IMPACT OF MITRAL VALVE ANNULOPLASTY ON MITRAL VALVE PERFORMANCE: A NUMERICAL STUDY

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INTRODUCTION

Ischemic mitral regurgitation (IMR) is a life threatening disease. Currently, only in the United States , 1.6-2.8 million patients are suffering from the chronic IMR. This represents almost one-third increase since 1995. Chronic or functional IMR is a result of a combination of annular dilatation and papillary muscle displacement without an existence of any pathological symptoms on mitral valve leaflets. Currently, undersized mitral annuloplasty is the preferable choice to reduce the annulus size and to prevent mitral regurgitation [1]. The evaluation process for the undersized annuluplasty operation is mainly conducted during the systolic phase of the cardiac cycle when mitral regurgitation flow is possible [2]. Recently, Magne et al. 2008 [3] concluded that undersized mitral annuloplasty in patients with ischemic mitral regurgitation could narrow the valve opening area during the forward mitral flow. Therefore, in the current study, the effect of undersized annuloplasty on the forward flow was investigated.

METHODS

The forward flow through the mitral valve was simulated in order to evaluate the flow dynamics and the transmitral pressure gradient during the diastolic phase. 3-D pulsatile flow through the mitral valve with different annulus sizes was simulated. Moreover, the left ventricle was modeled by considering a myocardial infarction. Finally, healthy case was simulated to be considered as a benchmark for our analysis and evaluation process (Figure 1).

RESULTS AND DISCUSSION

Due to the difference in leaflet opening angles, the flow patterns downstream of the valves were different from healthy ones. In general, flow separation and vortex formation were noticed in all cases. The maximum velocity dramatically increased from 0.44 m/s in the healthy case to 1.69 m/s for the smallest ring size (24 mm). Moreover, the flow direction changed from being central toward the apex in the healthy model to mainly lateral flow toward the posterior wall in all undersized mitral annuloplasty cases (Figure 2.a). Furthermore, the vortex formation scenario downstream of the mitral valve is highly dependent on mitral leaflets orientation. In the healthy model, the vortices are formed in the whole domain with major vortex at the middle of the ventricle and toward the aortic valve. On the other hand, in undersized mitral annuloplasty cases, the vortical flow was noticed mainly in the upper half of the left ventricle.

The elevation in the Transmitral Pressure Gradient (TPG) is proportional to the size of the annuloplasty ring [3]. Furthermore, by simulating the same ring size with two different leaflets orientation (healthy and undersized annulus), we found that not only the ring size has an effect on the TPG but also the leaflets orientation. As the leaflet tips are shifted toward the posterior wall, the pressure gradient becomes higher than for the healthy configuration where leaflets are parallel to the atrium central axis (Figure2.b).

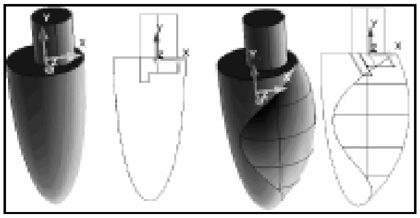

Figure 1: Left ventricle geometry for healthy (left) and pathological (right) conditions.

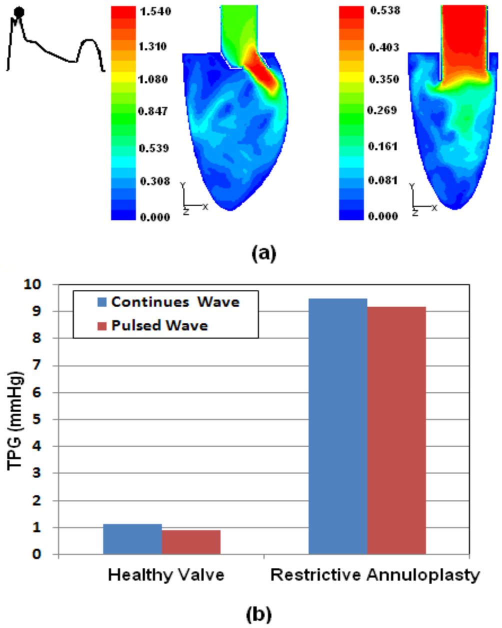

Figure 2: a) Velocity contours at the peak of E-wave for 24 mm undersized annulus (left) and healthy one (right).
b) Estimated maximum transmitral pressure gradient using different measurement techniques.

CONCLUSIONS

Results show that the maximum velocity magnitude and position is dramatically changed due to both annulus size and leaflet's orientation. Consequently, echo Doppler measurements could be affected due to misaligning the wave beam. In addition, transmitral pressure gradient increases significantly with the existence of undersized mitral annuloplasty which in turn could affect patient's functional capacity. Furthermore, leaflet orientations and ring size are significant determinants of the magnitude of transmitral pressure gradient.

REFERENCES

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