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DIGITAL MODEL OF RADIOCEPHALIC ARTERIOVENOUS FISTULA FOR DECISION SUPPORT AND IMPROVEMENT OF MATURATION

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Objectives: The native arteriovenous fistula (AVF) is the recommended first intention vascular access in dialysis patients. This non-physiological surgical construction implies many anatomical and hemodynamic parameters. Radiocephalic AVFs are preferred due to a low rate of long-term complications. The early rates of thrombosis and failure of maturation of the distal AVFs remain high, between 20 and 50%. The aim of this work was to obtain a faithful digital model simulating the flow of a radiocephalic AVF to guide the surgeon in the choice and the technical realization of AVFs in order to improve maturation.

Material and methods: We created a digital model simulating the flow using the Foam-extend 4.0 software with resolution by PISO algorithms (procedure of pressure to velocity calculation for the analysis of nonstable compressible fluid). We then analyzed the influence of five parameters on maturation: artery and vein diameters, distance between the two vessels, diameter and angle of the anastomosis. We evaluated the development of myointimal hyperplasia in the anastomotic and post-anastomotic zones by studying the wall shear-stress and the oscillating shear-stress. We finally compared the results of our simulation with the data of five patients.

Results: Our digital model allowed to predict the flow of an AVF according to the diameters and distances of the vessels and to advise against radio-cephalic AVF when the parameters are too unfavorable (too much loss of energy in the peri-anastomotic zone). Furthermore, the anastomotic angle was the parameter having the most influence on the maturation and the development of myointimal hyperplasia. The comparison between simulation and clinical data obtained with the 1-month duplex showed a good correlation in terms of flow and development of stenoses in the five cases.

Conclusion: Our digital model is reproducible and valid with a good correlation with the clinical cases.

It could give recommendations to the surgeon on chances of maturation of an AVF according to the preoperative anatomical parameters and the best anastomotic angle to have a good maturation. This model should now be tested on a larger number of clinical cases.

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