Estimation of wall shear stress in bypass grafts with computational fluid dynamics method

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Abstract
Coronary artery bypass graft (CABG) operation for coronary artery disease with different types of grafts has a large clinical application worldwide. Immediately after this operation patients are usually relieved of their chest pain and have improved cardiac function. However, after a while, these bypass grafts may fail due to, for example, neointimal hyperplasia or thrombosis. One of the causes for this bypass graft failure is assumed to be the blood flow with low wall shear stress. The aim of this research is to estimate the wall shear stress in a graft and thus to locate areas where wall shear stress is low. This was done with the help of a blood flow computer model. Post-operative biplane angiograms of the graft were recorded, and from these the three-dimensional geometry of the graft was reconstructed and imported into the computational fluid dynamics (CFD) program FLUENT. The stationary diastolic flow through the grafts was calculated, and the wall shear stress distribution was estimated. This procedure was carried out for one native vessel and two different types of bypass grafts. One bypass graft was a saphenous vein and the other one was a varicose saphenous vein encased in a fine, flexible metal mesh. The mesh was attached to give the graft a defined diameter. The computational results show that each graft has distinct areas of low wall shear stress. The graft with the metal mesh has an area of low wall shear stress (< 1 Pa, stationary flow), which is four times smaller than the respective areas in the other graft and in the native vessel. This is thought to be caused by the smaller and more uniform diameter of the metal mesh-reinforced graft.

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