A Critical Role of Platelet Glycoprotein Ibα in Arterial Remodeling

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The canonical role of platelets is hemostasis in which they function as highly specialized cells designed to plug holes in the blood vascular system. To accomplish this task, platelets have evolved unique molecular tools that enable them to function in the vascular environment, such as the GPIbα receptor complex that mediates platelet adhesion to the vessel wall in the face of high shear forces and stringent activation pathways that trigger adhesive interactions mediated by integrin receptors. It is becoming increasing apparent that platelets may also use these specialized molecular tools to perform vascular tasks other than plugging holes and preventing blood loss. Some of these more recently defined roles seem to be variants of their canonical role, for example, lymphovenous hemostasis that controls the flow of lymph into the blood circulation, and inflammatory hemostasis that prevents bleeding at sites of extremely high vascular permeability. Others seem to be truly nonhemostatic, for example, platelet adhesion to leukocytes to facilitate their passage across blood vessel wall at sites of inflammation. Common to these noncanonical platelet roles is the use of unique molecular mechanisms that allow platelets to respond to stimuli in the vascular environment that may be physical (eg, shear), cellular (eg, blood versus lymphatic endothelium), or molecular (eg, platelet activators such as thrombin, ADP).

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In the present issue of ATVB, Chandraratne et al describe a new role for platelets and for GPIbα, the platelet-specific receptor that enables cellular adhesion under shear, during the formation of collateral arteries after femoral arterial ligation (a process termed arteriogenesis, although it involves expansion of existing vessels rather than the growth of new ones). Using in vivo microscopy, they observe transient adhesion of platelets to the endothelium of small arteries destined to become collateral vessels shortly after femoral artery ligation and to that of adjacent veins as well. Platelet adhesion is dependent on the function of GPIbα, a receptor that binds endothelial-derived von Willebrand’s factor under high shear forces, and is coincident with firm leukocyte adhesion to the walls of those vessels. Loss of platelet GPIbα reduces leukocyte adhesion and migration across the walls of developing collateral vessels. The formation of platelet-leukocyte complexes is observed in whole blood shortly after femoral artery ligation, and loss of either platelets or GPIbα receptor function impairs the recovery of blood flow that results from collateral vessel expansion. These studies identify a role for platelets and the GPIbα receptor in facilitating the leukocyte migration associated with the expansion of collateral vessels after arterial ligation (Figure).

How do these new findings impact our understanding of platelet participation in nonhemostatic vascular responses? As observed in prior studies of platelet participation in inflammatory responses (eg, after vessel exposure to tumor necrosis factor alpha- or during lymphocyte extravasation in the high endothelial venule), an important aspect of the platelet role in collateral growth is to facilitate leukocyte extravasation at specific vascular sites through adhesive interactions. In inflammatory settings, this is accomplished by a subset of circulating platelets that are activated and express the adhesive ligand P-selectin. Thus, it will be important to determine whether platelet participation in arterial remodeling/collateral vessel formation also requires platelet activation and P-selectin expression. Unlike previous studies, Chandraratne et al specifically implicate the shear-responsive adhesive receptor GPIbα in collateral vessel formation. The precise stimuli that drive the remodeling of small arterioles to larger collateral vessels are as yet unknown, but one candidate is the rise in perfusion pressure and vascular shear forces to which these vessels are exposed after arterial ligation. Thus, changes in hemodynamic forces in potential collateral vessels may stimulate endothelial von Willebrand’s factor release and transient platelet adhesion through GPIbα, allowing platelets to bridge the vessel wall and circulating leukocytes that need to extravasate to drive vessel remodeling (Figure). In this manner, the molecular specialization developed to generate shear-resistant platelet thrombi may serve a second role in shear-dependent vascular remodeling.

These new findings raise numerous questions on the role of platelets in the vascular remodeling that underlies collateral vessel formation. Is platelet activation required? If so, what is the activating stimulus in an otherwise healthy vessel with intact endothelium? Significantly, the authors observe both platelet and leukocyte adhesion to venules and arterioles in the region of the ligated artery, events that are also GPIbα-dependent. It is not likely that arterial ligation would directly alter venous hemodynamics, raising the question of how adjacent venules become involved in this process. Collateral arteries arise gradually in human limbs and hearts in response to chronic tissue ischemia (eg, as native arteries become occluded by atherosclerosis). It is possible that ischemia in the tissues fed by the ligated or diseased artery results in changes...
in the venous blood drained from those tissues that alter the downstream venous endothelium to stimulate the platelet and leukocyte adhesion observed by Chandraratne et al.5 Future studies extending the insights of this study will address these questions and perhaps reveal new strategies to drive collateral vessel formation in patients with ischemic vascular diseases.

Disclosures
None.

References


Figure. Platelets facilitate collateral vessel formation. A, Before ligation of the femoral artery, small branch arterioles and venules are in a quiescent state associated with lower blood flow and lower vessel wall shear forces. B, After femoral artery ligation, proximal arterioles are exposed to increased flow and shear forces. These hemodynamic changes are associated with platelet adhesion to vascular endothelium that is mediated by interaction of the platelet GPIbα receptor (GPIb) with endothelial von Willebrand’s factor (vWF). Shear-resistant platelet adhesion facilitates the extravasation of blood leukocytes and the creation of a local inflammatory response that drives expansion of the vessel and development of collateral blood flow. Similar changes are observed in the neighboring veins, where the role of fluid shear is less defined (not shown).

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