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O21

MATURATION OF HEPG2 CELLS IS CLOSELY INFLUENCED BY THE MICROCHANNEL HEIGHT

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Objectives: Microfluidic systems provide valuable insights into tissue morphogenesis and *in vitro* stabilization of hepatocyte differentiation because of the large surface-to-volume ratio and behaviour similar to *in vivo*. Despite the efforts over two decades to define *in vitro* systems that can replace animal testing, an improved understanding of the interactions between cells and their constrained microenvironment will result in improved cell culture techniques and provide useful insights into how cells reorganize and communicate. Therefore, we focused on the exploration of the relationships between an array of cell activities and microchannel geometry.
Materials and Methods: Kinetics of HepG2 cells activities in conventional cell culture polystyrene dishes to those in PDMS microfluidic cell culture chambers of different heights were compared by using a non-invasive *in vitro* cell-based multi-components analysis method. Briefly, albumin secretion and glucose consumption were daily measured from culture media, while cell viability, morphology and cell membrane integrity were analyzed by using fluorescent dyes or indicators.
Results: We identified important and fundamental differences between PDMS micro-scale culture systems and polystyrene dishes. The results of glucose consumption and albumin secretion assays indicated that HepG2 cells were able to more effectively modulate their environment in micro-scale cultures than in macro-culture systems, while growth rates were lower within microchannels. In Microsystems, the peak of albumin secretion rate was reached sooner when the microchannel height was reduced, suggesting that cell activities are closely influenced by the height.
Conclusions: Reducing PDMS microchannels height provide promising conditions for long-term and stable cell growth, leading to improved structural organization and functionalities. The close influence of the channel height might be explained by an accumulation of functional soluble factors in the diffusion dominant microchannel environment.

Blood Trauma and Embolism

O22

INFLUENCE OF HEMODYNAMICS ON THE FORMATION OF AN INTRALUMINAL THROMBUS IN ABDOMINAL AORTIC ANEURYSMS

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Objectives: Thrombosis is typically observed in abdominal aortic aneurysms (AAA). The potential influence of hemodynamic forces on thrombosis has long been recognized, but it has mostly been studied in vessel geometries that induce abnormally high levels of shear stresses (e.g. stenoses). The purpose of the study is to investigate how hemodynamic factors could lead to the formation of an endoluminal thrombus in AAAs. More precisely, we will characterize the magnitude of the fluid stresses acting on circulating platelets and the time of exposure in the dilatation.
Materials and Methods: The trajectories of fluid particles are calculated using a Lagrangian particle tracking method applied to previously obtained velocity fields. Results of particle tracking conducted on *in vitro* measurements of velocity fields in AAAs are compared with others obtained from a numerical simulation.
Results: We show that the flow structures within the aneurysm tend to convect platelets towards the wall, which increases their probability of deposition onto the wall. The number of cells convected towards the wall increases with the aneurysm dilatation ratio. These platelets are entrained into regions of slowly recirculating flow, where they experience long residence times and low hemodynamic stresses.
Conclusions: The long residence times, low flow conditions and convective patterns towards the wall are hypothesized to be the main factors contributing to the thrombus formation in AAAs. Thrombosis within AAAs is therefore thought be linked to platelet aggregation through fibrinogen polymerization.

O23

VISUALIZATION OF THROMBUS FORMATION ON PIPE ORIFICE FLOWS

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Objectives: To suppress the hemolysis and avoid the thrombus is very important and serious problem in developing artificial organs, especially rotary blood pumps and stent. In this investigation, the thrombus formation on a pipe orifice flow with blood plasma is visualized by high speed camera, and analyzed to construct the prediction model of thrombus on shear flow by normal FDM (Finite Difference Method) or other method (lattice Boltzmann method).
Materials and Methods: Using the five transparent orifice configurations made of acryl resin, the flow is visualized by laser sheet light in the blood plasma circuit. In this case, the flow rate is 5 L/min and flow type is pulsatile, the total pressure loss in the circuit is 300 mmHg for every configuration by using additional smoothing resistance. In this experiment, we focus on the process of thrombus formation on the surface of acryl resin. Then we have both coating and no-coating on the acryl resin, so that there is difference of adhesion force on the wall between these conditions. Once accelerating the thrombus formation of blood plasma by using the aggregation drug, the polymerized protein in the flow can be visualized by light refraction. By image processing of the raw movie, the sequential image of the thrombus formation in the flow can be obtained.
Results: The thrombus formation is found to begin at the center of the recirculation area. The history of averaged brightness level is affected by changing orifice configuration. This means that effects of the shear stress distribution such as maximum shear stress on the thrombus formation, especially thrombus rate at the wall, are large. The effects of wall adhesion force are also confirmed by changing the thickness of coating layer on the acryl resin.
Conclusions: The thrombus formation in the blood plasma flow was visualized, and the effects of shear stress distribution and adhesion force of the wall on the thrombus formation were estimated for constructing CFD model of thrombus prediction.

O24

INVESTIGATIONS OF A COUNTERPULSATION HEART ASSIST DEVICE BY PIV AND WALL-PIV

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Objectives: The investigation of blood pumps for regions of blood stagnation allows a first estimation of the risk of thrombus formation. The pump under consideration is a novel long-term implantable counterpulsation device (CPD). The CPD is a single port, valveless 32mL stroke volume blood chamber. Attached to the subclavian artery, it can be implanted subcutaneously on the right anterior chest, similar to a pacemaker.
Materials and Methods: The investigation of the flow inside the CPD was done by Particle Image Velocimetry (PIV) to obtain the flow field in the central plane and Wall-PIV to obtain the near wall flow. Both methods were realized on a simplified mock circulation, consisting of a Windkessel and the blood pump. Filling time was 600ms plus a hold time of 850ms. The emptying time was set to 250ms. This corresponds to a 1in2 operation mode, which is more prone for thrombus formation. The pressure head was set to 90mmHg. As a test fluid we used a mixture of water and glycerin, simulating a blood viscosity of 3.5mm²/s. Images were recorded with a MotionPro X3 (Redlake Inc., USA) camera with 2000fps.
The central plane measurement setup allows an insight into the general flow pattern of the pump. For illumination we used a Quantum CW-laser at 0.65W.
To investigate the flow along the curved walls of the CPD, we used the Wall-PIV technique developed in our laboratory. Two LED light sources and a molecular dye at 0.3g/L (Patent blue V) allow the near wall region illumination with restricted light depth penetration.
Results: During ejection phase the fluid flows towards the port of the CPD uniformly, resulting in a good washout. A steadily rotating vortex, extending over the complete blood pump, with a permanently moving center, is observed during filling phase and hold time.
Conclusions: The investigated 1in2 mode has a good washout of the whole pump volume. Regions of stagnation are inhibited by a persistent steady rotating vortex. Due to this pump flow we expect a low risk of thrombus formation.