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The Capillary-Muscle Ratio in Normal and Hypertrophied Human Hearts.*

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In this investigation, the quantitative study of capillaries as initiated by Krogh[1] and by Wearn and collaborators[2, 3, 4] has been applied to normal and hypertrophied human hearts. The methods of injection and sectioning were essentially the same as those used on rabbit hearts in an earlier study from this laboratory.[4] Counts were made in 5 areas of each ventricle of the number of capillaries and fibers per square millimeter. Measurements were made to determine also the average diameter of the individual muscle fibers.

In this preliminary report we are able to compare the results of such a study in 10 normal and 10 hypertrophied human hearts. As compared with the normal hearts, the hypertrophied hearts show: (1) A marked increase in the average heart weight/body weight ratio and in the average heart weight, (2) a definite increase correspondingly in the average fiber diameter, and (3) a very evident decrease in the number of capillaries per square millimeter. At the same time, there is, (4) no change in the ratio of capillaries and

TABLE I.
A Comparison of Normal and Hypertrophied Human Hearts.

	Normal	Hypertrophied
No. of Hearts	10	10
Average Heart Weight (gm.)	289	650
" Ht. Wt./Body Wt. Ratio (x 10,000)	50.9	101
" Fiber Diameter (microns)	14	21
" " Area (sq. microns)	152	322
Capillaries per sq. mm. (average)	3992	2378
Fibers per capillary	1.4	1.3

* Presented at the joint meeting of the Experimental Medicine Section of the Cleveland Academy of Medicine and the Cleveland Section of the Society for Experimental Biology and Medicine, Cleveland, Ohio, October 15, 1937.

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1 Krogh, A., *The Anatomy and Physiology of Capillaries,* New Haven, Yale University Press, 1922, pp. 5-11.

2 Wearn, J. T., *J. Exp. Med.*, 1928, **47**, 273.

3 Wearn, J. T., *Diseases of the Coronary Arteries and Cardiac Pain,* edited by R. L. Levy, New York, Macmillan Company, 1936, pp. 31-57.

4 Shipley, R. A., Shipley, L. J., and Wearn, J. T., *J. Exp. Med.*, 1937, **65**, 29.

fibers; that is, the capillaries do not multiply to accompany the increase in muscle mass.

From this study on human material, which is in accord with the experimental study of Shipley, Shipley and Wearn[4] on normal and hypertrophied rabbit hearts, it is evident that there is an increase in the distance from the center of a given myocardial capillary to the periphery of its region of supply, which is approximately proportional to the degree of cardiac hypertrophy. At the present time the oxygen utilization of normal and hypertrophied hearts is being investigated to determine whether or not the diminished anatomical vascularization of hypertrophied hearts results in a physiological impairment to the exchange of metabolic substances.

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Fat Metabolism of the Isolated Heart.

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It is the conclusion of Cruickshank[1] that the isolated heart derives its energy at least in part from the combustion of fat. This deduction is based on the negative evidence that combustion of other fuels will not account for the total metabolism. According to Visscher and Mulder[2] the total oxygen consumption of the heart-lung preparation cannot be accounted for on the basis of the carbohydrate loss from the tissue and blood in that system. They found that in some cases as much as 80% of the total metabolism is non-carbohydrate, presumably fat. Previous studies on fat burning by striated muscle are conflicting. Palazzolo[3] reported a decrease, while Winfield[4] found no change in the fat content of muscle as a result of activity.

In order to elucidate this question further measurements of the total fat content of the mammalian ventricular muscle were made in two series of cases. For the first series hearts were obtained directly from anesthetized dogs, and for the second ventricular

1 Cruickshank, E. W. H., *Physiol. Rev.*, 1936, **16**, 597.

2 Visscher, Maurice B., and Mulder, Arthur G., *Am. J. Physiol.*, 1930, **94**, 630.

3 Palazzolo, Giovanni, *Archivio di Fisiologia*, 1912-13, **11**, 558.

4 Winfield, G., *J. Physiol.*, 1914-15, **49**, 171.