Influence of Shear Forces and Pressure on Vessel Wall Metabolism

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Introduction

Perfusion bioreactors are commonly used to develop small caliber vessel grafts for peripheral or aortocoronary revascularization. Mechanical strain caused by shear forces and pressure may alter vessel function and thus affect metabolism, nutritional requirements, and media wastage. This study used bovine veins as a model to determine the influence of increased shear forces and of luminal pressure on vessel wall function and metabolism in a perfusion bioreactor.

Materials and Methods

Bovine medial saphenous veins (BSV, 5-16 animals per group) were mounted in perfusion chambers and perfused for 4 days at 40 ml/min. Bioreactors were gassed with 20% O_2 and 5% CO_2. Starling resistors allowed to apply luminal pressure. Group 1+ BSV were perfused with perfusion medium (M199, 20% fetal calf serum, antibiotics). Group 2+ BSV were perfused with perfusion medium supplemented with 12% (w/v) dextran to adjust the viscosity to that of blood. Group 3+ BSV were incubated in the same medium, and luminal pressure (20 mm Hg) was applied. Group 1-, 2-, and 3- vessels were incubated accordingly, but were endothelium-denuded mechanically prior to perfusion. Media samples were blood-gas-analysed every day. Vascular function was assessed by tetrazolium dye reduction and by organ bath experiments before and after perfusion.

Results

There were no significant differences between groups 1+, 2+, and 3+ on day 4 in TDR and in receptor-independent contractions induced by KCl, whereas group 3+ BSV responded significantly stronger to noradrenaline (NA) on day 4 ($p<0.001$, ANOVA, Fig. 1). Without endothelium, TDR, KCl-induced contractions, and NA-induced contractions were significantly stronger in group 3- ($p<0.001$, ANOVA).

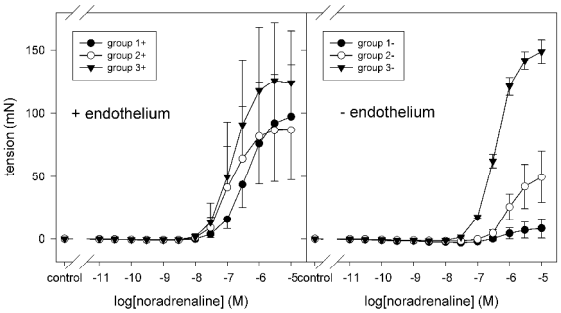

Fig. 1. NA-induced contractions of BSV (day 4)

Glycolytic indexes (normalized ratio of lactate production and glucose consumption) were 1.16/2.41, 1.01/1.42, and 1.58/1.77 ($p<0.001$, ANOVA) for groups 1+/1-, 2+/2-, and 3+/3-, respectively, indicating a shift towards energy sources other than glucose under load in the presence of endothelium, whereas glucose is generally of less importance in denuded vessels.

Discussion and Conclusions

Vessel wall function and metabolism are affected both by shear forces and by luminal pressure. Salutary effects of shear forces require an intact endothelium, whereas luminal pressure acts in an endothelium-independent fashion. BSV consume glucose without oxidative phosphorylation unless challenged mechanically. In this case, metabolism shifts toward the consumption of substrates other than glucose, which appears to be generally the case in endothelium-denuded vessels. Mechanical strain is beneficial for vessels in perfusion models, but care needs to be taken to provide sufficient energy sources besides glucose.

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Disclosures

none