串联心室辅助对主动脉旋动流特性影响的 PIV 实验研究

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摘要: 心力衰竭(心衰)是一种高危险、高发病率的心血管疾病。心室辅助装置作为心力衰竭的有效治疗手段正逐步应用于临床治疗中。虽然心室辅助装置得到了广泛的应用，但是心室辅助装置对主动脉旋动流特性的影响机制尚不清楚。本文采用 PIV 实验方法研究串联心室辅助装置对主动脉的血流动力学影响机制。

首先，根据心衰患者 CT 数据重建主动脉三维几何模型; 其次，采用新工艺制作真实的几何 PIV 实验模型; 最后，对真实主动脉模型在不同工况下进行 PIV 实验，以此来研究串联心室辅助装置(sLVADs)的辅助水平对主动脉血流动力学的影响机制。实验中，选取了模型的三个截面进行研究，所截取的 3 个截面为: S1: sLVADs 出口截面; S2: 主动脉弓入口截面; S3: 主动脉弓中段截面。实验结果显示，对于 sLVADs，S1 截面上血流速度矢量呈现出明显的旋动特性，血流旋动的中心均集中在截面中心附近位置，并且高速血流主要集中在主动脉血管壁处; S2 截面处血流速度场发生了偏转，其高速血流区出现在主动脉弓内壁处; S3 截面处的血流速度场的旋动中心靠近三根分叉血管根部，高速血流区出现在主动脉弓内壁处。

通过分析实验结果，得出以下结论: 结合 PIV 实验技术与真实主动脉模型能够获得心室辅助装置辅助下主动脉的真实血流动力学环境，为以后的真实病例研究提供了方法; 医学三维重建技术与高精度 3D 打印技术的结合，提供了更加真实的主动脉模型，从而获得了更加真实的实验数据。

关键词: 串联心室辅助; PIV 实验; 旋动流
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基底硬度的增加加剧肝血窦内皮细胞毛细血管化

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摘要: 肝血窦内皮细胞(Liver sinusoidal endothelial cell，LSEC)是肝内特化的毛细血管内皮，是保护肝细胞免受损伤的第一道防线。窗孔是 LSEC 的特征性结构，贯穿细胞，直径在 50~200 nm。LSEC 毛细血管化是肝纤维化过程中的一个显著病理特征，窗孔消失是毛细血管化的重要特征。目前对肝脏纤维化过程中组织硬度增加对 LSEC 影响的生物力学调控机制尚不清楚。本研究利用不同交联度的聚丙烯酰胺水凝胶体外模拟肝脏组织硬度的变化，并通过对相关力学敏感基因和蛋白表达检测、窗孔孔隙率的统计分析以及小分子抑制剂的使用，探究了基底硬度对 LSEC 毛细血管化和功能的影响及其相关分子机制。研究结果显示，硬度的增加加剧了 LSEC 的毛细血管化，在 1、6、60 kPa 的水凝胶上培养 LSEC 3 d，孔隙率随体外培养时间和基底硬度增加而下降，同时 LSEC 毛细血管化的标志分子 CD31 膜表达也增加。窗孔的形成和存在与细胞骨架的重组之间存在密切关联，荧光成像显示肌动蛋白微丝紧紧围绕在窗孔的周围; 使用肌动蛋白聚合抑制剂后，可观察到窗孔数目显著性增多; 相应地，随着硬度增加，LSEC 的肌动蛋白微丝也不断增加。采用 II 型肌球蛋白抑制剂处理 LSEC，因硬度增加所导致的窗孔退化加剧得到了有效抑制。此外，LSEC 对氧化低密度脂蛋白有很强的吞噬清除功能，这种能力随体外培养时间增加而降低;

有趣的是,在硬基底上的长时间培养比软基底上更好的保留了这种功能,提示一种可能的 LESC 细胞自我保护功能。对 1 kPa 和 60 kPa 水凝胶上培养的 LSEC 进行 RNA 测序分析,结果显示,在硬基底上与细胞骨架、胞间黏附、清道夫受体以及血管内皮细胞生长因子受体等相关的基因上调。以上结果表明,力学信号转导通路在肝血窦内皮细胞毛细血管化中扮演着重要作用,该研究的相关结果可为深入认识 LSEC 毛细血管化、治疗肝纤维化和肝硬化提供新思路。

关键词: 肝血窦内皮细胞; 基底硬度; 毛细血管化; 窗孔; 力学信号转导
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Predicting Coronary Plaque Morphology Changes Based on Multimodality FSI Models Using Follow-Up IVUS and OCT Data

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Abstract: Background Current bottleneck of patient-specific coronary plaque model construction is the resolution of in vivo medical imaging. The threshold of cap thickness of vulnerable coronary plaques is 65 microns, while the resolution of in vivo coronary intravascular ultrasound (IVUS) images is 150-200 microns, which is not enough to identify vulnerable plaques with thin caps and construct accurate biomechanical plaque models. Optical coherence tomography (OCT) with a 15-20 μm resolution has the capacity to identify thin fibrous cap. IVUS and OCT images could complement each other and provide for more accurate plaque morphology, especially, fibrous cap thickness measurements. A modeling approach combining IVUS and OCT was introduced in our previous publication for cap thickness quantification and more accurate cap stress/strain calculations. In this paper, patient baseline and follow-up IVUS and OCT data were acquired and multimodality image-based Fluid-structure interaction (FSI) models combining 3D IVUS, OCT, angiography were constructed to better quantify human coronary atherosclerotic plaque morphology and plaque stress/strain conditions and investigate the relationship of plaque vulnerability and morphological and mechanical factors. **Methods** Baseline and 10-Month follow-up in vivo IVUS and OCT coronary plaque data were acquired from one patient with informed consent obtained. Co-registration and segmentation of baseline and follow-up IVUS and OCT images were performed for modeling use. Baseline and follow-up 3D FSI models based on IVUS and OCT were constructed to simulate the mechanical factors which integrating plaque morphology were employed to predict plaque vulnerability. These 3D models were solved by ADINA (ADINA R & D, Watertown, MA, USA). The quantitative indices of cap thickness, lipid percentage were classified according to histological literatures and denoted as Cap Index and Lipid Index. Cap Index, Lipid Index and Morphological Plaque Vulnerability Index (MPVI) were chosen to quantify plaque vulnerability, respectively. Random forest (RF) which was based 13 extracted features including morphological and mechanical factors was used for plaque vulnerability classification and prediction. Over sampling scheme and a 5-fold cross-validation procedure was employed in all 45 slices for training and testing sets. Single and all different combinations of morphological and mechanical risk factors were used for plaque progression prediction. **Results** When Cap Index was used as the measurement, minimum cap thickness (MCT) was the best single predictor which area under curve (AUC) is 0.782 0;