

FINITE ELEMENT ANALYSIS ON THE INFLUENCE OF THE DISTANCE BETWEEN ANTERIOR AND POSTERIOR PAPILLARY MUSCLES ON THE STRESS DISTRIBUTION OF THE STENTLESS MITRAL VALVE AT CLOSURE

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Summary: BACKGROUND: We have developed a stentless mitral valve (NORMO valve). The valve consists of anterior and posterior leaflets sutured along an annuloplasty ring. Each leaflet of the valve has two legs as a function of chordae and is sutured on papillary muscle in left ventricle. In clinical settings, the distance between anterior and posterior papillary (A-P) muscles varies from patient to patient. Therefore, the degree of stress concentration on the NORMO valve at closure can be influenced by the distance.

AIMS: The aim of this study was to investigate influences of the distance between A-P papillary muscles on stress distribution of the NORMO valve at closure and to assess validity of the valve design.

METHOD: The NORMO valve with the annulus diameter of 27 mm was prepared. The three dimensional structure of the valve was taken under applying 10 mmHg from the ventricle side using a micro CT. The primary tetra-element was used for the finite element analysis using ADINA 9.2.3. The pressure load of 120 mmHg was applied to each element with the increment of 6 mmHg. Elastic modulus and Poisson's ratio of the valve leaflet were obtained using a uni-axial tensile test. Von Mises stress distributions of the leaflet under the conditions that the distances between A-P papillary muscles are 18, 24, 30, and 36 mm, respectively, were analyzed considering the variation in patients. RESULT & DISCUSSION: The higher Von Mises stress concentrations were observed when the distance between A-P papillary muscles were 18 mm and 36 mm (18 mm: 0.58 MPa, 24 mm: 0.21 MPa, 30 mm: 0.36 MPa, 36 mm: 0.62 MPa). These differences were caused by the design of the NORMO valve that the distance of the two legs of the valve is 25 mm. However, the stress concentrations were found to be less than the ultimate stress of the leaflet material by 10 times.

CONCLUSION: The Finite element analysis reveals that the stress concentration on the NORMO valve increases when the distance between the anterior and posterior papillary muscles is 18mm (smaller) or 36 mm (larger) and that the values were sufficiently low.