S23: Special Symposium to Celebrate the Centennial of Distinguished Professor Yuan-Cheng B. Fung -2

S23-1 Investigation on energy characteristic of red blood cell deformability: a quantitative analysis of extending and retracting curves based on Atomic Force Microscopy

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Deformability is a fundamental property of the cells and tissues of living organisms, which is commonly detected to indicate the state of the cells. And the cell deformability usually depends on the methods that we used, which is easy to be confused. The present research is designed to explore the energy characteristic of red blood cell deformability, based on a quantitative analysis of extending-retracting curves acquired from atomic force microscopy. ATP-depleted red blood cell are prepared by treatment with free-glucose Ringer solution. Our results clearly show that the Youngs' modulus of erythrocyte is closely depended on the concentration of intracellular ATP. Using the software of Matlab, we get the area between the extending and retracting curves. Analysis of the control and ATP-depleted RBC demonstrated that the area could clearly differentiate between normal and ATP-depleted, which imply that ATP-depleted cause the decrease of RBC deformability. Our measures unveil that cell deformability is closely related to the state of intracellular energy, which can be characterized by cell passive deformation and active deformation. This research also will provide the theoretical basis for study the erythrocyte senescence, and give the evaluating to the red blood cells apoptosis, and also provide the health indicator for clinical blood transfusion in storage of blood.

S23-2 Research on non-Newtonian shear thinning suspension for standard viscosity fluid of blood

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Research on non-Newtonian shear thinning suspension for standard viscosity fluid of blood. Blood viscosity detection is frequently applied for clinical blood test, but because of various instruments have been developed based on different detection methods and properties of non-newtonian fluid, the data is difficult to compare among different researches. And up to now, blood viscosity detection still lacks a reasonable standard. In this research, the non-Newtonian shear thinning standard viscosity suspension (NTSVS) was discussed for standardization. NTSVS simulate the energy absorption behavior of blood what could make the blood viscosity more comparable and available for clinical application.

The NTSVS was prepared with alginate microspheres suspended in glycerol and thin xanthan solution. Solution viscosity was mainly adjusted by glycerol concentration and the volume fraction of microspheres, and then we use calcium chloride to control the aggregation of microspheres. Xanthan act an assistant role to contribute elasticity, and xanthan as the thin colloid of this system alter the intensity of particle interaction under low shear rate. All these viscosity data was discussed by the linear fitting for Casson equation and based on an energy transport consideration.

Each factors make unique impact on the viscosity obviously. And according to the residual analysis of linear fitting, xanthan also change the mode of energy absorption behavior for the thin-colloid particle system monotonically.The NTSVS has both wide adjustable viscosity range and energy absorption behavior, this system could be applied to simulate the viscosity curve of blood and other shear thinning suspension.

S23-3 Effect of Curcumin Extract against Oxidative Stress on Both Structure and Deformation Capability of Red Blood Cell

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The aim of this study is to explore the effect of pre-treatment of curcumin extract on erythrocyte deformable capabilities and erythrocyte band 3 (SLC4A1; EB3). The association between alterations of EB3 and erythrocyte deformable capability induced by hydrogen peroxide has been investigated. The blood samples were divided among 3 groups: (i) control, (ii) pre-treatment either using curcumin extract or vitamin C and (iii) negative control group. The oxidant stress parameters and antioxidant status, erythrocyte deformable capability (deformability and elasticity), and also modifications of membrane proteins band 3 from each group were evaluated through immunoblotting and immunofluorescence staining. Erythrocyte deformability and elasticity was found to decline significantly in the oxidative groups compared with the control group. In this present study show that pre-treatment with curcumin extract help increased the antioxidant status, reduce the EB3 cross-linking and improve erythrocyte deformable capabilities better than vitamin C. This study may provide further insight of the effect of treatment with curcumin extract on erythrocyte damage.

S23-4 Nitric Oxide Regulates Human Erythrocyte Deformability through regulating Band 3 Phosphorylation Status in Hypoxia

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Aim : To increase the local blood flow in proportion to metabolic demand, NO regulates membrane mechanical properties thereby modulating RBC deformability and oxygen carrying-releasing function. But the clear mechanisms of NO regulate RBC membrane mechanical properties remain unknown.

Methods: we have carried out a systematic study to find the mechanisms of NO regulate RBC deformability under hypoxia. NO levels, RBCs membrane elongation index (EI), band 3 and membrane bound haemachrome were determined with an NO donor (sodium nitroprusside) or an NO synthase inhibitor (l-nitro-arginine methylester) under hypoxia.

Results: Hypoxia increased NO metabolites from 25.65±1.95 μmol L−1 to 35.26±2.01 μmol L−1 compared with control. The elongation index decreased after hypoxia for 60 min from 0.567±0.019 to 0.409 ± 0.042, H+SNP group 0.59±0.031, H+L-NAME group 0.422±0.035 at a shear stress of 30 Pa. Hypoxia-stress induced band 3 clustering and tyrosine phosphorylation increased, and both decreased after hypoxia with SNP（Fig.1 and Fig.2）. The elongation index increased in the hypoxia group with SNP compared with the hypoxia group and L-NAME group after hypoxia. NO improved SHP-2 tyrosine phosphatase activity, and also inhibited the activity of Syk-induced by hypoxia stress (Fig.3).

Conclusion: In the present article, it is determined that NO plays a potential role in maintaining RBC deformability in hypoxia through altering band 3 tyrosine phosphorylation by maintaining the activity of SH-PTP2 and reducing band 3 crosslinking, which may occur during hypoxic ischaemia diseases, and at high altitudes. This study may provide insights into the molecular mechanisms of RBC adaptation to hypoxia.

23-5 Development History, Progress and Future Prospects of Biorheology and Biomechanics in Chongqing University

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The study of biorheology and biomechanics at Chongqing University (CQU) began in the 1970s, which has always been guided and helped by Prof. YC Fung. With the endeavor of him, Prof. YP Wu founded the first Biomechanics Research Lab in China in the 1970s. Biomechanics of CQU was approved to set up the first program for master's degree in 1980, and one of the two doctoral programs in 1986, the first National Key Discipline, and got the first State Award for Inventions (1984) and Natural Science Award (1988) in the field of biomechanics and biorheology. The Open Lab on Biomechanics and Biorheology under the National Education Commission was set up in 1994. The College of Bioengineering of CQU was founded in 1998, which developed from Biomedical Electronics Teaching Lab and the Biomechanics Lab that were built in 1979. Since then over ten research bases were approved to establish such as National "111 project" Base on Biomechanics and Tissue Repair (2006) ; Key Lab for Biomechanics and Tissue Engineering of MOE(2008）, the Chongqing Public Experiment Center of State Bioindustrial Base (2008), Key Lab for Biorheological Science and Technology of MOE(2011）, State and Local Joint Engineering Lab for Vascular

Implants(2015). Biomedical engineering based on biomechanics and biorheology was approved to be first-level national key discipline and also were supported by the National "211" and "985" projects. Currently the College has developed into one of the largest research teams and the most influential high-level talent training bases of biomechanics and biorheology in China. This review summarizes the history, progress and future prospects of biomechanics and biorheology in CQU to celebrate the Centennial of Prof. Y C Fung and encourage the later generations to go forward.

23-6 Zebrafish caudal vein formation is flow sheer stress dependent

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Hemodynamic factors play a very important role in the process of blood vessel development and remodeling through the regulation of mechanosensory proteins. The different mechanosensory proteins on endothelial cells that transmit mechanical signals to the cytoplasm through their respective mechanical mechanoreceptive effects, and activated downstream chemical signals, which ultimately allow the endothelial cells to line up in the direction of fluid shear forces.

Unlike mammals, zebrafish can be observed in vivo. Thus, we are interested in investigating functional roles of hemodynamics on zebrafish blood vessel development. And we utilize the zebrafish as a model system to investigate the cellular and molecular mechanisms that contribute to zebrafish caudal vein formation. We have successfully utilized the transgenic fish Tg (flk1: GFP) to gain new insights that the zebrafish caudal vein is formed at 60hpf under physiologic blood flow. However, the caudal vein formation was blocked at 60hpf at low flow sheer stress. We used the transgenic fish Tg (Bre: GFP; kdrl: Mchrry) to find strong expression of bmp signal in zebrafish caudal vein.