BIOMECHANICAL ADAPTATION OF THE CAROTID ARTERY TO FLOW OVERLOAD IN A PORCINE ANASTOMOSIS MODEL

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1. Introduction

The formation of the arteriovenous (AV) anastomosis with the use of synthetic grafts is a common practice to the hemodialysis patients. This study focused on the biomechanical changes of the arterial part of AV anastomosis, which are induced by the alterations on the hemodynamics conditions of the anastomosed vessels.

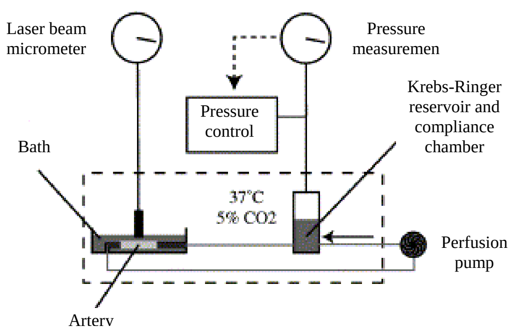

Figure 1: Schematic representation of the apparatus used for biomechanical testing

2. Materials and Methods

PTFE graft was fixed between the common carotid artery and the inner jugular vein in 6 Landrace pigs. The blood flow in carotid was measured before and after the AV anastomosis using perivascular flowmeter (Transonic). One month later, the intraluminal pressure was measured by catheters of high sensitivity (Millar) at the anastomosis carotid (AC) and at the contralateral carotid (CC) while the blood flow was measured as above, at the same vessels. Then, the animals were euthanatized, and the carotids were submitted in inflation-extension tests (Fig.1). The vessels were extended to the in situ length and after their mechanical preparation, pressure-diameter data from one inflation cycles (0 - 200 mmHg) were recorded for further mechanical studies. The experimental curves were converted to area-pressure curves and compliance was calculated as the first derivative of area over pressure while distensibility was calculated as the ratio of compliance to area. Wall stress in the circumferential direction was calculated from the Laplace equation $\sigma_\theta = P_i D_i / 2T$, and shear stress from the equation $\tau = kQ/(D_i/2)^3$, where P_i, D_i, T, k, Q are the intraluminal pressure, the inner arterial diameter, the arterial thickness and the blood flow, respectively and k depends on bloods' viscosity.

3. Results

The blood flow in the AC was significantly increased after the anastomosis formation (267.1±44.4 vs. 551.0±103.0; Fig 2a) and it did not alter until the animals' euthanasia

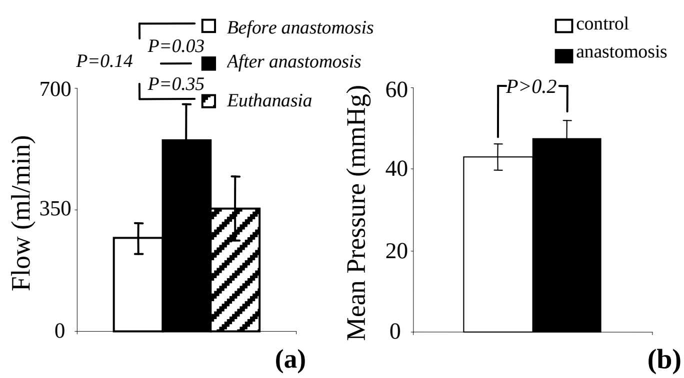

Fig.2: Mean flow at different phases (a) and mean pressure at different vessels

(414.9±86.4; Fig. 2a), while there was no difference between the pressures in AC and CC (47.5±4.4 vs. 42.9±3.2; Fig. 2b). Pressure-diameter curves of AC, was observed to be transposed to higher diameters compared to CC at all pressures (Fig. 3a). Both circumferential and shear stresses, at the mean pressure, were higher at the AC but the differences were not significant (9.8±2.0 vs. 6.9±0.4; Fig 4a, and 0.6±0.1 vs.0.4±0.1; Fig 4b, respectively). Compliance-pressure (Fig 3b) and distensibility-pressure curves (Fig 3c) of CC performed higher values at low pressures (0-30 mmHg) and lower values at higher pressures (30-200 mmHg), while at the in vivo pressure, both compliance was significantly higher at AC (0.361±0.058, vs. 0.077±0.012; Fig 4c) and also distensibility (0.009±6 x10^{-4} vs. 0.003±4 x10^{-4}; Fig 4d).

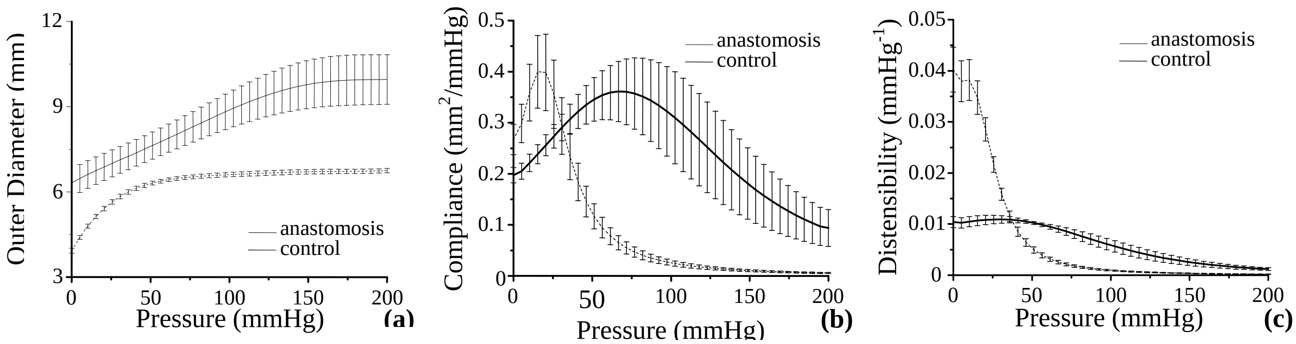

Fig.3 Diameter-pressure, compliance-pressure and distensibility-pressure curves

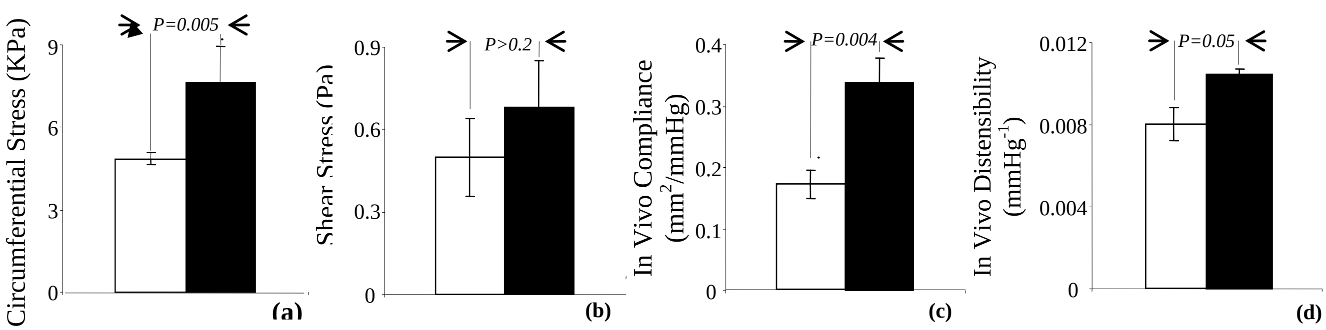

Fig.4 Circumferential stress (a), shear stress (b), compliance (c) and distensibility (d) at the in vivo mean pressure for the control (□) and anastomosis (□) vessels

4. Conclusions

As a consequence of AV anastomosis, both the blood flow and the shear stresses at AC were increased. As a result of those long term hemodynamics alterations, the diameter of AC was increased and the shear stresses returned to the physiologic range, whereas this was not observed to the circumferential stresses which remained increased. Moreover the AC biomechanical properties were changed, as both the compliance and the distensibility, at the mean pressure, were increased. It is evident, that in response to the hemodynamics changes, the arterial part of the AV anastomosis is remodeled, so that the shear stresses will be returned to their homeostatic values.

5. References

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