CARDIOVASCULAR FLASHLIGHT

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Computational fluid dynamics as a novel method to predict haemodynamic changes and guide transcatheter edge-to-edge repair

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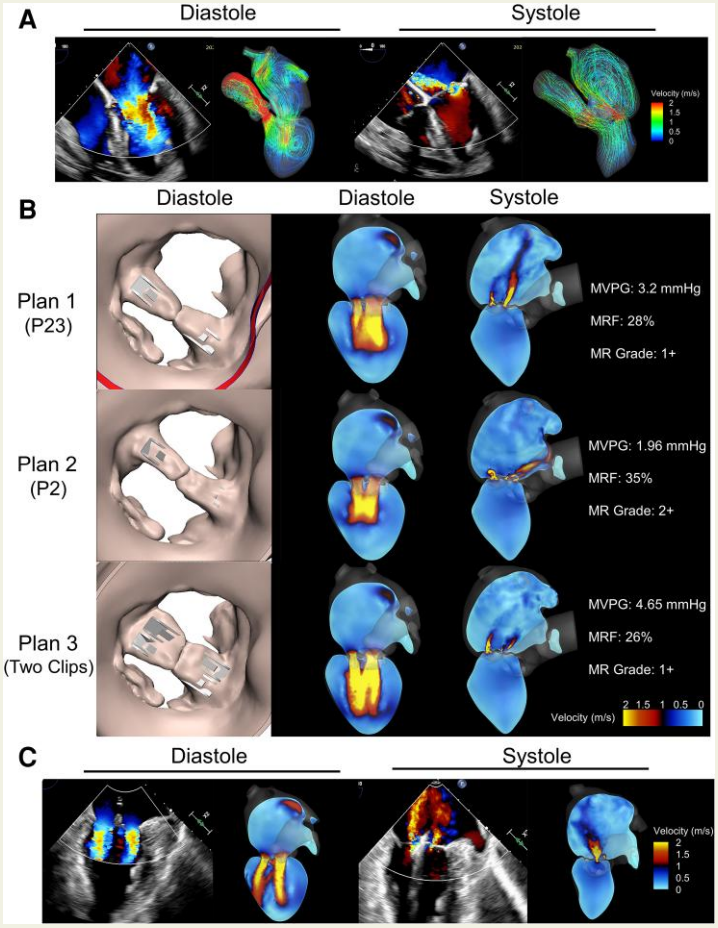
A 78-year-old female with severe mitral regurgitation (MR) presented with heart failure. Due to the high risk of surgery, transcatheter mitral valve edge-to-edge repair (TEER) was introduced. Computational fluid dynamics (CFD) has been widely used for cardiac function assessment. Here, we investigated the haemodynamic changes by using CFD and its predictive values in TEER.

The left heart system (LHS) was constructed from computed tomography and transoesophageal echocardiographic (TEE) images (Mimics 19.0, Leuven, Belgium; 3D Slicer software). The haemodynamics of LHS was calculated and visualized by 3D streamlines using the finite volume method and the combination of pressure-Implicit with splitting of operators and semi-Implicit method for pressure linked equations (PIMPLE) algorithm (OpenFOAM software) before the procedure, indicating perfect matching with the TEE view (*Panel A*). The reverse flow could be observed in the left atrium, and the MR fraction (MRF) calculated by CFD was 52%, similar to the echocardiographic diagnosis (MR 4+). The CFD-simulated mean mitral valve pressure gradient (MVPG) was 1.77 mmHg, consistent with echocardiography (2 mmHg).

Since the prolapse was located at the P2 scallop close to the P3 region, we planned three TEER strategies and simulated the haemodynamic changes (*Panel B*): (i) one clip was implanted at the most evident prolapsed scallops (P23), and both inflow and MR jets were displayed with two jets with MR reduction; (ii) one clip implanted at the centre of the A2-P2 region also showed two inflow and MR jets; however, MR jets were eccentric; and (iii) two clips were implanted at the P2 and P3 scallops, respectively. The MR degree decreased the most, whilst two inflow jets with the brightest signals indicated possible iatrogenic mitral stenosis.



Both Plans 1 and 3 decreased MRF to <30% (MR 1+), whilst Grade 2+ was achieved in Plan 2. Plan 3 (two clips) would lead to the most reduction of MR but might result in mitral stenosis with a mean MVPG of 4.65 mmHg. Therefore, we determined the one-clip-implanted P23 strategy with an NTR clip. The MR grade decreased to 1+, and the mean MVPG 2 mmHg evaluated by TEE was consistent with Plan 1 (*Panel C*).

To our best knowledge, this is the first study to predict acute haemodynamic changes and guide TEER by using CFD. Our results indicate that the CFD model is accurate and predictable with the echocardiography and the model would facilitate the formulation of clinical procedure strategies.

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The data will be shared on reasonable request.
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