Clinical Studies on the Ejection Phase of Auxotonic Contraction: Effects of Aortic Distensibility

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RECENTLY, many attempts have been made to evaluate the myocardial contractile state in connection with the increasing afterload on the myocardium throughout systole in an intact heart. From the experimental observations of the contractile force generated at different site of the myocardium, it was suggested that the evaluation of the contractile state in the isovolumetric phase did not concur with that in the ejection phase. Therefore, measurements of the generating force and the shortening velocity of the left ventricular (LV) myocardium in direct relation to the aortic property may provide a quantitative approach for the analysis of the myocardial function during the ejection phase of auxotonic contraction.

Determination of Volume Distensibility of the Ascending Aorta as a Primary Determinant of the Left Ventricular Afterload

At the moment of the aortic valve opening, the left ventricle is loaded by the aortic diastolic pressure as reflection of the peripheral resistance, whose alterations are of little significance for the LV afterload. During ventricular emptying the ejected volume from LV generates the aortic systolic pressure in relation to the property of the central arteries, “Windkessel Volume” and the velocity of ejection (Fig. 1). “Windkessel” can be defined as the distensible central arteries where most of the stroke volume is stored. If the property of the ascending aorta is further assumed to represent that of Windkessel system, estimation of distensibility of the ascending aorta should be indispensable for studying the load of the ejection left ventricle.

The cavity of the ascending aorta was visualized radiographically during routine cardiac catheterization and was calculated by the method employed in our laboratory (previously reported) while aortic pressure was recorded prior to the angiogram. With this approach it became possible to measure distensibility of the ascending aorta. Our data showed that maximum volume of the ascending aorta in aortic insufficiency was twice that of mitral insufficiency, but the mean values for volume distensibility in both groups did not differ significantly. The mean value for the aortic distensibility in 25 subjects with varying heart lesions was 0.847 ± 0.430 S.D.

Key Words: Auxotonic Contraction, Aortic Distensibility, Stress-Time Relation, Shortening Velocity, Hemodynamics

Fig.1. Representation of factors which affect the interrelation between the myocardial loading and the myocardial fiber shortening.

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percent per mmHg pulse pressure. The patients with LV dysfunction showed relatively increased volume and decreased volume distensibility of the aorta.

Effects of Aortic Distensibility on the Myocardial Force and Velocity

Myocardial wall force (stress) can be defined as the afterload of the ejecting LV myocardium, but also as the generating force of the same myocardium. Time course of LV wall stress during ejection, therefore, provides an index of contractile state of cardiac force as a function of

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time. Alterations in the duration of relatively high stress were represented as the duration of stress at 80% or above of the peak and its ratio to the left ventricular ejection time (D_{80}/LVET) in this study. The calculated value of the contractile element velocity (Vce) at the moment of maximal wall stress was reported as one of the useful indicis of the contractile state in the LV function. These parameters special reference to aortic distensibility were clearly shown in Fig.2A and 2B. In case with normal LV function, decreasing aortic distensibility effected the prolongation of high stress, the magnitude of which varied inversely with the extent of aortic distensibility (Fig.2A), and a significant positive relation between aortic distensibility and Vce at the peak stress was demonstrated in Fig.2B. From these clinical studies it is suggestive that, in the normal hemodynamic interrelation between the aorta and the left ventricle, the aortic property may have a primal determinant on the cardiac contraction. No significant relationships between indicis of the contractile state of the ejecting ventricle and other hemodynamic parameters; total systemic resistance, mean aortic pressure and total stroke volume, were apparent in the previous study.

**Hypertension:**

It was reported by the analysis of pressure and flow waves that the most important effects of hypertension of hemodynamics in large arteries are due to changes in distensibility of the large arteries. Distensibility of the ascending aorta in two cases of essential hypertension, obtained angiographically was significantly low among those of the patients with various heart lesions. Despite the rigid aorta, the shortening velocity of the myocardium was increased and the stress-time curve showed rapid decline after the peak in the same cases. In this approach, it may be feasible to investigate the mechanism of the responses of the myocardium to the aortic property in hypertension.

**CONCLUSION**

1) Standard hemodynamic measurements obtained from routine cardiac catheterization, which are total systemic resistance, mean aortic pressure and total stroke volume, do not become a primal determinant of the left ventricular load.

2) Angiographically obtained volume distensibility of the ascending aorta should provide an approach to evaluate the myocardial function in the ejection phase of autocyclic contraction, since the assessment of the contractile state during ejection must be analysed in direct relation to the loading of the arterial system.

3) Distensibility of the ascending aorta demonstrated a significant inverse relationship to the duration of LV wall stress at 80% or above of the peak, and a positive one to the contractile element velocity at the peak stress in patients with normal LV function. These results suggest that distensibility of the proximal aorta has a major role on the cardiac contraction.

**REFERENCES**


