Institute of Medical Research(Cedars of
Lebanon Hospital)

PROGRESS REPORT

31 July 1965 through 31 December 1965

A TECHNIQUE FOR TESTING HEART FUNCTION
BY ANALYSIS OF ITS VIBRATION SPECTRUM

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The work of the period from 31 July 1965 through 31 December 1965 can be summarized as follows:

I. Refinement of external methods for estimating cardiovascular parameters

A. Prediction of rate of left ventricular pressure rise (P')

A re-examination of the factors controlling the duration of isovolumetric contraction in animals revealed that the ratio of the aortic diastolic pressure to the rate of pressure change (ADP/P') had a significantly greater correlation with the isometric interval than did these terms as linear determinants. These results imply that the duration of isovolumetric contraction is largely governed by the aortic diastolic pressure, when the latter is normalized to the rate of ventricular pressure change. It is thus possible to predict maximum P' with a high degree of reliability from the ICT and ADP by the following relationship: (Figure 1)

$$ICT = 1.075 \frac{ADP}{P'} + 12.37, \ r = 0.85$$

B. Prediction of Stroke Volume

Previous experiments in animals illustrated that the stroke volume could be estimated from the ejection and isometric intervals. This study has been extended to the human subject and re-evaluation of the data made. It was found that the ratio of the ejection to the isovolumetric contraction intervals (ET/ICT) proved to be a more accurate means of estimating stroke volume in man than in animals. ($SV = 11 \frac{ET}{ICT} + 11.6$) Calculation of stroke volume by an indirect technique is simple and so far has shown a high correlation with cardiac catheterization measurements in man. (Figure 2)

C. Application of these techniques to the human subject

These measurements, in addition to other externally obtained cardiovascular performance measurements (Figure3,4) are currently being applied to patients recovering from acute myocardial infarction. These studies are being performed at the intensive and coronary care units at Cedars of Lebanon Hospital. This simple technique is already proving most exciting. A recent example will indicate its use. A patient in shock from myocardial infarction was doing very poorly despite digitalization, administration of Aramine, and other measures. Stroke volume was calculated to be 32 cc and cardiac output 2.6 liters/minute. After much discussion it was decided to add Levophed. At this time the patient began putting out urine and a blood pressure could be obtained. Calculation of stroke volume and cardiac output now showed a value of 42 and 3.7 respectively.

A continuous monitoring system is being constructed which will consist of a telemeterized microphone (already reported), an automatic interval timer (already reported), an F. M. receiving system, computer, and a recording system for continuous registration of stroke volume.

II. Examination of contractility indices in animals

Since the writing of the last report, several investigations have been performed by independent research groups in the country which substantiate the use of the length-tension-velocity relationship for the determination of cardiac contractility. Further, a means of estimating contractility in the intact preparation has been described, which involved relating the impulsive force developed by the ventricle (summed ventricular pressure) to the maximum rate of development of pressure (P') during the phase of isometric systole in which the P' maintains 90% of its maximum value. (Max $\frac{dP/dt}{IIT}$) Yet another means of estimating contractility has been described in the relationship between the max P'.

$$\left(\frac{\text{Max } dP/dt}{\text{Time - Max } dP/dt} \right)$$

It was decided to test these indices in closed chest animals under a variety of experimental conditions. Ten such experiments were performed in which drugs were infused which altered the preload, afterload, and contractile state of the ventricle in varying degrees (levarterenol, angiotensin and isoproterenol). These experiments indicated that both contractility indices did indeed parallel the expected alterations in ventricular function imposed by the agents administered.

Present experiments on this phase of the work are incomplete but indicate that such contractility indices can be obtained from external measurements.

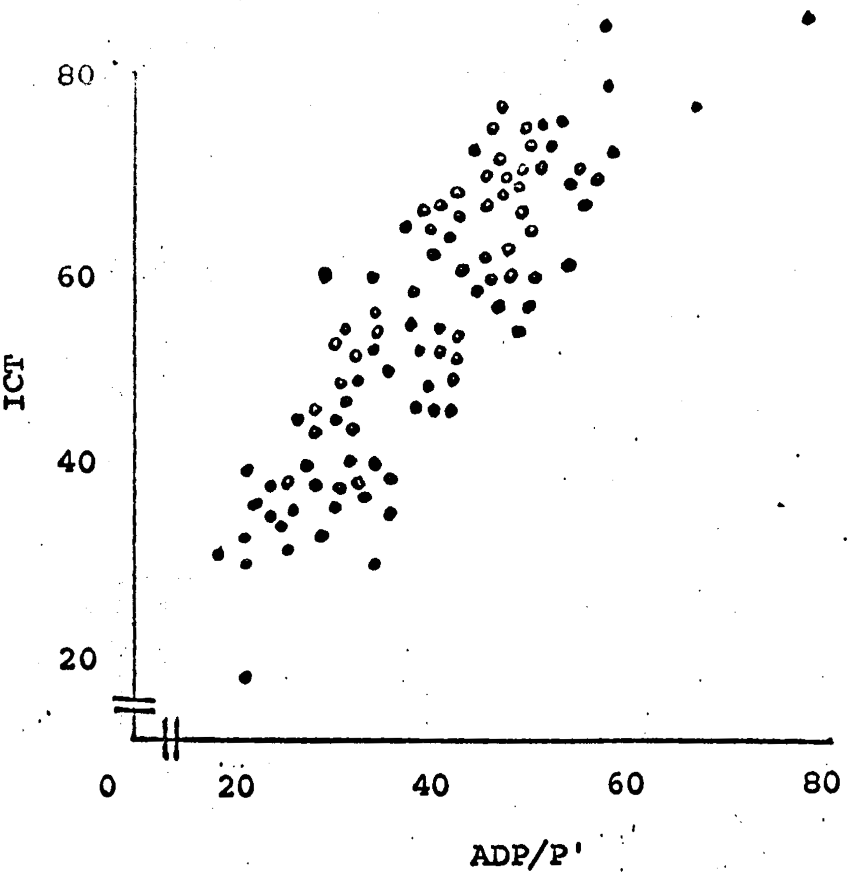


Figure 1

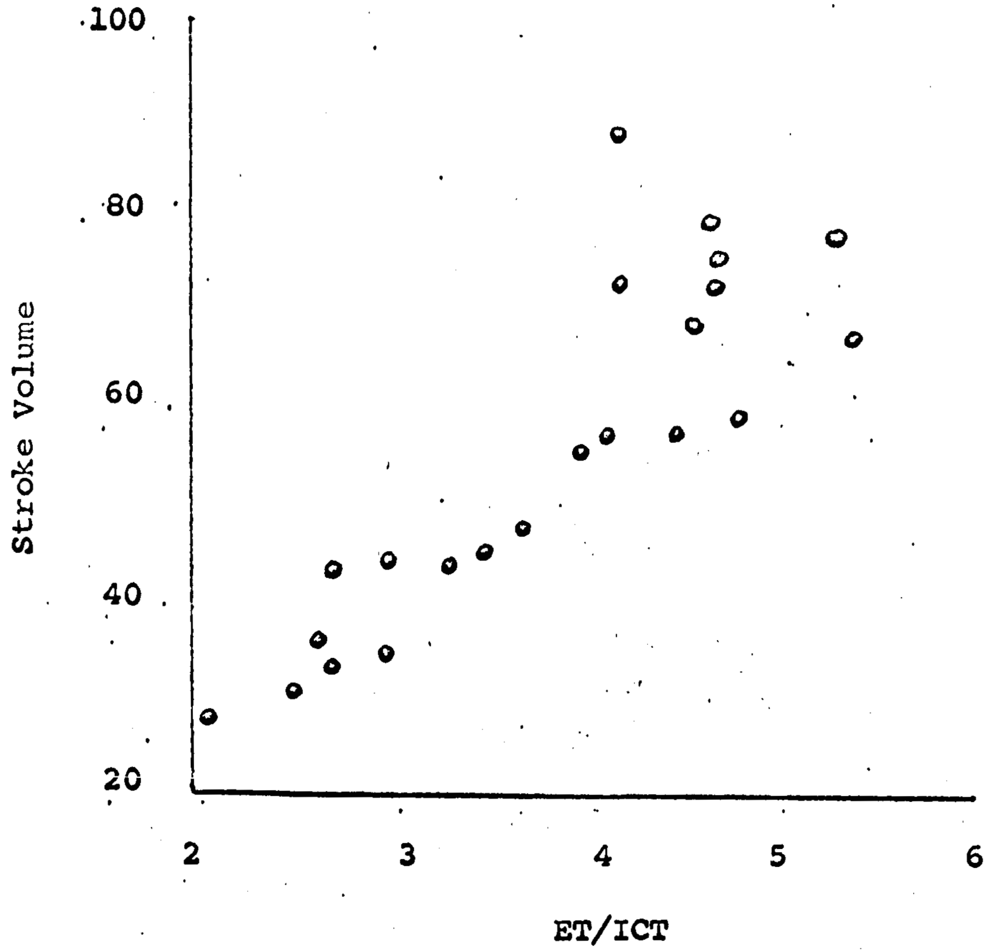
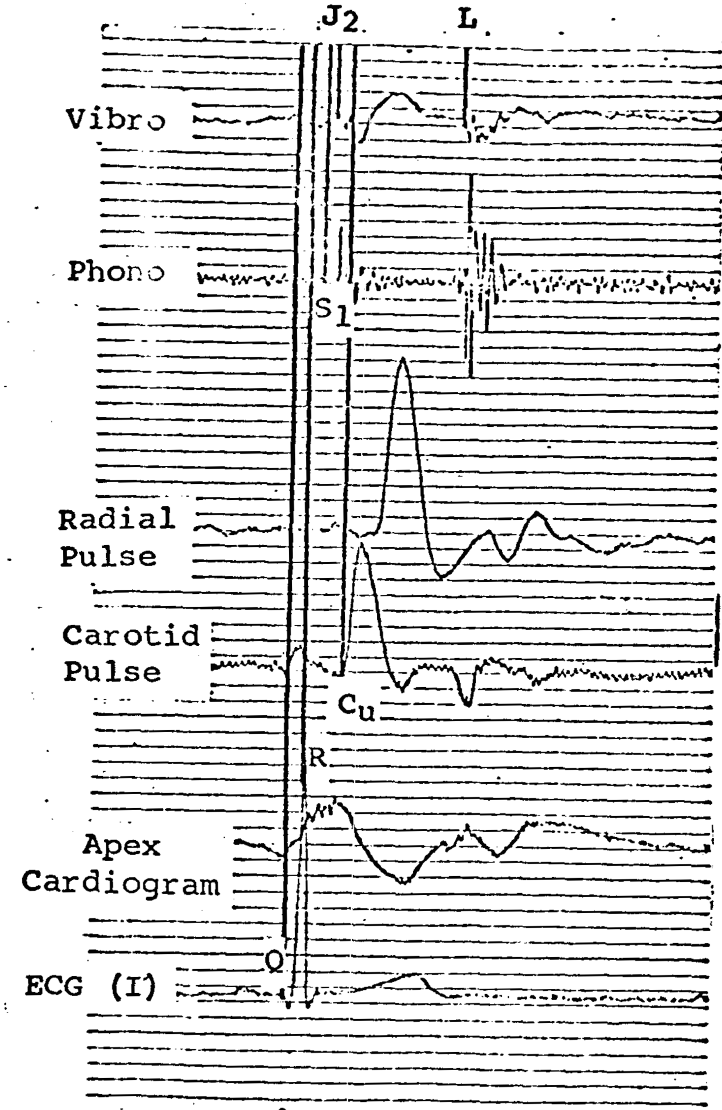


Figure 2



Q-S_1 = Electromechanical Lag

R-S_2 = Isometric Contraction

J_2-L = Ejection

J_2-C_u = Pulse Delay

R-L = Mechanical Systole

Figure 3

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CLINICAL DATA

DERIVED CALCULATIONS

Stroke Volume	$11(ET/ICT) + 11.6$
Cardiac Output	$SV \cdot HR$
Maximum dP/dt	
Stroke Work	$MAP \cdot SV$
Minute Work	$SW \cdot HR$
Contractility Index	$\frac{dP/dt}{ICT}$
Peripheral Resistance	MAP/CO
Pulse Wave Velocity Index	$PWV/s \cdot p$
Predicted Ejection Time	$402 - 1.89\ (HR)$
Predicted Mechanical Systole	$.324 \sqrt{R\text{-}R_{sec}}$
Corrected Q-T	$Q\text{-}T/\sqrt{R\text{-}R_{sec}}$

Figure 4