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Design, Realization and Optimization of a Disposable Bioreactor for Culturing and Testing Heart Valves

Introduction
The most common heart diseases include stenosis (improperly closing and opening of the aortic valve, see Figure (1)). In severe cases a heart valve replacement is needed. Nowadays this is done by using a mechanical valve or a tissue valve that are not able to grow and have a higher risk of thrombo-embolism. Tissue engineered heart valves, as shown in Figure (1), constructed of cells of the patient seeded on a scaffold and cultured in a bioreactor by mechanical conditioning, are a third alternative. Existing bioreactors have a large number of parts, either flow or strain applied and testing the heart valve is not possible. This results in the need for a new disposable bioreactor.

Design realization
Figure (3) shows the mould used for injection moulding the bioreactor shells and a injection moulded bioreactor assembly (consisting of shells, clips, pressure caps, tubes, connectors and a heart valve adapter) with air pressure actuated valves and membranes. Pressures measured in front of and behind the valve (in this case a hand made polyurethane valve) and the positions of the membranes (measured by ultrasonic sensors) and used for feedback control.

Results
Figure (4) shows the results of the aortic and valve closing pressure imitation obtained using cycle volumes of 35 [cc] (80 [cc] in vivo) and therefore reduced maximum flows of 200 [cc/sec] (600 [cc/sec] in vivo).

Conclusions and Recommendations
A symmetrical, two component, mouldable and disposable bioreactor design is established with all functions for culturing and testing tissue engineered heart valves. A mould is designed and fabricated, bioreactor parts are injection moulded and used for a bioreactor assembly wherein physiological flows and pressures are successfully imitated, which can still be improved. A user friendly interface for an easy culture protocol implementation is needed, wherein pressure profiles and cycle volumes gradually increase in order to reach test values at the end.

References