



## Original Article

## Can Pulse Transit Time Be Useful for Detecting Hypertension in Patients in a Sleep Unit? ☆



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## ABSTRACT

**Introduction:** Pulse transit time (PTT) is the time that a pulse wave takes to travel between two different arterial points, and may be useful in estimating blood pressure. This noninvasive technique, which does not add any cost to the procedure, offers the advantage of avoiding ‘arousals’ during sleep measurement as it occurs with ambulatory blood pressure monitoring (ABPM). We aim to confirm the usefulness of PTT for the detection of hypertension, and to study the correlation between both the measurements.

**Methods:** Prospective observational study in a multidisciplinary sleep unit. We recruited 30 consecutive patients attending a sleep clinic and ran a baseline polysomnography followed by an ABPM the following day. Average systolic and diastolic blood pressure (SBP, DBP) by PTT were calculated and compared with ABPM results. In accordance with international guidelines, patients with mean nocturnal ABMP  $\geq 120/70$  mmHg were diagnosed as having arterial hypertension.

**Results:** Mean age was of 60 years; 66% were male, of whom 80% suffered from sleep apnoea (OSAS). Taking the ABPM as the reference technique, we found that the diagnostic sensitivity of PTT is 85% with a specificity of 88% in the case of SBP, with a positive predictive value of 85% and negative predictive value of 88%. By studying the relationship between mean SBP measured by ABPM and PTT, we found a linear correlation coefficient (*R*) of 0.88, showing a distribution of all subjects with a difference of  $\pm 15$  mmHg between the tests. There is also a positive correlation between mean DBP measured for the two tests and with a weaker linear correlation.

**Conclusions:** Pulse transit time shows a strong correlation with blood pressure (measured by ABPM). PTT provides continuous, non-invasive, cuffless blood pressure monitoring free of additional cost and could be an alternative for screening hypertension.

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### ¿Puede ser el tiempo de tránsito de pulso útil para detectar hipertensión arterial en pacientes remitidos a la unidad de sueño?

## RESUMEN

**Introducción:** La relación causal entre el síndrome de apneas e hipopneas de sueño (SAHS) y la hipertensión arterial (HTA) es un hecho establecido en la literatura. El tiempo de tránsito de pulso (PTT) representa el tiempo que tarda el pulso en viajar entre 2 puntos arteriales diferentes, y puede ser útil en la estimación de la presión arterial (PA). Con este estudio se pretende valorar la utilidad del PTT en la estimación de la PA, ya que además de ser una técnica no invasiva y exenta de coste adicional, ofrece la ventaja de evitar *arousals*, como sucede con la monitorización ambulatoria de la PA (MAPA).

## Keywords:

Sleep apnea

Polysomnography

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Sleep-disordered breathing

Arterial hypertension

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**Métodos:** Estudio prospectivo y observacional realizado en una unidad multidisciplinar de sueño con la colaboración del servicio de Nefrología. Se reclutaron 30 pacientes consecutivos que acuden a consulta de sueño por sospecha de SAHS a los que se les realiza una polisomnografía (PSG) basal seguida de MAPA al día siguiente. Se calcula la PA sistólica (PAS) y la diastólica (PAD) media por PTT en la PSG y se compara con los resultados de la MAPA. Se diagnosticaron como pacientes con hipertensión arterial aquellos con cifras medias de MAPA durante la noche iguales o superiores a 120/70 mmHg, siguiendo normativas internacionales.

**Resultados:** Edad media de 60 años (66% varones). El 80% eran SAHS (36% SAHS grave). La validez diagnóstica de HTA del PTT con respecto a la MAPA considerada como técnica de referencia fue: sensibilidad, 85%; especificidad, 88%; valor predictivo positivo, 85%, y valor predictivo negativo, 88%. El coeficiente de correlación lineal (R) entre la PAS media medida por MAPA durante la noche (desde las 24:00 h del día siguiente hasta las 6:00 h) y por PTT fue de 0,88, con un coeficiente de correlación intraclase de 0,88 (intervalo de confianza: 0,76–0,94), observándose una distribución de todos los sujetos entre  $\pm 15$  mmHg de diferencia entre las pruebas.

**Conclusiones:** Existe una correlación positiva entre el PTT y la MAPA en la HTA sistólica. El PTT podría ser una alternativa capaz de ofrecer una medición continua y no invasiva de cribado de HTA no conocida o mal controlada.

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## Introduction

The association between obstructive sleep apnea-hypopnea syndrome (OSAHS) and hypertension (HT) has been widely studied since the 1980s, and is now fully accepted in the literature. It is estimated that 30% of the patients with systemic HT have moderate or severe OSAHS,<sup>1,2</sup> while between 45% and 68% of OSAHS patients have HT.<sup>3,4</sup>

A direct relationship has been observed between the severity of OSAHS and the probability of suffering hypertension, to the extent that OSAHS is considered as the most common cause of secondary systolic hypertension.<sup>5–10</sup> Furthermore, despite medical treatment, over 50% of the hypertensive population does not achieve target blood pressure (BP) goals. A total of 10% have persistently inadequate BP control, despite therapeutic compliance with more than three drugs (one of which is generally a diuretic) at optimal doses. This phenomenon is known as resistant HT<sup>11</sup> and is associated with a greater incidence of cardiovascular episodes and complications.<sup>12</sup> Several studies show a high rate of OSAHS (greater than 70%) in patients with resistant HT.<sup>10,13</sup>

The aim of early detection of hypertension and appropriate control with medication is to prevent cardiovascular complications and reduce high healthcare costs.<sup>14</sup> Continuous positive airway pressure (CPAP) in OSAHS patients with poorly controlled systolic HT provides better systolic control and even leads to recovery of the nocturnal dipper pattern, resulting in an improved prognosis.<sup>15</sup>

Given the variability of HT, various strategies for determining this parameter have been designed, each providing complementary information: BP measurement at a specific time point, self-measured BP (SBPM) and 24-h ambulatory BP monitoring (ABPM).

ABPM has become the reference technique for the diagnosis of HT. An average daytime or active value of <130/85 mmHg, an average nocturnal or resting value of <120/70 mmHg, and <125/80 mmHg for the 24-h period have been accepted as the normal limits. This technique consists of a Holter or automatic monitoring of BP every 15 min during the day and every 30 min at night, according to the recommendations of the European Society of Hypertension and the European Cardiology Society in their 2007 guidelines on the management of HT.<sup>14</sup>

However, although it is indicated in the guidelines as the reference non-invasive method, this technique has various limitations. Firstly, continuous recording is impossible and variations occurring over short periods throughout the night may be missed. Moreover, inflation of the cuff may affect not only the quality of

sleep, by causing small arousals, but can also produce changes in the measurement of nocturnal BP.<sup>16</sup> Finally, the discomfort of wearing the cuff for 24-h periods makes it difficult to recruit participants for research studies, or to persuade patients to agree to repeat these measurements over time, with the consequent loss of data.

At the other extreme, arterial catheterization, considered the gold standard, is too invasive to be considered a practical method for the diagnosis of HT.

An electrocardiogram and a pulse oximetry are standard techniques applied during a sleep study, and these procedures also permit the detection of the pulse wave or curve. From these two recordings, that do not involve any additional cost, the pulse transit time (PTT) can be estimated, thus providing continuous BP measurement.<sup>17,18</sup>

The aim of our study was to evaluate the correlation between the BP measurement obtained by ABPM (during the night) and by PTT using polysomnography (PSG) and also to evaluate the usefulness of PTT in the diagnosis of unknown or poorly controlled HT in patients monitored in a sleep unit.

## Materials and Methods

Prospective, observational study performed in a Multidisciplinary Sleep Unit, in association with the Department of Nephrology of the same hospital.

### Inclusion of Patients

A total of 35 consecutive patients attending the sleep-disordered breathing clinic for the first time due to a clinical suspicion of OSAHS who required a baseline nocturnal PSG (Somnoscreen plus, SOMNOMedics, analyzed with DOMINO software, version 2.5.0) were selected. Inclusion criteria were age over 18 years, no known sleep-disordered breathing and agreement to undergo ABPM the following day.

### Exclusion of Patients

PSG with a recorded sleep time of less than 3 h was considered invalid. A total of 5 patients were excluded from the analysis for this reason.

### Measurement of Pulse Transit Time

To determine PTT, the time between the R-wave on the electrocardiogram (representing ventricular contraction and start of

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