Analysis of the heparin coating of an EXCOR® Ventricular Assist Device after 855 days in a patient

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Introduction: A heparin-coated Berlin Heart EXCOR® Ventricular Assist Device (VAD) was used to support an end stage heart failure patient (male, 76 years old) for as long as 855 days. After having reached its expected life span, the VAD was replaced and the used unit was retrieved for analysis of the coated surfaces. The purpose of the study was to collect data reflecting the longevity of the blood compatible heparin coating (Carmeda BioActive Coating, CBAS) (Olsson P. J. Biomater. Sci. Polymer Edn 2000, 11;11: 1261-1273) on a device retrieved after this uniquely long period of clinical use.

Experimental: The device was disconnected from the patient and immediately rinsed thoroughly with physiological saline solution. It was then filled with fresh solution and shipped to Carmeda for analysis. The VAD was cut open and the inner surface visually inspected for deposits of biological material. Samples for surface analysis were then punched out from different areas of the pump, both the housing and the membrane. The samples were further cleaned by incubating in 2M sodium chloride solution for 20h at room temperature. Remaining parts of the device were stained with Toluidine Blue in order to visualize the coating.

The functional activity of the surface-immobilized heparin, determined as the capacity to bind the physiological coagulation inhibitor antithrombin, was measured using an enzymatic assay. Subsequently, on the same samples, the amount of bound heparin was quantified.

Results

Visual appearance and staining: The inside surface of the pump appeared clean, except for some deposits at the mid section of the housing. Staining for heparin with Toluidine blue showed uniform coating on the membrane, metal valves and the main part of the housing. However, no stain was seen on the mid part of the housing where deposits were seen, suggesting that the coating was masked by biological matter.

Assay results: Measurement of the amount of surface bound heparin showed detectable quantities on all samples, both from the housing and the membrane. The average result was 1.5 μg/cm^2 (SD = 0.6, n=11), which is to be compared to the amount on this product prior to use (normally 3 – 4 μg/ cm^2). The results indicate that approximately half of the initial amount of surface bound heparin is still present after 855 days in the blood circulation.

Heparin activity was detected on all membrane samples (n=4). Average AT-uptake values were 5.4 pmol of AT per cm^2 (SD=6.5, n=4), which is to be compared to the estimated activity of this kind of device prior to use (in the range 8 – 10 pmol/cm^2). On the housing values were in the range of 1 pmol/cm^2 (SD 0.1, n=3). Hence, more than 50% of the initial activity of the immobilized heparin is still expressed on the surface of the membrane and less on the housing of this extensively used VAD.

Conclusion

The CBAS-coated EXCOR® unit studied in this report was retrieved after more than two years and four months of ventricular assist. Analysis of the heparin coating revealed that after this remarkably long period of use, still roughly half of the initial amount of immobilized heparin could be detected on the blood-exposed surfaces of the device and, at least on the pulsating membrane, the functional activity was preserved to a similar extent. Deposits of biological material were detected in areas of the housing where the blood flow is low. This case report thus indicates that even after extensive use in the circulation of a patient the Carmeda BioActive Surface retains, at least in part, its blood compatible properties.