Hemocompatibility of Various Heart Valve Materials

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Statement of Purpose: Hemocompatibility is a crucial component of a successful heart valve. Current heart valve designs can be mechanical or bioprosthetic. Each design has limitations. Mechanical heart valves are highly thrombogenic, which necessitates the patient to be on lifelong anticoagulation therapy. Bioprosthetic heart valves are not as durable as mechanical valves, which means they must be replaced much sooner. Both types of valves can cause many complications, including thromboembolism and endocarditis [1]. The goal of this project is to create a material which is non-thrombogenic and has the durability characteristics of a mechanical valve. This will be achieved by coating a base material with hyaluronic acid (HA). In this study, we have investigated the platelet adhesion on various types of potential heart valve materials.

Methods: Samples of LLDPE, ePTFE, Dacron, and bovine and porcine pericardium were created by using an 8-mm biopsy punch. Samples of polystyrene as a control were created by drilling out 8 mm diameter discs. SEM images of the samples were obtained to visualize the surface topography. Contact angle measurements of deionized water droplets on the surfaces of the samples will be taken to determine the hydrophilic nature of the samples. The samples were exposed to human plasma for 2 hours. The cytotoxicity was analyzed by LDH assay. Platelet activation was analyzed by live staining with Calcein AM and SEM images.

Results: SEM images of the untreated and uncoated base materials show ePTFE and Dacron to be most porous of all of the materials. LLDPE and polystyrene did not show any porosity. No surface topography could be distinguished with SEM imaging.

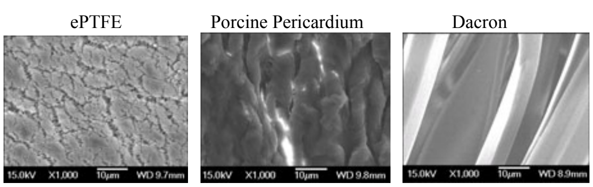

Fig. 1: Representative SEM images of ePTFE, porcine pericardium, and Dacron at 1,000X

The preliminary results of this study show similar platelet adhesion on ePTFE, LLDPE and polystyrene. Porcine pericardium and Dacron showed higher levels of platelet adhesion. The platelets tended to bond along the fibers of the pericardium and Dacron, which resulted in clear patterns of platelet adhesion. On all other material surfaces, there was no pattern that could be seen. This was determined by fluorescence microscopy.

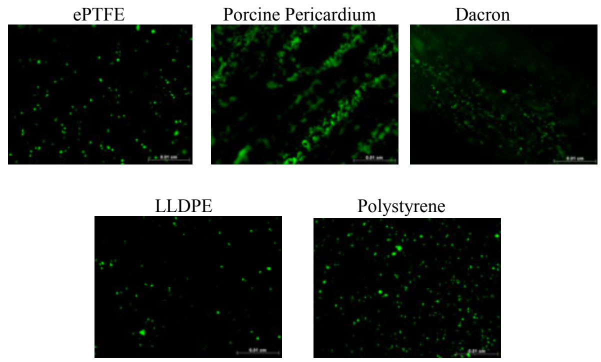

Fig. 2: Representative fluorescence microscopy images of adhered platelets stained with calcein-AM of ePTFE, porcine pericardium, Dacron, LLDPE, and polystyrene at 20X

SEM imaging showed similar results to the fluorescent microscopy in terms of number of platelets adhered to the surfaces. It appears as though porcine pericardium and Dacron have higher numbers of platelets adhered because of the increased surface area of the materials. The morphology of the adhered platelets was determined by SEM imaging as well. While porcine pericardium and Dacron had higher numbers of platelets, the platelets that adhered to ePTFE, LLDPE and polystyrene tended to show higher levels of activation.

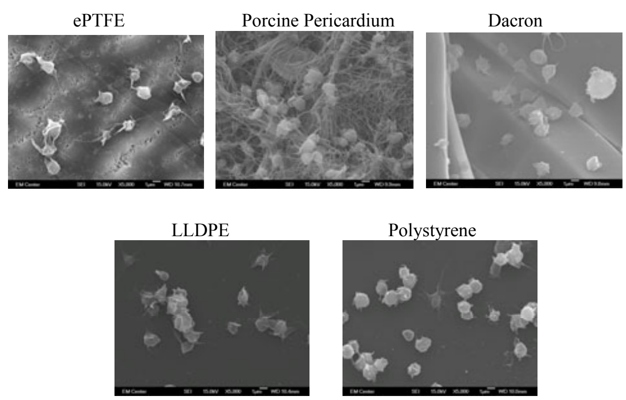

Fig 3: Representative SEM images of adhered platelets on ePTFE, porcine pericardium, Dacron, LLDPE, and polystyrene at 5,000X

Conclusion: The less porous materials will be more difficult to consistently coat with HA. Since all of these untreated materials react similarly with platelets, we should expect to see better results with the materials that allow for more consistent coating.

References:

1. Vongpatanasin, W., Hillis, L.D., and Lange, R.A., Prosthetic Heart Valves. The New England Journal of Medicine, 1996. 335(6): p. 407-416