

Original Research Article

Correlation between plantar acceleration time and Doppler ultrasound with the ankle-brachial index in patients with peripheral arterial disease

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ABSTRACT

Background: Due to the inaccuracy of the ankle-brachial index, especially in diabetic patients, different alternative strategies have been considered to evaluate patients with peripheral arterial disease, such as the measurement of plantar acceleration time with Doppler ultrasound. The use of plantar acceleration time was described, which consists of measuring the morphology of the wave produced by the time elapsed from the beginning of systole until reaching the maximum systolic peak, as represented on Doppler ultrasound. A morphological change in the wave could indicate some interaction due to the presence of resistance to flow and arterial ductility.

Methods: Sixty-five inframalleolar ultrasound studies were performed in patients with peripheral arterial disease. The acceleration time was calculated, and statistical analysis was conducted using linear regression and analysis of variance. The patients were correlated with the ankle-brachial index and among the studied inframalleolar arteries.

Results: Correlations were calculated with a non-parametric method: Spearman's correlation coefficient and it was identified that the plantar acceleration time was not significantly correlated with the ankle-brachial index. Probably due to the presence of non-compressible ankle-brachial indices, a significant correlation was found between the inframalleolar arteries studied.

Conclusions: The plantar acceleration time is a necessary complementary study for evaluating patients with peripheral arterial disease. It is essential to perform more inframalleolar ultrasound studies in patients for whom the ankle-brachial index is compressible and assessable, to establish a significant correlation within our population.

Keywords: Peripheral arterial disease, Angiosome, Inframalleolar Doppler ultrasound, Plantar acceleration time, Ankle brachial index

INTRODUCTION

Arterial Doppler ultrasound and ankle-brachial index (ABI) are the most accepted and commonly used methods to evaluate arterial perfusion of the lower extremity. It has

been shown that in diabetic patients the measurement of the ankle-brachial index is not reliable, and, in many cases, it is not possible to measure it, so with the use of arterial Doppler ultrasound it is possible to evaluate the inframalleolar distal arterial vessels in the context of

peripheral arterial disease. Peripheral arterial disease occurs because of obstruction at the arterial level with a subsequent decrease in blood flow. This pathology could occur in patients with clinical symptoms of intermittent claudication, presence of skin lesions such as ulcers or even pain at rest. In some patients it could occur without clinical manifestations.¹ Multiple pathologies associated with peripheral arterial disease have been reported, among which is a high prevalence of metabolic syndrome, which is associated with multiple risk factors for peripheral arterial disease such as diabetes, high blood pressure and dyslipidemia.² To diagnose peripheral arterial disease, the patient's symptomatic condition is evaluated, and in some cases, the measurement of the ABI is used non-invasively. This is a highly specific measurement (80-100%) in patients who present with stenosis greater than 50%. However, it presents variable sensitivity; lower sensitivity and specificity have been reported in diabetic patients, patients with chronic kidney disease, and the elderly due to a greater formation of calcifications at the arterial level in these populations.³

Due to the limitation of the ABI along with other limitations in the assessment of adequate lower extremity perfusion, the use of plantar acceleration time (PAT) was described, which consists of measuring the morphology of the wave produced by the time elapsed from the beginning of systole until reaching the maximum systolic peak, as represented on Doppler ultrasound. A morphological change in the wave could indicate some interaction due to the presence of resistance to flow and arterial ductility. Arevalo-Zamora, et al found an association of a higher PAT value with a lower ABI index, which meant a greater commitment of patients with peripheral arterial disease.⁴ The plantar acceleration time has a significant correlation ($p < 0.001$) with the ankle-brachial index, classifying it into 4 groups according to Sommerset et al (Table 1).⁵ The objective of this study was to know the usefulness of plantar acceleration time as a complementary study of the ABI in patients with peripheral arterial disease.

Table 1: Comparison between PAT and ABI measurements.

PAT (ms)	ABI
0-120	0.90-1.3
121-180	0.69-0.89
181-224	0.40-0.68
>225	0.00-0.39

METHODS

A prospective study was carried out in the vascular laboratory of the vascular and endovascular surgery Angiology service of the Adolfo López Mateos Regional Hospital during June 2023-June 2024 in patients with peripheral arterial disease. The research protocol was approved by the research committee and ethics committee, with registration number: 244.2020. Sixty-five

inframalleolar ultrasound studies were performed in patients with peripheral arterial disease. The acceleration time was calculated in milliseconds (ms) for each limb, and statistical analysis was conducted using linear regression and analysis of variance (ANOVA) tests with a Microsoft excel database. The patients were correlated with the ABI and among the studied inframalleolar arteries.

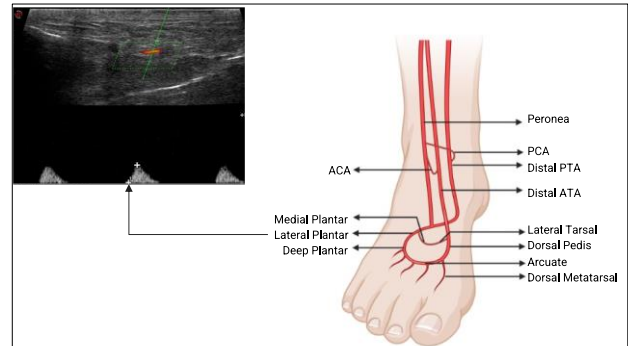


Figure 1: Schematic representation of the arteries evaluated, as well as the peak systolic wave obtained for PAT measurement.

RESULTS

In total there were 65 studies analyzed. In multiple studies, patients were found who did not have patency of all the inframalleolar arteries, so missing values were eliminated in these cases. To calculate the correlations, it was first determined whether the distribution of the data was normal or not; for this purpose, it is calculated with the Kolmogorov-Smirnov normality test. The ABI variables, pediatric and arcuate arteries showed normal distribution, the dorsal metatarsal, medial plantar, lateral plantar, and deep arch arteries variables showed to be non-normal.

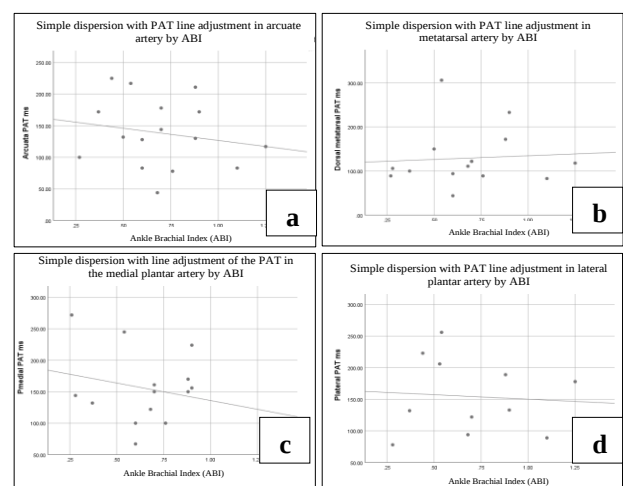


Figure 2: Correlation between ABI and PAT in the arteries: (a) arcuate, (b) metatarsal, (c) medial plantar, and (d) lateral plantar.

Correlations were calculated with a non-parametric method: Spearman's correlation coefficient and it was identified that the plantar acceleration time was not significantly correlated with the ABI. Probably due to the presence of non-compressible ankle-brachial indices, a significant correlation was found between the inframalleolar arteries studied (Figure 2).

DISCUSSION

To make an adequate approach to the patient with peripheral arterial disease, clinical suspicion with a correct history and complete examination is required. The ankle-brachial index has been described as an easily accessible, low-cost and non-invasive tool with high specificity and variable sensitivity. However, different limitations have been described in its use in some populations with a higher risk in which an underestimation of the index was found. Therefore, the usefulness of Doppler ultrasound and plantar acceleration time has recently been described as an alternative in the diagnostic approach of patients with peripheral arterial disease.¹

To carry out the PAT it is important to keep in mind a good technique and consider some recommendations such as obtaining at least 3-4 waves to obtain a spectral window and adjust it to a medium level, in addition the decrease in the color scale and increase the gain to make an artery filling. The color box should be adjusted in the appropriate direction and place the Doppler sample at an angle less than or equal to 60 degrees centered. Finally, the image is frozen and a measurement is made from the beginning of the systolic rise to the peak of systole. The artery evaluated in this technique is generally the lateral plantar artery, which is the one that can be most easily visualized by ultrasound. If the lateral plantar artery cannot be visualized, plantar acceleration can be evaluated in the arcuate artery, medial plantar artery or deep plantar arteries. The classification of time includes 4 categories. Ranging from findings without ischemia, mild ischemia, moderate ischemia and severe ischemia. The PAT has an invaluable utility in indicating the severity of the disease in more distal diseases, with a predictive value in the wound healing process and decision making for surgical management. Doppler ultrasound is more useful in distal vessels due to the ability to detect vessels that have a low velocity that failed to fill with contrast medium.⁶

In those patients with non-compressible and diabetic pressures, Doppler ultrasound, due to its availability and the fact that it is a non-invasive method, is the image of choice in the diagnosis of peripheral arterial disease, as it presents a high sensitivity and specification while providing information on arterial morphology regardless of the presence or absence of calcifications in it. However, its biggest disadvantage is that it is operator dependent.⁷ One of the main disadvantages in the use of Doppler is its operator-dependent characteristic. Vascular surgeons from the early stages of their training must know its management and interpret the results, since it has been

shown that in patients with peripheral arterial disease, Doppler ultrasound will allow focusing medical, surgical or endovascular management. Offering greater reliability in the diagnosis of peripheral arterial disease.⁸

The learning curve of the Eco Doppler is variable, and it is estimated that achieving good training will require multiple practice sessions to generate reliable results. With proper training, any doctor can perform an ultrasound study.⁹ Therefore, a timely diagnosis could be one of the necessary pillars to combat peripheral arterial disease.¹⁰

PAT is a reliable, unique and novel technique that could be applied to the patient when ABI, finger-brachial index or perfusion pressure cannot be obtained. A plantar acceleration time of less than 120 ms is considered normal. An acceleration time of more than 225 ms is considered severe and correlates with critical ischemia. This study has been useful for the pre- and post-surgical assessment of patients with ischemic wounds, as well as for making therapeutic decisions.

Limitations

This is one of the first studies reported in the Mexican population on the use of PAT in patients with peripheral arterial disease; the sample size should be improved in subsequent studies as well as a multicenter analysis.

CONCLUSION

The plantar acceleration time is a necessary complementary study for evaluating patients with peripheral arterial disease. It is essential to perform more inframalleolar ultrasound studies in patients for whom the ABI is compressible and assessable, in order to establish a significant correlation within our population.

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