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Non-invasive Computed Tomography-Derived Therapeutical Monitoring Tool for Pulmonary Hypertension

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Pulmonary arterial hypertension (PAH) is a progressive disease of the small pulmonary arteries characterized by vascular proliferation and remodelling, increased pulmonary vascular resistances (PVR) and endothelial dysfunction [1]. Previous studies have demonstrated by means of computational fluid dynamic (CFD) analysis and 4D-flow magnetic resonance imaging (MRI) that wall shear stress (WSS) is involved both in the progression and maintenance of pulmonary arterial hypertension (PAH) [2-3]. Previous computational analyses have demonstrated that WSS in pulmonary artery of PAH patients were lower than those in healthy subjects [4]. Current diagnostic techniques used to assess PAH severity and therapy effectiveness, as transthoracic echocardiography and right heart catheterization are graved by a number of drawbacks including operator's dependence and invasiveness. The therapeutic response to Bosentan 125 bis a die was monitored in a 65-year old man affected by post-embolic PAH at intermediate risk (WHO III class) by using computed tomography-derived WSS at main pulmonary artery bifurcation. Specific pulmonary artery geometries for each tertiles of mPAP have been reconstructed using the mean values of the areas, lengths and diameters of the MPA, left (LPA) and right pulmonary artery (RPA). The geometrical domain of interest for the study included the MPA from its origin until its bifurcation. Geometrical analysis, segmentation and reconstruction have been performed using Osiri X (Pixmeo, Geneva, Switzerland) and Rhinoceros v. 4.0 Evaluation software (McNeel & Associates, Indianapolis, IN). To analyse the spatially resolved WSS, blood was modelled as a non-Newtonian viscous and incompressible fluid. The numeric grid was created from the 3-D geometry using ANSYS Meshing 14.0 (Ansys, Inc., Canonsburg, PA) while the simulations were conducted using the commercial software ANSYS FLUENT 14.0 (Ansys, Inc., Canonsburg, PA). After 12-month therapy , the mean area of high WSS was larger (Figure panel C – external and D –internal three dimensional reconstruction) at the main pulmonary artery (MPA) bifurcation and D) than before the start of the treatment (Figure panel A – external and B –internal three dimensional reconstruction) whereas the mean WSS value decreased. This was congruent with a decreasing of mean pulmonary artery pressure and mean wedge pressure and an increase of cardiac index from 45. mm Hg, 10.2 mmHg and 2.2 to 35.6 mmHg, 7.1 mmHg and 2.5, respectively. Although extensive studies are needed, mean WSS area calculated by computed tomography derived CFD analysis has the potential to represent a complete non-invasive rapidly computed-calculated tool to monitor drug's effectiveness in patients with PAH.

CONFLICT OF INTEREST

None to declare

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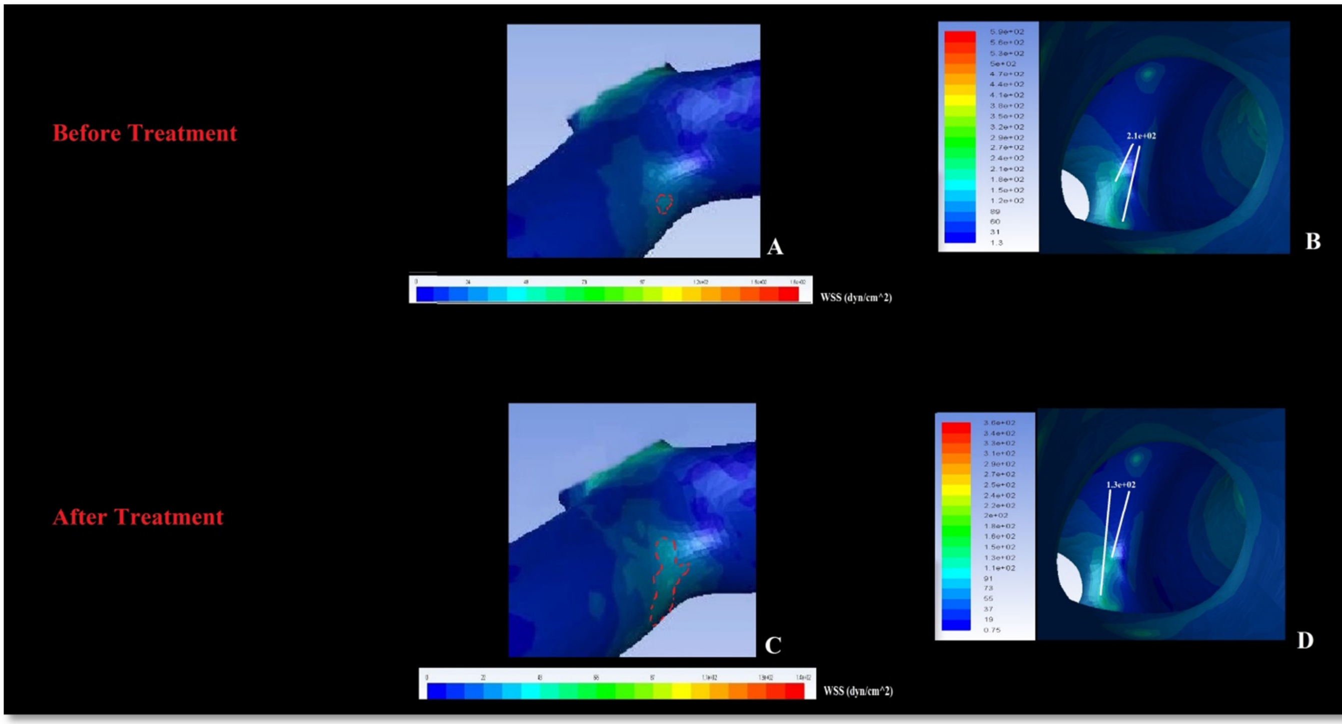

Figure 1. External (A) and internal (B) views of the main pulmonary artery bifurcation computed flow dynamic analysis of the wall shear stress forces before treatment: the area of high shear stress forces is small and the mean value is low. After 12-month Bosentan therapy the area is clearly increased even if the mean value in decreased in both external (C panel) and internal views (D panels).

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