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Inside Hemodynamics of Bifurcated Aortic Graft

The interesting article by Kontopodis et al. about hemodynamics of different sizes and features of implanted bifurcated aortic prostheses merits to be deepened in some pathophysiological features.[1] First, in the medium/long term, these vascular prostheses, termino-lateral implanted on the abdominal aorta, become wrapped by fibrous constrictive reaction, greatly limiting their parietal elasticity. Second, their insertion angle on the aorta and reduced caliber concur to transform the normal aortic pulsating laminar flow into a turbulent one with a high Reynolds number. Consequently, the main blood flow splits into multiple streams, some of which with an obliquely incident or even opposite direction against the original force vector, which, for the forces parallelogram, decreases its strength. Third, the ''windkessel'' phenomenon, that in elastic arteries transfers part of the blood stream energy from systolic to diastolic phase, is canceled (Fig. 1). It results that part of the blood flow original kinetic energy is lost through a mechanism of parietal dispersion. Distally, in the prosthesis branches, the blood flow, consisting of a non-Newtonian fluid, progressively reduces its velocity, sometimes switching from a turbulent to a laminar flow, as per a low Dean number. However, for the Hagen-Poiseuille law, its total energy decreases proportionally to the conduit length, reduced radius, and increased peripheral resistances. Moreover, the original blood stream vector, crossing from the aorta to the graft upper straight segment and downstream to its branches, changes its direction, first in a sagittal plane and then in an oblique-concave one, decreasing its power proportionally to the size of each angle. Many of these pathophysiological elements correlate with 3D computed tomography, Color Doppler ultrasound, and mainly 4D magnetic resonance reformatted imaging, capable to outline the different streamlines inside a vessel or prosthesis of large/medium caliber.[2-6] Of importance, the decreased compliance of the implanted prosthesis highly opposes the progression of systolic waves, canceling, when present, also the right-handed helical flow, beneficial in reducing blood stream turbulence.[7,8] These drawbacks suggest some technical tricks. In particular, the bifurcated prosthesis that will be termino-lateral implanted on the aortic wall, upward is trimmed obliquely and in a beveled fashion, to minimize the corresponding bending angle. Correspondingly, its main body length is calculated to reduce the angle sizes with each of its 2 branches; thereafter, it is arranged to avoid any torsion and deformation of its round section.[9-11] All this is intended to reduce the blood flow energy dispersion and maintain as far as possible a normal rheological feature, reducing the risk of a ''prosthesis disorderly flow disease''. This complication predisposes to thrombosis and insufficient peripheral blood supply, mainly in the case of lower limbs with increased vascular resistances. The same principles can be applied in endovascular surgery, where an endoprosthesis, optimized design, caliber, and length would reduce the endoleak risk.

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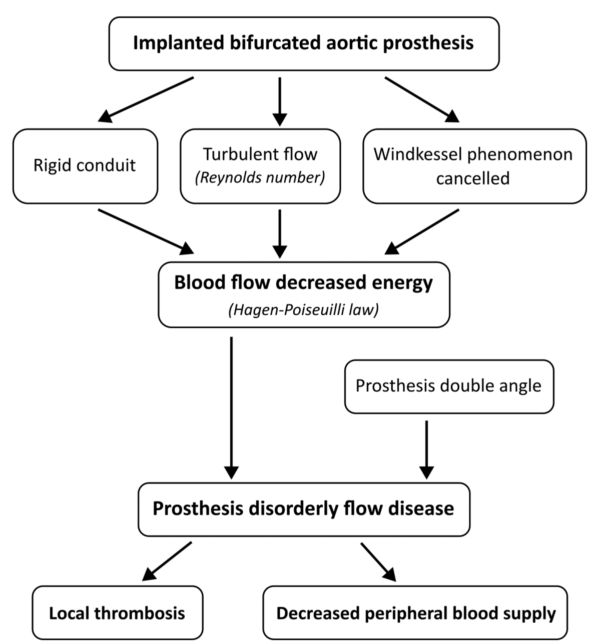

Fig. 1. Possible cascade of hemodynamic negative events after bifurcated aortic prosthesis implantation.

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