

# Analisis Computational Fluid Dynamic pada Pasien Aneurisma Aorta Abdominalis Infrarenal untuk Surveilans terjadinya Ruptur Aneurisma = Computational Fluid Dynamic Analysis in Infrarenal Abdominal Aortic Aneurysm for Surveillance of Aneurysm Rupture

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## Abstrak

Latar Belakang: Penyakit AAA sebagian besar berlokasi pada infrarenal. Mortalitas meningkat dengan ruptur. Faktor risiko utama ruptur adalah diameter aneurisma dan hipertensi. Analisis computational fluid dynamic (CFD) pada aliran darah memungkinkan untuk mengetahui predileksi area tempat terjadinya ruptur. Wall shear stress (WSS) dan tekanan dinding merupakan parameter yang bisa dianalisis melalui CFD untuk melihat potensi ruptur pada AAA. Tujuan: Mengetahui morfologi aneurisma AAA infrarenal beserta sebaran nilai WSS dan tekanan dinding aneurisma berdasarkan CFD untuk memprediksi ruptur aneurisma. Metode: Studi cross-sectional dengan analisis CT angiogram pasien AAA infrarenal di Divisi Vaskular dan Endovaskular-Departemen Bedah dan Departemen Radiologi RSUPN Dr. Cipto Mangunkusumo pada bulan Juli–Desember 2022. Data CT angiografi diolah dengan Radiant Viewer untuk dijadikan model 3D. Dari keseluruhan sampel, dikelompokkan menjadi 5 tipe aneurisma. Kemudian masing-masing model dilakukan proses pembuatan solid vessel dengan Meshmixer. Proses selanjutnya adalah geometri, meshing, setup parameter CFD, dan solution untuk menghasilkan kontur WSS dan tekanan dinding pada berbagai kecepatan dan tekanan darah dengan program ANSYS 2022 R2 Academic Student. Hasil visual pada tiap tipe dianalisis dan dibandingkan. Uji statistik non-parametrik WSS dan tekanan dinding pada tiap tipe dan antar grup menggunakan SPSS 25.0 dengan nilai p dianggap bermakna jika  $p < 0,05$ . Hasil: Dari 93 CT angiogram, setelah eksklusi didapatkan 40 sampel. Median usia 67 (47-76 th), dengan 90% adalah laki-laki. Sebanyak 25% sampel memiliki komponen sakular. Hasil analisis visual, terdapat korelasi area antara WSS terendah dengan tekanan dinding tertinggi. Perubahan kecepatan dan tekanan darah inisial juga mengubah nilai dan luas area pada kontur WSS dan tekanan dinding aorta, meskipun pusat perubahan kontur masih berada pada area yang relatif sama. Terdapat perbedaan bermakna pada WSS dan tekanan dinding ( $p=0,038$  dan  $p < 0,001$ ). Kesimpulan: Area WSS terendah berkaitan dengan lokasi tekanan dinding tertinggi. Berubahnya kecepatan dan tekanan darah, mempengaruhi luas dan nilai dari WSS dan tekanan dinding.

.....Background: AAA disease is mostly located in infrarenal. Mortality increases with rupture. The main risk factors for rupture are diameter sac and hypertension. Computational fluid dynamic (CFD) analysis of blood flow allows for a detection where rupture area will occur. Wall shear stress (WSS) and wall pressure are parameters that can be analyzed through CFD to see the potential location for rupture in AAA.

Objective: Knowing the morphology of infrarenal AAA along with the distribution of WSS values and aneurysmal wall pressure based on CFD to predict aneurysm rupture. Method: Cross-sectional study with CT angiogram analysis of infrarenal AAA patients in the Vascular and Endovascular Division-Department of Surgery and the Department of Radiology RSUPN Dr. Cipto Mangunkusumo in July–December 2022. CT angiography data was processed with Radiant Viewer to be used as a 3D model. From the whole sample, grouped into 5 types of aneurysms. Then for each model the process of making a solid vessel is carried out with the Meshmixer. The next process is geometry, meshing, CFD parameter setup, and solutions to produce

WSS and wall pressure contours at various speeds and blood pressures with the ANSYS 2022 R2 Academic Student program. Visual results for each type were analyzed and compared. WSS and wall pressure non-parametric statistical test were performed for each type and between groups using SPSS 25.0 with a p-value considered significant if  $p < 0.05$ . Results: Of the 93 CT angiograms, after exclusion, 40 samples were obtained. Median age 67 (47-76 years), with 90% were men. As much as 25% of the sample had a saccular component. The results of the visual analysis showed that there was an area correlation between the lowest WSS and the highest wall pressure. Changes in velocity and initial blood pressure also changed the value and area of the WSS and the aortic wall pressure contours, although the center of the contour change was still in the relatively same area. There was a significant difference in WSS and wall pressure ( $p=0.038$  and  $p<0.001$ ). Conclusion: The area of lowest WSS corresponds to the location of the highest wall pressure. Changes in blood velocity and pressure affect the area and value of WSS and wall pressure.