalizability. The number of events per variable remained close to the recommended limits; therefore, the results should be interpreted with caution regarding the model's stability. The results were expressed as odds ratios (OR) with their 95% confidence intervals (95% CI). The model's performance and discriminatory power were assessed with the area under the ROC curve (AUC), and standard diagnostic metrics such as sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy were calculated over 1000 bootstrap iterations to estimate their stability.

Model calibration was verified using the Hosmer-Lemeshow test and calibration curves. All analyses were performed using RStudio software (v4.4.0), and a p-value < 0.05 was considered statistically significant.

Ethical considerations

The study was conducted in accordance with the principles of the Declaration of Helsinki. (16) Given the retrospective nature of the analysis and the use of anonymized data, individual informed consent was not required.

RESULTS

General description of the population

A total of 1795 patients diagnosed with hypertension and complete complementary studies were included, of whom 88 (4.9%) had a confirmed diagnosis of OSA via polysomnography. The mean age of the cohort was 59.3 ± 14.2 years, with a predominance of females (53%). In the OSA group, a higher proportion of males was observed (63.6% vs. 46.2%; $p=0.002$) and the mean age did not show statistically significant differences (56.9 ± 11.9 vs. 59.4 ± 14.3 years; $p=0.115$). Regarding cardiovascular risk factors, in the OSA group, the percentage of patients with diabetes mellitus was similar (15.9% vs. 17.0%; $p=0.902$) but the body mass index was higher (32.9 ± 6.5 vs. 29.3 ± 5.5 kg/m²; $p<0.001$). Likewise, the prevalence of diastolic

dysfunction was significantly higher in the OSA group (51.1% vs. 34.7%; $p=0.002$). Regarding cardiovascular events during follow-up, no statistically significant differences were observed between the two groups; the remaining baseline characteristics are presented in Table 1.

Variable selection using machine learning algorithms

In the variable selection analyses, both methods, the stepwise and LASSO, demonstrated high stability in identifying predictors of OSA. The selection frequency was plotted graphically, showing that variables such as age, sex, BMI, diastolic dysfunction, and cardiovascular history remained among the most consistently selected. The comparative map between the two methods revealed a group of variables that simultaneously exceeded the consensus thresholds ($\geq 75\%$ selection in both stepwise and LASSO methods), thus reinforcing their robustness as predictors. In this graph, the shaded area represents strict consensus between methods, while the size of each point reflects the weighted score (a 50/50 average of the proportions in both algorithms), allowing us to appreciate not only the consensus between methods but also the degree of stability of each variable. In contrast, other variables appeared more sporadically or were method-dependent, suggesting lower stability. These findings are summarized in Figure 1, which shows a Selection Concordance Map (LASSO - stepwise). In the comparative analysis, a small subset of variables showed a high frequency of simultaneous selection in both methods (consensus zone), which are the most stable predictors. The remaining exhibited low frequencies or were dependent on a single approach, which reflects lower consistency. In line with these findings and to prioritize model parsimony, diabetes mellitus was not included in the final model. Although it showed an association in the bivariate analysis, this could be explained by its multicollinearity with BMI and other cardiometabolic factors. Additionally, the limited number of events in the cohort constrained the number of variables that could be included in the multivariate model; therefore, its exclusion should be interpreted as a methodological decision aimed at preserving the model's stability rather than as a lack of clinical relevance.

Multivariate analysis: predictors of OSA

The presence of diastolic dysfunction, gender, age between 45 and 65 years, and BMI were associated with the presence of OSA. Other variables, such as a history of diabetes, coronary artery disease, or biochemical parameters, did not show a statistically significant association (Table 1). In the multivariable analysis, the independent predictors of OSA were diastolic dysfunction (OR 2.39; 95% CI 1.54-3.74; $p<0.001$), male gender (OR 2.12; 95% CI 1.35-3.38; $p=0.001$), age between 45-65 years (OR 1.71; 95% CI 1.10-2.66; $p=0.017$), BMI (OR per 1 kg/m² 1.08; 95% CI 1.05-1.11; $p<0.001$).

Final prediction model

The final model showed an AUC of 0.70 (95% CI 0.59-0.81), 71% sensitivity, 55% specificity, 8% PPV and 98% NPV. Calibration—assessed using the Hosmer-Lemeshow test—showed no significant differences ($p>0.05$), which indicated a good fit. The diagnostic performance of the model is presented in Figure 2.

DISCUSSION

Our findings can be summarized in three main points. First, we observed a low prevalence of OSA in our cohort of hypertensive patients, which likely reflects a selection bias, given that polysomnography was not performed systematically. Second, we identified that routine clinical and echocardiographic variables, easily obtainable in daily practice—such as gender, middle age (45–65 years), BMI, and diastolic dysfunction—were independently associated with OSA. Finally, we developed and internally validated an exploratory clinical model for OSA. The model demonstrated moderate discriminatory power consistent with tools based on simple clinical variables and acceptable sensitivity along with high negative predictive value, which suggests potential utility as a complementary tool to guide indication for polysomnography in outpatient practice.

Regarding prevalence, our results contrast with those reported in the literature. Globally, it is estimated that more than 936 million adults have OSA at any degree, and approximately 425 million cases are moderate-to-severe. (3) In hypertensive patients, the reported prevalence ranges from 30% to 50%, and in the subgroup with resistant hypertension it ranges approximately from 70% to 80%. (1,2,17,18) These differences reinforce the idea that in our cohort, the prevalence is likely underestimated, consistent with observations in other clinical settings where the indication for sleep studies depends on clinical suspicion. (19, 20)

Regarding associated variables, left ventricular diastolic dysfunction was the most consistent echocardiographic finding in our model. The intermittent hypoxia and nocturnal pressure overload characteristic of OSA promote myocardial and atrial remodeling, which is associated with an increased risk of atrial fibrillation and disease progression (5,15,21,22). Likewise, male sex, middle age (45-65 years), and elevated BMI are widely validated predictors in screening scales such as STOP-Bang and NoSAS. (6,7)

Although tools such as STOP-Bang and NoSAS have demonstrated good performance in the general population, their applicability in hypertensive patients may be limited as they do not consider cardiac structural variables. In this regard, our model incorporates diastolic dysfunction as a marker of cardiovascular remodeling, which could add a potentially relevant pathophysiological dimension in this specific population. This approach could represent an advantage over tools based exclusively on clinical and an-

Table 1. Baseline characteristics

Variable	Overall	No OSA	OSA	p
n	1795	1707	88	
Female, n (%)	951 (53.0)	919 (53.8)	32 (36.4)	0.002
Age (years), mean (SD)	59.25 (14.2)	59.37 (14.3)	56.86 (11.9)	0.107
BMI, kg/m ² , mean (SD)	29.50 (6.0)	29.32 (5.9)	32.90 (6.5)	<0.001
Daytime SBP, mmHg, mean (SD)	139.52 (15.6)	139.36 (15.6)	142.47 (16.1)	0.069
Nighttime SBP, mmHg, mean (SD)	126.27 (18.2)	126.05 (18.1)	130.56 (20.6)	0.024
LA area, cm ² , mean (SD)	24.06 (8.8)	24.12 (8.9)	22.83 (7.6)	0.179
IVS, mm, mean (SD)	11.18 (1.7)	11.17 (1.7)	11.37 (1.6)	0.278
Total cholesterol, mg/dL, mean (SD)	181.11 (41.0)	181.10 (40.7)	181.38 (47.5)	0.951
LDL, mg/dL, mean (SD)	105.76 (36.1)	105.86 (36.1)	103.67 (37.7)	0.579
HDL, mg/dL, mean (SD)	49.89 (16.8)	50.14 (16.9)	45.07 (13.3)	0.006
CICr, mL/min, mean (SD)	110.34 (49.9)	109.72 (49.5)	122.38 (55.9)	0.020
Diabetes mellitus, n (%)	304 (16.9)	290 (17.0)	14 (15.9)	0.906
Dyslipidemia, n (%)	559 (31.1)	518 (30.3)	41 (46.6)	0.002
Statins, n (%)	520 (29.0)	486 (28.5)	34 (38.6)	0.054
Diastolic dysfunction, n (%)	637 (35.5)	592 (34.7)	45 (51.1)	0.002
LVH, n (%)	333 (18.5)	312 (18.3)	21 (23.9)	0.240
Treatment, n (%)	1,401 (78.6)	1,329 (78.4)	72 (83.7)	0.295
Treatment with 3 or more drugs, n (%)	252 (14.0)	237 (13.9)	15 (17.0)	0.500
Age 45-60 years, n (%)	612 (34.1)	570 (33.4)	42 (47.7)	0.008
CrCl <50 ml/min, n (%)	111 (6.2)	109 (6.4)	2 (2.3)	0.182
Albuminuria >20 mg/day, n (%)	508 (28.3)	486 (28.5)	22 (25.0)	0.560
HTN stratum, n (%)				0.397
Controlled HTN	653 (36.4)	624 (36.6)	29 (33.0)	
Isolated systolic HTN	469 (26.1)	450 (26.4)	19 (21.6)	
Isolated diastolic HTN	105 (5.8)	100 (5.9)	5 (5.7)	
Systolic and diastolic HTN	568 (31.6)	533 (31.2)	35 (39.8)	
Follow-up, months, mean (SD)	43.16 (24.1)	42.98 (24.1)	46.62 (24.8)	0.167
MACE, n (%)	162 (9.0)	158 (9.3)	4 (4.5)	0.189
Death, n (%)	53 (3.7)	51 (3.8)	2 (2.3)	0.684
Treatment, n (%)	1,401 (78.6)	1329 (78.4)	72 (83.7)	0.295

BMI, body mass index; CrCl, creatinine clearance; HDL, high-density lipoproteins; HTN, hypertension; IVS, interventricular septum; LA, left atrium; LDL, low-density lipoproteins; LVH, left ventricular hypertrophy; MACE, major adverse cardiovascular events; OSA, obstructive sleep apnea; SBP, systolic blood pressure; SD, standard deviation.

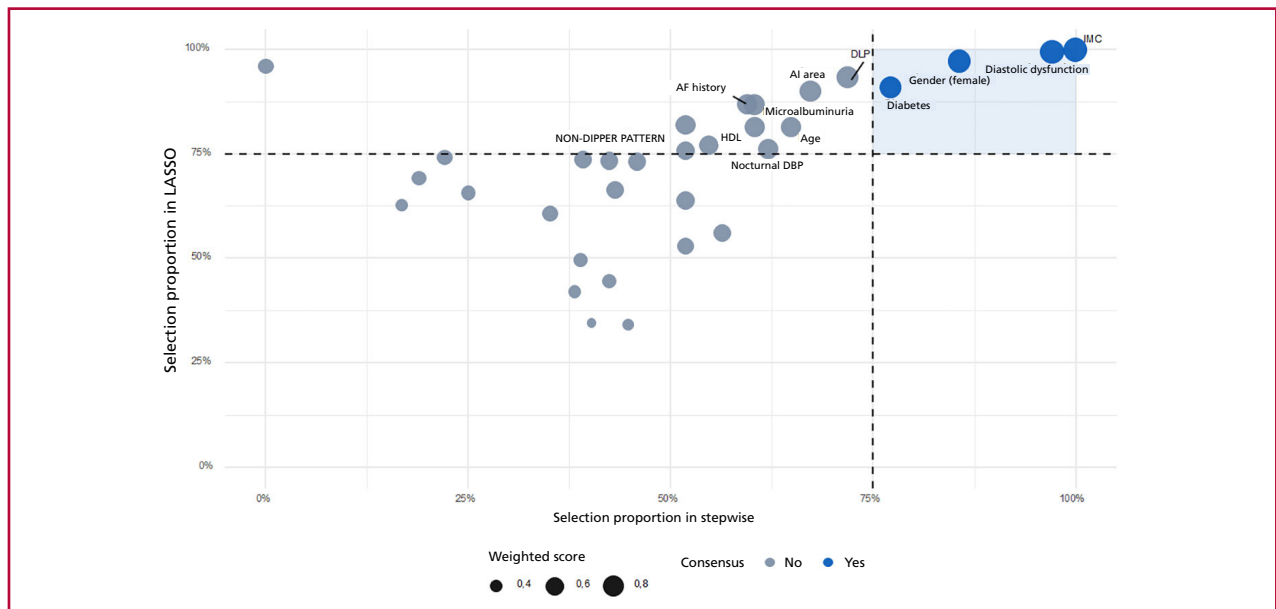
thropometric variables, particularly in populations with high cardiovascular risk, such as hypertensive patients. However, the absence of a direct comparison with these scores in our cohort constitutes a limitation; therefore, future studies should further evaluate the relative performance and incremental utility of this model compared to widely validated screening tools.

Although diabetes showed an association in the bivariate analysis, it did not remain a predictor in the final model, which could be explained by its multicollinearity with other cardiometabolic variables,

particularly BMI. Additionally, the limited number of events in the cohort constrained the number of variables that could be included in the multivariate model; therefore, its exclusion should be interpreted as a methodological decision aimed at preserving the stability of the model rather than as a lack of clinical relevance. (23,24)

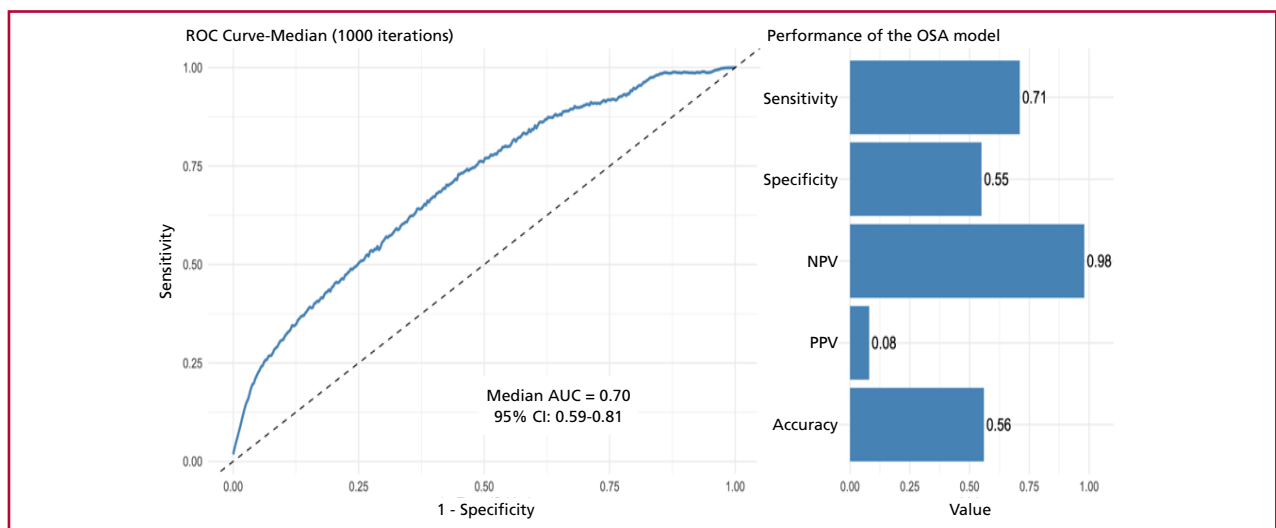
From a methodological standpoint, the combined use of two variable selection strategies (LASSO and AIC stepwise) within an internal validation framework using bootstrapping made it possible to identify clinically relevant predictors with good stability in or-

Fig. 1. Stability map: LASSO vs. stepwise



Size = weighted score (50% LASSO / 50% STEP). Shaded region = consensus (75% / 75% thresholds).
 AF: atrial fibrillation; BMI: body mass index; DBP: diastolic blood pressure; DLP; dyslipidemia; HDL: high-density lipoprotein; LA: left atrium; MACE: major adverse cardiovascular events.

Fig. 2. Performance of the OSA predictive model



ROC curve obtained with 1,000 bootstrap iterations. Median AUC: 0.70 (95% CI: 0.59-0.81). On the right, model performance with 71% sensitivity, 55% specificity, 98% negative predictive value (NPV), 8% positive predictive value (PPV), and 56% overall accuracy. OSA: obstructive sleep apnea

der to reduce the overfitting risk. (9,25) Unlike other scores developed in the general population, this model was derived from a cohort of hypertensive patients, a high-risk group with a high prevalence of OSA (1-3, 22,23,26), which could enhance its applicability in outpatient clinical practice. The clinical implications of detecting OSA in hypertensive patients are significant. Untreated OSA contributes to the progression of hypertension and is associated with an increased risk of cardiovascular events. (15,27) In this regard, the

American Heart Association has emphasized the importance of considering screening strategies in high-risk subgroups, such as those with resistant hypertension. (24) Similarly, interventions such as continuous positive airway pressure (CPAP) have demonstrated a reduction in blood pressure, especially in patients with resistant hypertension or an altered nocturnal blood pressure profile. (23,28)

Finally, among the limitations of our study, its retrospective and single-center design should be noted,

which could restrict the generalizability of the results. The low prevalence of OSA in the cohort, along with the small number of events, may have limited statistical power and affected the stability of the model, with a potential risk of overfitting in the selection of predictors. However, the implementation of variable selection techniques and internal validation using bootstrapping sought to mitigate this effect. Likewise, the low prevalence of OSA may have affected the diagnostic metrics, particularly the positive predictive value. The high negative predictive value observed should be interpreted in this context, given that prevalence directly impacts its magnitude. In this scenario, the model may prove more useful for ruling out the disease than for confirming it, although its performance should be evaluated in populations with higher prevalence.

Since the indication for polysomnography was not systematic but rather guided by clinical suspicion, the analyzed cohort represents a selected subgroup of patients, which introduces potential selection and verification bias. Consequently, the results should be interpreted in the context of a population with an increased pretest probability of OSA. Future studies should validate this model in larger multicenter cohorts, compare it with existing screening tools, and explore the incorporation of biomarkers and parameters derived from nocturnal blood pressure and left atrial strain, in order to optimize its performance. (14,15) Taken together, these findings provide preliminary evidence regarding the value of a clinical screening model in this population, which needs further confirmation in prospective studies and other cohorts.

CONCLUSION

The developed clinical model, based on simple variables that are easily obtained in outpatient practice, demonstrated moderate discriminatory power and high negative predictive value, which suggests its utility as a screening tool to rule out OSA in hypertensive patients. Its implementation could optimize screening, rationalize the indication for polysomnography, and promote early detection of a highly prevalent and frequently underdiagnosed condition. However, external validation in different settings and populations is required before widespread clinical adoption.

Conflicts of interest

None declared.

(See authors' conflict of interests forms on the web).

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