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Sonnenblick E H. Force-velocity relations in mammalian heart muscle. *Amer. J. Physiol.* **202**:931-9, 1962.
[Lab. Cardiovascular Physiology, Natl. Heart Inst., NIH, Bethesda, MD]

In this paper, the mechanical properties of mammalian heart muscle were studied *in vitro*, providing a muscular analogue for analysis of ventricular performance and a rational basis for quantifying cardiac function. [The *SCI*® indicates that this paper has been cited in over 680 publications since 1962.]

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In the late 1950s, I was fortunate to obtain an investigator's position in Stanley Sarnoff's laboratory at the National Heart Institute in Bethesda where the thrust of investigation was to define the complex performance of the heart under controlled conditions.

Unprejudiced by prior training and unfettered by conflicting responsibilities, I was free to explore wherever interest would take me. Needing an area that would not require the resources of a large animal laboratory, I chose to explore the characteristics of the ventricle with the isolated papillary muscle as a simple analogue. The methods were provided by the seminal studies of Lundin[1] and Abbott and Mommaerts,[2] demonstrating that such an approach was feasible.

The present study demonstrated that the apparently complex function of the intact heart could be explained and modeled by the muscle properties of the ventricular wall and laid the basis for subsequent quantitative descriptions of ventricular performance. Indeed, the "heart was a muscle."[3]

Specifically, the paper showed how cardiac muscle could be studied *in vitro* to dissect the mechanisms by which force generation is altered by changes in initial muscle length as contrasted with alterations in activation (contractility). Theoretical constructs to explain these direct findings have been a continued thrust in the field.

Subsequently, this study served as a point of departure for quantitative analysis of an intact ventricular performance in both health and disease and also as a focus for ultrastructural studies of the contractile apparatus at a more fundamental level. The paper is widely cited as one of the first quantitative approaches to simple physiological analogues for cardiac function, and the data are provided for further conceptualization.

The study also reflects a somewhat unique era in cardiovascular science. Due to circumstances of compulsory military service and the open opportunities at the National Institutes of Health in Bethesda, young physicians were brought into a scientific environment at a young age, largely freed from clinical responsibilities, closely supervised by superb scientists, and surrounded by virtually unlimited facilities without the need to generate grant support. In my own case, I particularly benefited from the advice, criticism, and encouragement of Richard Podolsky. The result was a blooming of scientific medicine—young physicians were trained in the methods of science, and great productivity ensued. Ultimately, those physicians returned to their own institutions with these traditions. This cycle has largely ended now, but the paper cited reflects the start of this relatively brief but productive era.

1. **Lundin G.** Mechanical properties of cardiac muscle. *Acta Physiol. Scand.* 7(Suppl. 20):1-85, 1944. (Cited 100 times since 1955.)
2. **Abbott B C & Mommaerts W F H M.** A study of inotropic mechanisms in the papillary muscle preparation. *J. Gen. Physiol.* **42**:533-51, 1955. (Cited 370 times.)
3. **Brutsaert D L & Sonnenblick E H.** Cardiac muscle mechanics in the evaluation of myocardial contractility and pump function: problems, concepts, and directions. *Prog. Cardiovasc. Dis.* **16**:337-61, 1973. (Cited 60 times.)

