

This Week's Citation Classic

CC/NUMBER 20
MAY 16, 1983

Weissler A M, Harris W S & Schoenfeld C D. Systolic time intervals in heart failure in man. *Circulation* 37:149-59, 1968.
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The systolic time intervals constituted the first contemporary quantitative noninvasive measure of global left ventricular performance in man. In this investigation, normative data were established and the pattern of change in left ventricular decompensation was documented. [The SCJ® indicates that this paper has been cited in over 700 publications since 1968.]

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March 28, 1983

"In the mid-1960s, technical developments in cardiac catheterization had emerged to the point where virtually all hemodynamic measures characterizing the performance of the cardiac chambers could be determined in patients with cardiovascular disease. With the escalating cost of cardiac catheterization and knowledge that vast numbers of patients required cardiac evaluation, it soon became evident that newer, less expensive, and less intrusive diagnostic methods were needed. It was at this time that I promoted the view that valid quantitative physiologic measures of the performance of the heart could be derived by methods which involved only the recording of potentials and pulsations at the body's surface. Adding to the advantage of modifying and reducing the use of invasive diagnostic modalities, such methods offered the benefits of reduced risk, less discomfort, and a potential for diminished expense in medical care.

"In conceptualizing such methods, it became apparent that of the various measures of cardiac performance conventionally applied, the determination of the duration of the events of the cardiac cycle was the most neglected. I hypothesized that the heart must be regulated relative to the timing of its performance. Thus, just as alterations in chamber pressure, volume, and output occurred in left ventricular decompensation, the time intervals of the contractile cycle might also change in a predictable fashion.

"In this paper, my colleagues, W.S. Harris and C.D. Schoenfeld, and I established the

normal linear regression relationships between heart rate and the duration of the systolic time intervals among 121 normal male and 90 normal female subjects in the age range of 19-65 years. These normative data were the first to be established by modern methods. They served as a basis for comparison with patients with cardiovascular disease. In order to focus on the effects of left ventricular decompensation on systolic intervals, studies were performed on cardiac patients in sinus rhythm who retained normal ventricular depolarization, and who were receiving no digitalis or antihypertensive medication. The studies demonstrated that the failing left ventricle is characterized by the presence of a prolonged systolic pre-ejection period (PEP) and an abbreviated left ventricular ejection time (LVET) while total electromechanical systole remains within normal limits. Both subcomponents of the PEP, the Q-1 interval and the isovolumic contraction time, were found to be prolonged. Since this study was performed prior to the availability of ejection fraction measurements, the alterations in systolic time intervals were related to the left ventricular stroke volume and the cardiac output as measured by the indicator dilution technique. It was demonstrated that the prolongation in the PEP and the abbreviation in the LVET were well correlated with the reduced stroke volume and cardiac output. In addition, it was shown that when arterial diastolic pressure exceeded 100 mm Hg, there was independent prolongation of the PEP with no influence on the LVET.

"This study was the first to establish the consistent pattern of alterations in systolic time intervals in patients with left ventricular decompensation. It provided a new dimension of left ventricular function which could be added to conventional expressions for quantitating left ventricular decompensation. The systolic time interval measurement offered the special advantage that it could be obtained by entirely noninvasive methods. Indeed, the systolic time intervals constituted the first measure of left ventricular performance to which the term noninvasive was applied. Numerous papers on the application of systolic time intervals followed.¹ In subsequent years the use of echocardiography and radioisotopic methods for determining the extent and rate of left ventricular chamber contraction were added as useful noninvasive modalities."

1. Weissler A M, Lewis R P & Boudoulas H. Key references, systolic time intervals. *Circulation* 64:862-7, 1981.