

## Abdominal Aortic Aneurysm Causes Hemodynamic Abnormalities in the Iliac Arteries

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### INTRODUCTION:

Iliac artery aneurysms (IAAs) co-exist with abdominal aortic aneurysms (AAAs) in 10–20% of cases, whereas, isolated IAAs are rare, accounting for only 2% of all aorto-iliac aneurysms (1). Low Wall Shear Stress (WSS) and high oscillatory shear index (OSI) have been postulated to lead arterial wall to atherosclerosis (2, 3). We hypothesized that hemodynamic abnormality of the iliac arteries, which are initiated by AAAs, is one factor in the progress of IAAs at the most initial stage.

### PURPOSE:

The aim of this study was to assess whether the presence of AAAs change the hemodynamics of the downstream iliac arteries with use of recently innovated time-resolved 3D phase contrast (PC) MRI (4D-Flow) that allows measurements of the blood flow velocity vectors within the entire geometry within the vasculatures throughout the cardiac cycle *in-vivo* (4).

### PATIENTS AND METHODS:

Written informed consent was provided in all cases for this IRB approved study. Eight patients (six males and two females; 66-85 years), who had AAA but whose iliac arteries were not dilated (<15mm), were recruited (Group A). For group B with undilated abdominal aorta and common iliac arteries, age matched eight patients, were included. MR imaging: All examinations were performed on 1.5T MR scanner (Signa TwinSpeed with Excite). Gadolinium enhanced 3D MRA was performed prior to the 4D flow. 4D Flow is based on a SPGR sequence encoding flow velocities in three orthogonal directions. The parameters used were TR/TE/FA/NEX of 4.5-5.0/1.6-2.0/15/1, FOV of 30-34 cm, Matrix of 224-256x160-224, 2-3 mm thickness, 12 phases during one cardiac cycle. The value of velocity encoding was determined by the flow velocimetry performed with axial 2D phase contrast image. Acquired data were post processed with flova (flow analysis software).

### IMAGE ANALYSIS

Mean WSSs in each cardiac cycle of the common iliac arteries were calculated and the average value (Ave WSS), the maximum value (Max WSS), the minimum value (Min WSS) and OSIs were calculated for each cases. Hemodynamic abnormalities were visually assessed using obtained streamlines in each cardiac phase.

### RESULT&DISCUSSION

All WSSs of Group A were significantly lower than those of Group B. Especially in Max WSS, which was during systolic phase, the difference between two groups were most conspicuous (Chart 1). Vortex and/or turbulent flows generated in AAAs affected the downstream iliac arteries, and thereby, reduced WSSs. This phenomenon was most prominent in the systolic phase (Fig 1). Even in Group B there were arteriosclerotic changes (i.e. tortuosity and irregularity of the artery wall) to some extent, and they reduced focal WSSs. However, the blood flow was mostly laminar and overall WSSs were relatively high (Fig 2). The low WSSs in the common iliac arteries in AAA patients may ultimately lead to co-existing iliac artery aneurysms. Conversely, this can explain that isolated iliac artery aneurysm is rare. Interestingly, OSIs of Group A and B showed no significant difference; 0.11(+/- 0.07) and 0.1(+/- 0.07) respectively. This may be due to its peculiar location (i.e. downstream to the bifurcation of aorta), which is prone to vortex or turbulent flow.

### CONCLUSION

AAAs disturbs laminar flow of the iliac arteries and reduces their WSSs, which may suggest that the presence of AAAs may play an important role in the ultimate induction of the iliac artery aneurysm.

Chart 1

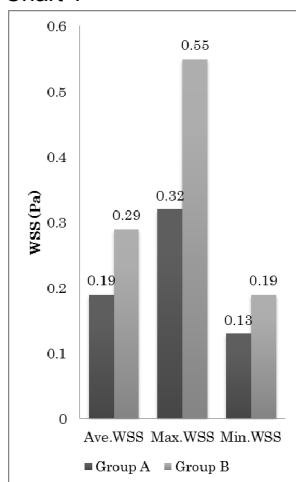


Fig 1a stream line

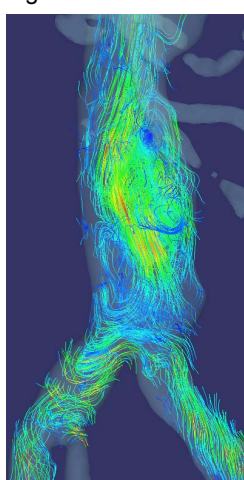


Fig 1b WSS

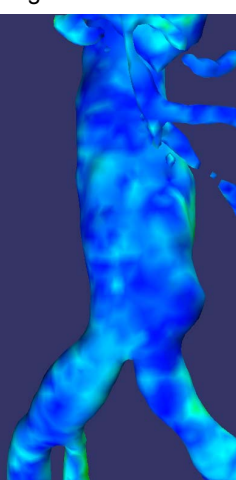


Fig 2a stream line

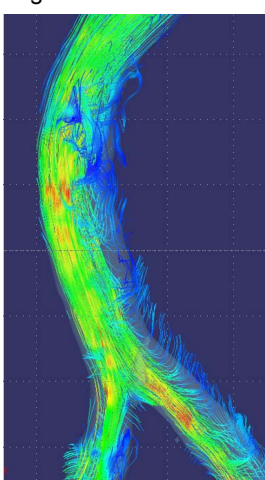


Fig 2b WSS

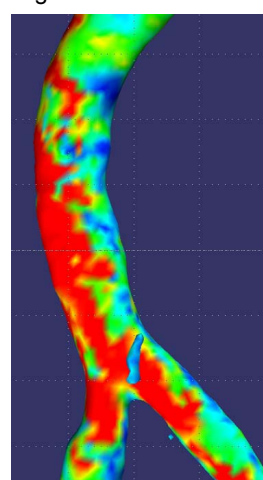


Fig 1 shows the aorta and iliac arteries of the patient with AAA and Fig 2 shows that no-dilated aorta. Vortex and/or turbulent flows are generated in AAAs that affect the flow in the iliac arteries and reduce WSSs (Fig 1a, 1b). In undilated aorta, laminar flow is predominant and the WSS is relative high. The turbulent flow can be seen locally, but only in the inner curvature of aorta to the left iliac artery and the

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