Characterization of the active response of carotid arteries measured by pressure myography.

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Abstract

The biomechanical analysis of arteries represents a fundamental area of research to understand their behavior under physiological and pathological conditions. The carotid arteries, major vessels supplying blood to the brain, are critical for hemodynamic regulation and metabolic exchange to brain tissue. Their central role in the cardiovascular system makes them an ideal model to explore mechanobiological phenomena in both normal and pathological conditions (1).

This work analyzes carotid arteries extracted from rats raised under normal conditions and subjected to hypobaric hypoxia, aiming to identify differences in their active contractile response. These arteries exhibit biomechanical characteristics, including highly anisotropic walls with an organized extracellular matrix that supports both continuous and pulsatile pressures (2). Therefore, the contractile properties of smooth muscle in the carotids play an essential role in regulating cerebral blood flow, highlighting the importance of studying their active response under chemical and mechanical stimuli.

The pressure myography used allows the evaluation of the active response of the carotid arteries under controlled conditions, simulating both physiological and pathological pressure ranges. Measurements were taken under both static and pulsatile pressures to reflect the complexity of hemodynamic conditions. The arteries were exposed to a Krebs Ringer physiological solution enriched with KCl to induce smooth muscle contraction, providing a direct view of how hypobaric hypoxia affects the active contractile response and arterial stiffness (3).

The chemical-mechanical model developed by Murtada has been used to describe the contractile behavior of the carotid arteries in isometric activation studies (4). This model combines interactions between the cellular components of smooth muscle and the passive properties of the extracellular matrix. The fitting process is carried out using a non-linear least squares method applying finite element simulations, achieving a representation of arterial behavior in both experimental groups.

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The study emphasizes the relevance of the active response in carotid arteries as a model for understanding vascular adaptations to hypoxic conditions. In low oxygen pressure situations, such as those found at high altitudes, the carotids undergo structural remodeling that can alter their mechanical and functional properties. This has direct implications for the regulation of cerebral blood flow and the predisposition to cerebrovascular diseases. The integration of experimental tools, such as pressure myography, and theoretical models, such as Murtada's chemical-mechanical model, enables a comprehensive approach to the complex mechanobiological phenomena that govern the behavior of these arteries.

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