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Preface: The First International Symposium on Biomechanics and Mechanobiology in Cardiovascular System

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Cardiovascular disease remains as the leading cause of death worldwide, and the technologies developed by different groups need to be communicated and shared with all related research communities for a boarder implementation. Challenges in imaging technology, mathematical modelling, material description, mechanical representation, disease progression, prediction methods, and final transition to clinical applications are calling for collaborative effort of the entire research community to act together and bring research effort closer to actual clinical applications. Researchers from different disciplines need to reach out to share their expertise, as well as to listen to other people to understand the big picture, understand what their discipline can contribute, what other discipline needs from their discipline that they are in, what their discipline can benefit from others, and figure out future research directions. Therefore, the Southeast University Biomechanics Laboratory was pleased to organize the first international symposium on Biomechanics and Mechanobiology in Cardiovascular System which was held in December 18-20 in Nanjing, China.

The objective of this workshop was to gather researchers in the fields of biomechanics/ mechanobiology and cardiovascular diseases to exchange state-of-the-art techniques in their respective fields, provide mutual professional training so that participants could broaden their skills and knowledge basis. The workshop was able to identify challenges and critical needs in all related areas by listening to experts from other areas. In this symposium, sixteen invited plenary talks were delivered by the leading experts in the fields of biomechanics, mechanobiology and cardiovascular diseases. 31 abstracts were presented as posters by researchers from over 30 institutes. A total of 45 extended abstracts were included in this special issue, with a good spectrum of coverage.

In the symposium, Professor Andrew McCulloch first presented their work on systems modelling of cardiomyocyte mechanobiology [Tan, Buchholz, Cao et al. (2019)]. He summarized their systems model of cardiomyocyte mechano-signaling and discussed new approaches in extending these models to predict cardiac myocyte gene expression in response to stretch [Tan, Buchholz, Cao et al. (2019)]. Professor Mian Long discussed their recent work on mechano-biological coupling of neutrophil-dependent monocyte recruitment in atherosclerosis, which provided an insight in understanding the occurrence

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and development of atherosclerosis and intervening the potential attenuation of cardiovascular diseases. Professor Jonathan Golledge presented the research activities in the Queensland Research Centre for Peripheral Vascular Disease and emphasized their intention in translating research findings into improved management of aortic aneurysm and other peripheral vascular conditions. Professor Jianhua Wu summarized their research work in mechano-biology of platelet and leukocyte in blood flows and discussed the underlying biphasic force-dependent cellular and molecular activities [Fang and Wu (2019)]. Professor Jolanda Wentzel presented the research work by her group in the investigation of the role of (multidirectional) shear stress on plaque progression, destabilization and rupture at different stages of the atherosclerotic disease [Wentzel (2019)]. Professor Xiaobo Gong presented an analytical investigation of *in vivo* mechanical references for mechanobiological experiments of vascular cells and concluded that the mechanical niches of vascular cells strongly depend on the physiological site and aging process [Yang, Gong, Qi et al. (2019)]. Professor Dalin Tang discussed his recent research activities in multi-modality image-based modeling approach for cardiovascular disease in the aspects of simulation, assessment, prediction, and virtual surgery [Tang (2019)]. Professor Kairong Qin presented their work in the application of hemodynamic study in modulation of common carotid arterial function by excises and indicated that it may be feasible to choose reasonable exercise modalities to accurately modulate the hemodynamic variables, including blood pressure, blood flow and wall shear stress in carotid artery and then improve its structure and function [Qin (2019)]. Professor Karlheinz Peter introduced their work in the development of novel biotechnological approaches for the prevention and treatment of myocardial infarction. Professor Shengxian Tu talked about their activities in research and clinical applications of biomechanical analysis in optimization of coronary interventions [Tu (2019)]. Professor Stéphane Avril presented his group's work in fluid structure interactions in ascending thoracic aortic aneurysms and their identification approaches based on digital image correlation field measurements and inverse methods, which have demonstrated the link between the heterogeneity of mechanical properties and the existence of localized failure modes [Avril (2019)]. Professor Shengzhang Wang summarized his work on finite element analysis for type B aortic dissection treated with two types of stent grafts and discussed the occurring reasons of new lesions from the biomechanical and mechanobiological view when stent-grafts were implanted into the true lumen to treat an aortic dissection [Meng, Ma, Wang et al. (2019)]. Professor Haibo Jia's presentation discussed the role of intracoronary OCT in diagnosis and treatment of acute coronary syndrome [Jia and Yu (2019)]. Professor Fuyou Liang presented their work on computational modeling and discussed the reliability and variability of hepatic venous pressure gradient as a surrogate of portal pressure gradient [Liang and Wang (2019)]. Professor Peng Wu presented their work on the image-based non-invasive diagnosis of cardiovascular diseases [Wu, Gao, Wei et al. (2019)]. Finally, Professor Zhi-Yong Li summarized his group's work on imaging-based computational modelling and simulation of the interaction between blood flow and atherosclerotic plaque, and also discussed the recent developments in multiphysical modelling of plaque progression and destabilization. The significance and translation of the modelling study to clinical practice were discussed in order to better assess plaque vulnerability and accurately predict a possible rupture [Li (2019)].

The other included abstracts and the poster presentations covered a wide range of research activities, including computational modelling and simulation studies [Feng and Liu (2019); Qiao (2019); Hou and Qiao (2019); Fan, Yao, Yang et al. (2019); Jin and Liu (2019); Peng, Cui, Qiao et al. (2019); Zhu, Wei, Yuan et al. (2019); Zhu, Cai, Yuan et al. (2019); Shen, Zhu, Ji et al. (2019); Xu, Yin and Liang (2019); Yu, del Nido, Geva et al. (2019); Wang, Tang, Canton et al. (2019); Zhang, Wang, Mai et al. (2019)], Mechanobiology investigations [Huang, Qiu, Wang, et al. (2019); Liu, Zhang, Ding et al. (2019); Li, He, Zhang et al. (2019); Guan, Li, Li et al. (2019); Gao, Wang, He et al. (2019)], mechanical characterizations [Zhang and Tong (2019); Chen, Sari, Segers et al. (2019)], mathematical modelling [Guo, Cai and Li (2019)], clinical applications [Li, Peng, Wang et al. (2019); Guo, Tang, Molony et al. (2019); Li, Yao, Yang et al. (2019); Zhang and Jiang (2019)]. Other applications were also included, such as the effect of different particles on cardiac structure and function in myocardial infarction [Pei, Li, Huang et al. (2019); Huang, Pei, Li et al. (2019)]. Recent developments in artificial intelligence technology were also applied in cardiovascular field and were also included in this symposium, such as the characterization of coronary atherosclerotic plaque composition based on machine learning [Yin, He, Xu et al. (2019); Zhang, Guo, Tang et al. (2019)]. Moreover, two presentations about the vascular deformation and stress analysis based on in vivo intravascular optical coherence tomography imaging were also gathered a lot of interests in the symposium [Huang and Sun (2019); Jia and Sun (2019)].

The workshop will play a significant role in linking researchers and integrating related disciplines together to tackle the challenging task: a better understanding of cardiovascular disease progression and development of novel tools in quantitative assessment of cardiovascular disease burden.

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(In the order of presentations, presenting author marked by bold)

Abstracts of invited presentations

Avril, S. (2019)**:** Fluid structure interactions in ascending thoracic aortic aneurysms. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 17-18.

Fang, Y.; Wu, J. (2019): Some aspects in mechano-biology of platelet and leukocyte in blood flows. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 5-6.

Jia H.; Yu, B. (2019): Role of intracoronary OCT in diagnosis and treatment of acute coronary syndrome. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 23-24.

Li, Z. (2019): Atherosclerotic plaque rupture prediction: imaging-based computational simulation and multiphysical modelling. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 29-30.

Liang, F.; Wang, T. (2019): Reliability and variability of hepatic venous pressure gradient as a surrogate of portal pressure gradient: insights from a computational model-based study. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 25-26.

Meng, Z.; Ma, T.; Wang, S.; Dong, Z.; Fu, W. (2019): Finite element analysis for type b aortic dissection treated with two types of stent grafts. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 19-21.

Qin, K. (2019): Modulation of common carotid arterial function by exercise: a hemodynamics study. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 13-14.

Tan, P. M.; Buchholz, K. S.; Cao, S.; Aboelkassem, Y.; Omens, J. H. et al. (2019): Systems modeling of cardiomyocyte mechanobiology. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 13-14.

Tang, D. (2019): Multi-modality image-based modeling approach for cardiovascular disease: simulation, assessment, prediction, and virtual surgery. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 11.

Tu, S. (2019): Research and clinical applications of biomechanical analysis in optimization of coronary interventions. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 15-16.

Wentzel, J. J. (2019): The role of shear stress in atherosclerotic plaque progression, destabilization and rupture. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 7-8.

Wu, P.; Gao, Q.; Wei, R.; Wang, H.; Wang, L. (2019): On the image-based non-invasive diagnosis of cardiovascular diseases. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 27-28.

Yang, S.; Gong X.; Qi, Y.; Jiang, Z. (2019): An analytical investigation of *in vivo* mechanical references for mechanobiological experiments of vascular cells. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 9-10.

Abstracts of poster presentations

Chen, S.; Sari, C. R.; Segers, P.; Wang, G.; Ma, X. (2019): Papillary muscle related biomechanical properties of mitral valve chordae tendineae. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 69-70.

Fan, L.; Yao, J.; Yang, C.; Xu, D.; Tang, D. (2019): Echo-based FSI models to simulate ventricular electrical signal conduction in pig pacemaker models. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 41.

Feng, Y.; Liu, Y. (2019): Study on the influence of right atrial pressure on the numerical calculation of fractional flow reserve. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 31-32.

Gao, Y.; Wang, M.; He, Y.; Li, L.; Cui, X. et al. (2019): The role of P35 in transdifferentiation of EPCs into smooth muscle cells induced by oscillatory shear stress. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 93.

Guan, X.; Li, H.; Li, X.; Zhang, X.; Cui, X. et al. (2019): The role of autophagy in the differentiation of EPCs Induced by shear stress. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 91.

Guo, M.; Cai, Y.; Li, Z. (2019): Neovascularization and intraplaque hemorrhage in atherosclerotic plaque destabilization-a mathematical model. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 91.

Guo, X.; Tang, D.; Molony, D. S.; Yang, C.; Samady, H. et al. (2019): Predicting plaque progression using patient-specific fluid-structure-interaction models based on IVUS and OCT images with follow-up. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 75-76.

Hou, Q.; Qiao, A. (2019): The effect of sinus diameter on the opening and closing performance of aortic valve under the expansion of aortic root. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 37.

Huang, J.; Sun, C. (2019): Vascular deformation analysis based on *in vivo* intravascular optical coherence tomography imaging. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 67-68.

Huang, L.; Qiu, J.; Wang, G. (2019): TET1 alternative isoform regulates oscillatory shear stress induced endothelial dysfunction. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 33-34.

Huang, Y.; Pei, N.; Li, L.; Huo, Y. (2019): The effect of short-term exposure in PM0.1 on cardiac remodeling and dysfunction in myocardial infraction mice. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 47.

Jia, J.; Sun, C. (2019): Vascular stress analysis during *in vivo* intravascular optical coherence tomography imaging. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 61-64.

Jin, C.; Liu, Y. (2019): Influence of competitive flow caused by different stenosis on coronary artery bypass hemodynamics and PIV study. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 51-52.

Li, C.; Yao, J.; Yang, C.; Xu, D.; Wang, L. et al. (2019): Biomechanical implications of bicuspid pulmonary valve dynamic deformation in patients with repaired tetralogy of fallot. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 77-78.

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Li, J.; He, Y.; Zhang, X.; Li, H.; Guan, X. et al. (2019): Effect and mechanism of Kir2.1 channel overexpression on transdifferentiation of endothelial progenitor cells. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 89.

Liu, N.; Zhang, Y.; Ding, Y.; Li, H.; Guan, X. et al. (2019): High glucose reduces the shear stress-induced CD59 expression on EPCs through F-Actin alteration. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 87.

Pei, N.; Li, L.; Huang, Y.; Huo, Y. (2019): Effect of ultrafine nano-zinc particles on cardiac structure and function in myocardial infarction rabbits. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 45.

Peng K.; Cui, X.; Qiao, A.; Ohta, M.; Shimoyama, K. et al. (2019): Mechanical analysis of a novel biodegradable zinc alloy stent based on degradation model. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 53.

Qiao, A. (2019): Approach to the flow rate distribution of coronary branches in the calculation of fractional flow reserve. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 35.

Shen, X.; Zhu, H.; Ji, S.; Jiang, J.; Deng, Y. (2019): Finite element analysis of fatigue behavior of stent in tapered arteries. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 65.

Wang, Q.; Tang, D.; Canton, G.; Wu, Z.; Hatsukami, T. S. et al. (2019): Using 3D thin-layer model with in vivo patient-specific vessel material properties to assess carotid atherosclerotic plaque vulnerability. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 81-82.

Xu, L.; Yin, L.; Liang, F. (2019): Comparison of aortic flow patterns in patients with and without aortic valve disease: hemodynamic simulation based on PCMRI and CTA data. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 71-72.

Yin, Y.; He, C.; Xu, B.; Li, Z. (2019): Characterization of coronary atherosclerotic plaque composition based on convolutional neural network (CNN). *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 57.

Yu, H.; del Nido, P. J.; Geva, T.; Yang, C.; Wu, Z. et al. (2019): Ventricle stress/strain comparison between models using different zero-loaddiastole and systole morphologies and models using only one zero-load morphologies. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 73-74.

Zhang, C.; Guo, X.; Tang, D.; Molony, D. S.; Yang, C. et al. (2019): Automatic segmentation methods based on machine learning for intracoronary optical coherence tomography image. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 79-80.

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Zhang, Z.; Jiang, C. (2019): Numerical simulation of the granulation tissue resection operation in human trachea. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 83-84.

Zhang, Z.; Tong, J. (2019): Mechanical characterization and constitutive modeling of rabbit aortas in health and diabetes. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 43.

Zhu, G.; Cai, W.; Yuan, Q.; Chen, L. (2019): Numerical investigation of the hemodynamics characteristics in coronary bifurcation region with different dual stent implantation techniques. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 59-60.

Zhu, G.; Wei, Y.; Yuan, Q.; Yan, G.; Yang, J. (2019): Numerical investigation of the hemodynamic environment change in patient-specific intracranial aneurysm with progressive stenosis in unilateral internal carotid artery. *Molecular & Cellular Biomechanics*, vol. 16, supplemental 1, pp. 55-56.

Biomechanics Laboratory of Southeast University

The Biomechanics Laboratory of Southeast University was founded by Prof. Zhi-Yong Li after he returned to China from University of Cambridge in 2010. The laboratory targets the clinical diagnostic demands of cardiovascular diseases, and aims to solve the key issues of biomechanical mechanism in the diseases by modeling patient's heart and vascular vessel based on medical images and *in vivo / in vitro* testing of the mechanical properties of the soft tissue, *etc.* The laboratory explores the development of the cardiovascular diseases with multi-crossed disciplinary knowledge including mechanics, biology, materials *etc.*, and multi-dimensional methods including theory, numerical simulation, image processing, biological and mechanical experiments. The multifaceted model and *in vivo / in vitro* experiments help develop new methods for cardiovascular disease prevention and treatment.

At present, the laboratory has 2 professors (including 1 expert of national “thousand talents plan”, 1 winner of “excellent youth”), 1 associate professor and 2 lecturers. In the past five years, the laboratory has hosted and undertaken more than 10 national and provincial scientific research projects and conducted a series of studies in the fields of early estimation of vulnerable plaques, aneurysm rupture risk, hemodynamics, angiogenesis, multi-scale mechanical modeling and biomechanical testing of biological materials. Relevant results have been published in *Circulation, New England Journal of Medicine, Nature Review Cardiology, Journal of American College of Cardiology, Journal of Biomechanics* and other international professional academic journals.