Microvascular abnormalities and hemodynamic alterations in arteriovenous fistulas and malformations.

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Introduction

Arteriovenous fistulas (AVFs) and malformations (AVMs) are vascular anomalies characterized by abnormal connections between arteries and veins. These conditions can result in significant microvascular abnormalities and hemodynamic alterations, leading to clinical manifestations ranging from cosmetic concerns to life-threatening complications. This article provides an in-depth review of the microvascular abnormalities and hemodynamic alterations associated with AVFs and AVMs, focusing on their underlying mechanisms, diagnostic approaches, and therapeutic implications [1].

Arteriovenous fistulas and malformations are congenital or acquired vascular anomalies characterized by direct connections between arteries and veins, bypassing the normal capillary bed. These abnormal vascular communications disrupt the natural hemodynamic balance, resulting in microvascular abnormalities and altered blood flow dynamics. Understanding the underlying mechanisms and consequences of these microvascular abnormalities and hemodynamic alterations is crucial for accurate diagnosis, risk assessment, and effective management of AVFs and AVMs [2].

Microvascular abnormalities in AVFs and AVMs encompass a spectrum of structural and functional changes within the affected vascular bed. Dilated and tortuous vessels, arteriovenous shunting, microaneurysms, and abnormal capillary networks are among the common manifestations. These abnormalities are a result of altered vascular remodeling, endothelial dysfunction, and dysregulated angiogenesis. The presence of abnormal microvasculature contributes to tissue hypoxia, impaired tissue perfusion, and altered metabolic demands, which can lead to tissue ischemia, organ dysfunction, and secondary complications.mThe presence of AVFs and AVMs disrupts the normal hemodynamic balance by creating high-flow arteriovenous shunts. Hemodynamic alterations include increased blood flow velocity, elevated arterial pressure, turbulent flow patterns, and altered shear stress within the abnormal vascular connections. These alterations can lead to endothelial damage, inflammation, and thrombosis. Additionally, the hemodynamic burden on the heart and surrounding vasculature may result in cardiac overload, heart failure, and vascular remodeling [3,4].

Accurate diagnosis of AVFs and AVMs requires a combination of clinical evaluation, imaging modalities, and hemodynamic assessments. Various non-invasive and invasive imaging techniques, such as ultrasound, magnetic resonance imaging (MRI), computed tomography angiography (CTA) and catheter-based angiography, are employed to visualize the vascular anatomy, identify microvascular abnormalities, and evaluate hemodynamic parameters. Advanced imaging techniques, such as 4D flow MRI and micro-ultrasound, offer valuable insights into the complex hemodynamics of AVFs and AVMs. Treatment strategies for AVFs and AVMs aim to restore normal hemodynamics, relieve symptoms, and prevent complications. Therapeutic options include embolization, surgical resection, radiosurgery, and targeted pharmacotherapy. Selecting the appropriate treatment approach depends on several factors, including the anatomical characteristics, clinical presentation, and associated complications. Furthermore, advancements in endovascular techniques and personalized medicine approaches hold promise for improving outcomes and reducing the risk of recurrence [5].

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