# Progress report: Simulation and Analysis of Mechanism in Aortic Dissection

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## 1 Purpose

The aorta is made up of three layers: a tunica intima, a middle layer called the tunica media, and an outer layer, the tunica adventitia. Aortic dissection is a pathological state in which a tear develops in the intima layer of the aorta, the blood enters at the site of the tear, separates the media layer of the aorta, and spreads the dissection. Aortic dissection is the commonest catastrophe affecting the aorta, occurring more frequently than rupture. The presentation, investigation and treatment of aortic dissection are well described and commonly accepted in the literature. However, there remains considerable uncertainty regarding the pathogenic aetiology of aortic dissection. The purpose of the research is to find that why and how the dissections occur and analyze the role of factors especially mechanical factors in aortic dissection by using Fluid Structure Interaction (FSI) method. Defining the process of aortic dissection may provide useful data for inclusion in the design of prevention systems. A reduction in the incidence and severity of aortic dissection could be expected to result in a lowering of mortality and morbidity far greater than that derived from more timely and accurate diagnosis and treatment.

## 2 Idea and approach

Since the dissection first propagates rather than tearing back through the intima or out through the adventitia, a 3-layer finite element model is established in order to analyze the stresses in different layers. We will analyze the change of the stresses as the elasticity of the layers changes in order to understand the effect of layers elastic properties to propagation of aortic dissection. This research will use FSI method and establish a 3-layer wall structure elastic finite element model to do the simulation. Recent years, FSI method has been improved and began to be used into bio-fluid simulation. It first builds a 3-layer aorta wall structure from simple model to

realistic model and completely analyzes the role of the blood pressure, shear rate, elastic properties of each layer, and aorta local site conditions in the propagation of aortic dissection. The simulation could show the distribution of radial stress, circumferential stress, and longitudinal stress in layers.

## 3 The progress of research

At first we concentrated on a problem that was simplified with respect to geometry, materials and boundary condition. We had built the 1 layer structure aneurysm and stenosis model and simulate the interaction between blood flow and elastic wall under steady condition. The results show that elasticity of the blood wall can affect the stress distribution and displacement direction in aneurysm and stenosis. Subsequently, we developed a 3 layers straight model and simulated the FSI. Recently, the 3-layer arch aorta model was developed and the fluid-structure interaction was simulated under steady flow. The variations of circumferential stress, longitudinal stress, radial stress, and shear stress were investigated and the distributions of circumferential stress, longitudinal stress, radial stress, and shear stress in layers were showed. We found that the circumferential stress and longitudinal stress are higher in media layer, the radial tensile stress exists in outer wall and inner wall, the shear stress concentration is in the media layer. So this can explain the possible process of aortic dissection.

## 4 Future direction

1. In the next year, depending on completed work, I will further develop a 3-layer arch aorta model with aneurysm to simulate the FSI and investigate the stresses distribution in aneurysm.
2. The arch aorta model with 3 branches will be developed and the FSI will be simulated. The the site effect of branches will be investigated by showing the simulation results.
3. The FSI under unsteady flow in aortic arch will be simulated and the pulsatile effect on the wall stresses will be investigated.

## 5 publication

Feng Gao, Teruo Matsuzawa. Numerical Simulation of Interaction between Blood Flow and Elastic Arteries in Aneurysm and stenosis, WCCM VI in conjunction with APCOM04, Sep.5-10, 2004, Beijing, China
Feng Gao, Masahiro Watnabe, Teruo Matsuzawa. The effect of elastic property of different layers of aorta wall on wall stresses and its role in the propagation of aortic dissection, B-J-K Symposium on Biomechanics, Feb.26, 2005, Kanazawa, Japan