Study on effect of flow in Aortic Arch with torsion

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1 Purpose and Background

Recently aneurysm of aorta which is one of the disease on circulatory organs increases in the senior citizen in Japan. Aneurysm of aorta is the disease which makes a bump at the aortaD It is dangerous disease, because it is almost no disease's symptom, and the patient might die if the bump ruptures. Therefore we had better take preventive care before the bump is made, or we notice the aneurysm before the bump ruptures and care it. But as matters stand there is only one way that we regularly receive the medical examination to find aneurysm. It is known that almost of circulatory organs diseases develop the where the blood flow is changed. (ex. branches of aorta, aorta with bulge.) In this research, The model of aortic arch that is one of the where aneurysm develops frequently is used.

Considering about torsion of aortic arch is important thing when we analyze the blood flow in the aortic arch. Human's aortic arch is twisted in 3 dimension. But for that matter it's torsion is different from one by one. Yoshii researched shapes of aortic arch constructed with the 3 dimension CT image in order to express torsion of it. He defined four characteristic on aortic arch when it is observed from the upper part, and connects them by the straight line. So he measured each done angle that they made. Then He defined them as torsion of aortic arch. He confirmed that torsion of

patient's aortic arch is larger than healthy person's one. As a result it is known that size of the torsion of aortic arch is related to aneurysm.

The blood flow in aortic arch of aneurysm patient's model and healthy person's model was analyzed in this research.

2 Method

In this research, the four characteristics which was defined by yoshii was used to make aortic arch models with torsion. The four characteristics is as follows,

1. Joint point of valve of aorta and ascending aorta
2. The outside point of ascending aorta @
3. The top of aortic arch @
4. Joint point of aortic arch and descending aorta

First of all they are connected by the spline curves to make the center line model. Secondary, the round tube was made for surroundings of it. The size of torsion was defined by two angles. One is angle that 1, 2, and 3 form(δ angle). The other is angle that 2, 3, and 4 form(γ angle). The most popular angles which was defined by yoshii were used in this research. In Aneurysm case, δ angle is 120°, γ angle is 18°. In healthy person's case, δ angle is 141°, γ angle is 46°.

The model which has only δ angle or γ angle was made to research influences by each one. Then the models which have branches were made, because more realistic case was needed. The models is as follows,

Table 1: Analysis models

Model No.	i	ii	iii	iv	v	vi	vii	viii
δ	120°	141°	None	None	120°	141°	120°	141°
γ	None	None	18°	46°	18°	46°	18°	46°
branches	×	×	×	×	×	×	◯	◯

The models (i˜vi) were calculated with uniform steady flow, and considered about influence of each angles. Next, the realistic models (vii, viii) were calculated too same conditions, and compared with no branches model's results and two branches model's results each other. Furthermore, the pulsatile flow was used in this research. The number of Womersly is one of the parameters that show the speed of the pulsatile. The larger it is, the faster pulsatile's speed is. Whitmore reported human's pulsatile is 13-21. Womersly number 21 was used as basic research in v and vi cases, because almost of aneurysm patients have high blood pressure. And Womersly number 13 and 17 were used, and compared with basic research's results. Finally branches models were calculated with pulsatile flow. (Womersly number is 21.)

In this research, calculation lattices were used Non-structure lattices. So the finite volume method was used for the discretization. Fluent6.1 was used as the solver.

3 Results

In this research, the model of human's aortic arch was made and analyzed. The results is as follows. The torsion influences the blood flow and wall-shear stress. δ angle influences the blood flow and wall-shear stress at descending aorta. γ angle influences the blood flow and wall-shear stress at ascending aorta. The larger the angle is, the more the flow's speed difference grows. The areas where wall-shear stress is high or low appear remarkably by the torsion's influence. If the model has two angles, influence of torsion grows a lot.

The results that the areas of wall-shear stress and aneurysm were compared is as follows. The area of low wall-shear stress at entrance of aortic arch is near the area of Saccular aneurysm of aorta. The area of low wall-shear stress at descending aorta is near the area of aneurysm of descending aorta. The results of this research is same the theory that aneurysm becomes easily at the area of low wall-shear stress. It can not confirm whether patient of aneurysm had large torsion or not before bump was made, because yoshii researched after the bump was made. But in this results, it is seemed that the patient had the large torsion of aortic arch before the

bump was made.