Monophasic distal flow: It does not always mean atherosclerosis

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Resumen
La enfermedad arterial periférica es generalmente de origen aterosclerótico, aunque existen otras condicio-
nes que generan la presencia de flujos monofásicos arteriales distales en ausencia de estenosis. La ecogra-
fía Doppler es el estudio no invasivo de primera línea para la valoración del árbol arterial y caracterización de lesiones vasculares con una exactitud comparable a la angiografía.
El patrón de flujo normal (trifásico) puede verse suplantado por un patrón espectral monofásico en diversas condiciones fisiológicas y patológicas.
La presencia de flujo monofásico en arterias sin altera-
ciones parietales puede estar dado por la presencia de vasodilatación distal, ya sea de naturaleza fisiológica debido a un estado hiperdinámico (ejercicio), o bien debido a la presencia de lesiones vasculares de los

Abstract
Peripheral artery disease is usually secondary to athe-
rosclerosis, although there are other conditions that generate the presence of monophasic distal flows in the absence of stenosis. Doppler ultrasound is a non-invasive first-line examination for the evaluation of the arterial tree and characterization of vascular lesions with similar accuracy to angiography.
The normal flow pattern (triphasic) can be supplanted by a monophasic spectral pattern in various physiologi-
ical and pathological conditions.
The presence of monophasic flow in arteries without parietaal alterations can be the consequence of distal vasodilation either of a physiological nature due to a hyperdynamic state (exercise), or due to the presence of vascular lesions of the soft tissues that determine distal hyperflow.

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Arteries in the lower extremities can be affected by several pathologies, but the most frequent is atherosclerosis with a great epidemiological importance due to its morbidity and mortality (1).

The study of the arterial tree in lower extremities is performed regularly with B-mode ultrasonography (gray-scale), color flow Doppler ultrasound, and spectral Doppler ultrasound with a lineal high-frequency transducer (7-9 MHz) and sometimes with a convex transducer (3-5 MHz) to examine the aortoiliac segment or distal segments in obese patients or in those with severe edema in their lower extremities.

The exam is performed with the patient lying on his back with external rotation of the hip and the knee of the limb under study slightly bended. The examination goes from the common femoral artery to the distal segments of the tibial-peroneal trunks.

By means of gray-scale images, the vascular and perivascular anatomy as well as arterial walls are studied. By means of the color Doppler and spectral Doppler technique, the blood flow pattern and its speed can be analyzed (2).

The disadvantages of this method lie in its incapacity to generate a panoramic image, since the study is performed in segments and its quality depends on the operator (3).

Among other study methods, the multislice Angio-tomography, Magnetic angio-resonance, and digital angiography, are considered as the gold standard methods.

In peripheral arteries, the arterial flow pattern is triphasic under optimal conditions of room temperature and rest. The initial peak of this pattern or first antegrade deflection is the result of the ventricular systole. This is followed by a reverse flow of short duration or retrograde deflection in the early diastole caused by an increased resistance of the small...
peripheral and capillary arteries, and finally, a small flow peak or second antegrade deflection in the late diastole resulting from the decreased wall elasticity of the peripheral arteries. The absence of any of these components creates a loss of the triphasic pattern and dictates the dismissal of any alteration in the arterial distal or proximal tree (1).

In normal arteries, i.e., with healthy walls, erythrocytes move in parallel layers forming a laminar flow and the color Doppler shows them as uniform and with a clean window below the systole (3).

The characteristic pattern of the peripheral arteries flow, including those of lower extremities, is triphasic and has high resistance with a decreasing speed in a distal sense. The normal values are 100 cm/sec at the level of the common femoral artery, 80-90 cm/sec at the level of the superficial femoral artery, 70 cm/sec at the level of the popliteal artery, and 50-40 cm/sec at the level of the tibial-peroneal arteries (1).

The distal vascular resistance depends mainly on the arteriole and it is determined mainly by muscle tissue at rest or muscle tone. It can be altered by several physiological or pathological conditions, but the most clinically important is the one occurring posteriorly to the sites of stenosis hemodynamically significant. Others are local inflammatory processes, presence of arteriovenous fistula or inflammations after exercise.

Vasodilation of small distal arteries or recruitment of distal circulation modifies the morphology of the proximal flow spectrum.

The monophasic flow is characterized by presenting a unique antegrade deflection with a decrease or absence of the other two components of the triphasic spectrum due to the decrease in the peripheral vascular resistance (1).

**Peripheral artery disease**

Oclusive peripheral artery disease is generally the consequence of atherosclerosis. When there is significant stenosis (>70%), the flow is often monophasic and has low resistance. It is due to vasodilation secondary to ischemia, recruitment and arteriolar dilation, and the development of collateral circulation (Figures 1a, 1b, 1c and 1d) (4).

**Arteriovenous fistula**

Arteriovenous fistulas can be secondary to arterial puncture or penetrating traumatisms. The most frequently involved sites are femoral vessels due to their anatomical disposition.

There may be signs of distal ischemia, presence of collateral vessels, or signs of heart failure in large fistulas.

The characteristic sign is the arterialization of the venous spectrum that becomes pulsating, which helps in identifying the fistulous tract. If communication is significant, the distal arterial spectrum can be monophasic and have low resistance, which indicates a certain degree of distal ischemia (Figures 2a, 2b, 2c and 2d) (5).

**Arteriovenous malformation**

Arteriovenous malformations have a congenital vascular origin and can act as arteriovenous shunts and bypass the distal capillary network. They cause an increase in venous return with arterialized flow. In the event that the lesion is significant, it can appear with a hyperflow towards it, with consequently presence of arterial monophasic flow secondary to vasodilation (Figures 3a, 3b, 3c and 3d) (6).

**Inflammatory processes**

Inflammatory and infectious processes of soft tissues like erysipelas or cellulitis produce a histamine, prostaglandins and leukotrienes release. These inflammatory mediators have a direct effect on the arteriolar walls causing vasodilation as a first response. This arteriolar dilation permits the arrival of a greater blood flow to the affected area, which attracts a greater number of inflammatory mediators and this stimulates the cycle (7).

As mentioned above, the decrease in peripheral vascular resistance due to vasodilation alters the spectrum of the normal triphasic flow turning it into monophasic flow (Figures 4a, 4b, 4c and 4d).

**Exercise**

When there is a decrease in the peripheral local resistance and a generation of distal vasodilation, there
is a consequent disappearance of the reverse flow during diastole, where a low resistance monophasic flow can be observed.

This can be reflected in the case of a healthy adult patient who did exercise. The spectrum of the flow at the level of the posterior tibial artery before and after exercise was recorded (Figures 5a and 5b) (8).

This should be taken into account when examining a patient in search of peripheral arterial diseases, since although they do not create confusion, they could be overlapping with obstructive arteriopathy with an overestimation of results and thus jeopardizing the analysis.

Conclusion
Peripheral atherosclerotic disease has a great epidemiological significance; therefore, the ability to distinguish and dismiss other causes of monophasic flow is essential in everyday practice.

Figure 1.
Diffuse parietal atheromatosis with a mosaic pattern in color Doppler (A) and monophasic spectrum at the level of the superficial femoral artery (B), popliteal artery (C) and posterior tibial artery (D).
Figure 2.
There is a fistulous vascular tract at the level of anterior tibial vessels (A and B) with presence of monophasic flows distal to fistulae (C and D).

Figure 3.
There are monophasic spectra in anterior (A) and posterior (B) tibial arteries secondary to the presence of arteriovenous malformation in the soft tissues of the foot (C) with a characteristic high-speed arterialized venous flow (D).
Figure 4.
There is normal triphasic spectrum flow at the level of the superficial femoral artery (A) in a patient with erysipelas in the leg (B) and consequent monophasic flows in anterior (C) and posterior (D) tibial arteries due to vasodilation.

Figure 5.
There is normal triphasic flow at the level of the anterior tibial artery in a healthy patient at rest (A) with a record of monophasic flow at the level of the same artery (B) after doing physical exercise.
Bibliography


