Although improved models (discs, semispherical, etc.) have been manufactured in recent years, artificial prostheses of heart valves have several shortcomings: a high percentage of thromboembolic complications, not always satisfactory hemodynamic characteristics, liability to rupture of the closing element, tendency to support infection processes [1, 2].

Biological prostheses of heart valves (xenogenic, allogenic) do not show the most important of the shortcomings mentioned, i.e., they do not produce thromboembolic complications, but they do not satisfy the cardiologists because the mechanical strength is lost long after the operation [3-5]. In our opinion, one of the main causes of this complication is the inadequate constructive solution used in the cardiologic surgery of the supporting frame (Fig. 1) for fixation of the valve bioprosthesis, which requires cutting of the folds so that the arched bow, the aortal part of the Valsalva sinuses and the part of the aorta over the arched ring are necessarily cut away (Fig. 2). The elements mentioned together with the commissures, the folds, and the ring of the valve basis constitute a biological construction which operates as a single unit [6, 7].

Since the deformation behavior of all elements of the valve-aorta complex is important, in the present study the mechanical characteristics of the elements of the valve-aorta complex of a pig were investigated. The tests were done with an Instron-1122 rupture machine. The rate of loading \( \dot{v} \) for every element of the valve was determined in a preliminary series of experiments. The rate \( \dot{v} \) was determined from the condition of reproducibility of the load-elongation curves under repeated-static loading and the lowest hysteresis losses during cyclic loading along the nonlinear part of the curve.

Samples were cut from the aorta wall and from the wall of the sinuses in the form of 5-mm-wide bands in the axial direction with respect to the longitudinal axis of the valves and perpendicular to the axial direction.

**Fig. 1.** Supporting frame for fixation of a valve xenoprosthesis: 1) support; 2) supporting ring; 3) collar for fixation of the xenovalve.

*Paper presented at the Second All-Union Conference on Biomechanics, Riga, April 1979.*
Fig. 2. Root of the aorta: 1) aorta; 2) arched ring; 3) commissures; 4) folds; 5) aortal part of the Valsalva sinus; 6) ring of the valve basis.

Fig. 3. Directions of cutting samples: 1, 2) axial and peripheral direction of the aorta; 3) arched ring; 4) commissure; 5, 6) axial and peripheral direction of the sinus; 7) ring of the valve basis; 8, 9) perpendicular and parallel to the free edge of the line.

along the periphery. Samples of 2 mm width were cut from the folds along the line of the commissure at various distances from the commissure and perpendicular to it (Fig. 3).

The other elements of the complex, viz., the ring of the basis, the commissures (the intersection of the commissures with the wall of the aorta), and the arched ring have less distinct outlines. For example, the arched ring, which is connected to the apex of the commissures by three edges [7], hardly differs in thickness from the wall of the aorta. Therefore, "generalized" characteristics of these elements were investigated; for this purpose the ring of the basis and the arched ring were tested in the form of bands and rings cut without rupturing the structural bonds with the surrounding elements of the complex. The commissures were tested in the form of samples including parts of the aorta wall, the arched ring, and the ring of the basis (Fig. 3).

The p-Δl curves taken in the machine were converted into true load-deformation diagrams by applying the procedure described in [8]. From the true σ - ε diagrams we determined the rupturing stress, the deformation at rupture, the deformations ε nonl which correspond to the nonlinear part of the dependence, the actual values of the elasticity module for various values of ε in the nonlinear region. The tangential elasticity modules were determined from the linear range of the σ =f(ε) plot. Averaged experimental values and their evaluation are given in Table 1.

From Table 1 it is evident that the ring of the valve basis is the strongest and most rigid element. The commissures and the arched ring are the elements which come next in the sequence of decreasing rigidity characterized by the deformations ε nonl and ε max and the moduli E nonl act and E11 act tang, and the arched ring has a reserve of deformation capacity which hardly differs from the deformation capacity of the wall of the sinuses and the aorta in the peripheral direction. The value of the actual modules in a large part of the nonlinear region of the deformation curve for the arched ring is more than double that for the samples of the walls of an aorta and the sinuses in the peripheral direction. The nearly equal values of the actual modules in the initial part of the nonlinear region for commissures and the wall of the sinuses in the axial direction indicates that the commissures do not prevent deformation of the aortal part of the Valsalva sinuses in the axial direction at low pulling stresses. However, the value of E act for commissures increases steeply at the end of the nonlinear region, exceeding by a factor 3.75 the value for axial elongation of the wall of the sinus. The deformation ε nonl in the nonlinear region for commissures is a factor 1.5 lower than ε nonl for axial stretching of the wall of the sinus.

The elastic properties shown by the walls of the sinuses of the aorta and characterized by the values of E act for various deformations indicate anisotropy of the properties of their material. The actual moduli for the samples cut in the axial direction equal on the average half E act for samples in the peripheral direction. The wall of the sinuses, whose thickness is on the average 2.5-3 times smaller than that of the wall of the aorta, has a high rigidity and strength in the axial and peripheral directions at an equal deformability. In our opinion, this can be ascribed to the circumstance that a structure corresponding to the median shell of the aorta [7] is almost completely absent in the wall of the sinuses. The strength of the walls of the sinuses and the aorta in the peripheral direction is 1.33 times higher than the strength in the axial direction, whereas the