NOISE OF THE BILEAFLET MITRAL VALVE

*[1]Voskoboinick V., [2]Redaelli A., [2]Fiore G.B., [1]Tereshchenko L., [1]Voskoboinick A., [2]Lucherini F.

[1] Institute of Hydromechanics NASU, Kyiv, Ukraine,
[2] Politecnico di Milano, Milan, Italy

Over 55% of heart valve replacements use mechanical heart valves, with bileaflet heart valves currently the most popular design [1]. The fluid dynamics of mechanical valves may differs substantially from those of native valves. Flow is eccentric in monoleaflet valves and composed of 3 separate jets in bileaflet valves. The study of ventricular flow *in vivo* is limited by the time and space resolution of available noninvasive measuring methods. The details of fluid flow can be appreciated only *in vitro*, where high-resolution techniques in space and time can be used. During few last decades a number of researches have been carried out using by the laboratory models, focusing on PIV and pressure measurements in an order to investigate a valve impedance and unsteady velocity and pressure fields [2]. The research purpose is *in vitro* study of peculiarities of the flow noise of the open prosthetic bileaflet mitral valve and the definition of the spectral characteristics of noise sources.

Features of formation of jet flow, vortex structures, which are generated at the boundary layer separation, and hydrodynamic noise, were carried out at different values of constant flow rate of water. The tests were conducted in the μLab laboratory of Politecnico di Milano, Italy. Experimental setup, which is based on a test bench, was used for the measurements. The test bench consisted of the inlet fitting, the model of the atrium chamber, the model of the left ventricular chamber, the outlet fitting, the housing mitral valve, the coordinate device of moving the sensors, the correlation block of the absolute pressure and pressure fluctuation sensors, the pressure sensor in the atrium chamber. The prosthetic bileaflet mitral valve Sorin biomedica cardio (25 LFA) of 25 mm internal diameter (d) was used in this research.

The group of miniature pressure sensors [3], which measured static and dynamic pressure inside the ventricular chamber, was placed downstream to the mitral valve. Pressure sensors were flush mounted with the rigid surface of the sensor block and were moved in the vertical direction along the jets that flowed from the open holes of the mitral valve. The sensor block consisted of three piezoceramic sensors of wall pressure fluctuations and two piezoresistive sensors of absolute pressure. Vibroacoustic diagnosis of experimental setup and its components was done before the pressure measurements.

Processing and analysis of experimental results were carried out with the use of methods of mathematical statistics and probability theory. Statistical moments of the first and second order were determined. Spectral characteristics of fields of pressure fluctuations and accelerations were obtained with the use of fast Fourier transformation and Hanning weighted window.

It was found that inside the atrium and left ventricular chambers, the mean pressures and pressure fluctuations increase with increasing the flow rate. It should be noted that inside the left ventricle chamber for the open bileaflet mitral valve mean pressures are higher near side jet than near central jet. The highest intensity of pressure fluctuations is observed near central jet inside the model of the left ventricular chamber.

It was obtained that the highest levels of the pressure fluctuations occurred inside the atrium upstream in a frequency range (0.4-10) Hz. The highest spectral levels of the pressure fluctuations inside the left ventricle chamber were observed for flow rate of 20 l/min in the frequency range from 0.03 Hz to 200 Hz. The lowest spectral levels of the pressure fluctuations occurred for flow rate of 5 l/min near the side jet downstream to the open mitral valve. For the flow rate of 5 l/min the lowest levels of the pressure fluctuations are detected near the central jet downstream to the open valve in the frequency range f<12 Hz. It was found that with an increase of flow rate the spectra of the pressure fluctuations expanded to high-frequency region, especially near side jet.

It was shown that three areas of the high spectral levels of the pressure fluctuations are observed in frequency ranges (3-4) Hz, (8-9) Hz and (55-60) Hz inside the left ventricle chamber downstream to the open valve. They are caused by low-frequency oscillations of the jet and vortex flows, by separations of large-scale vortex structures from the edges of the mitral valve and by the separations of small-scale vortices from the leaflets and also by their sub-harmonics and high harmonics. If sensors are located at distances greater than 2.5d downstream to the open valve, the largest decrease of spectral levels are observed in the frequency range (20-70) Hz. With the increase of the distance from the valve a small-scale vortex structures are degenerated.

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