A Muscle Column Preparation from the Rat's Left Ventricle

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A muscle preparation from the left ventricle of the rat heart suitable for in vitro studies is described. It consists of one of the trabeculae carneae of the posterior ventricular wall extending from the apex of the ventricle to the auriculoventricular junction. Studies on the excitability, extensibility, tension development, and oxygen consumption of the preparation are reported. The preparation offers economic and technical advantages over other types of isolated heart muscle preparations currently in use.

Our laboratory has completed a series of control studies on a mammalian heart muscle preparation, the use of which has not heretofore been reported. The preparation consists of one of the trabeculae carneae of the posterior wall of the left ventricle of the rat heart. As shown in figure 1, the muscle column projects prominently into the interior of the ventricle near the interventricular septum, and extends from the apex of the ventricle to the atrioventricular junction. It is easily separated from the ventricular wall by means of a blunt probe. It is cylindrical in shape and in a 200 to 250 Gm. rat has a diameter of about 1 mm. and a usable length of approximately 1 cm. The preparation is functionally very durable in that it shows no loss of developed tension over a 10 hour period in a perfused oxygenated Ringer's bath.

Methods and Materials

Thirty-five normal male Sprague-Dawley rats were used. Each animal was decapitated and the heart immediately excised, opened, and the described muscle column removed.

Refractory periods, strength-duration curves, and length-tension diagrams were determined for 20 of the preparations in a constantly perfused and oxygenated bath of Ringer's solution made as described by Feigen and associates. The muscle was held in the bath in a vertical position by means of small clamps, the lower clamp containing chlorided silver stimulating electrodes, and the top clamp attached to a horizontal spring wire. Vertical adjustment of the spring wire altered the resting tension and length of the muscle. The spring wire was in turn attached to a Statham strain gage, the amplified output of which was recorded on a Grass ink-writing oscillograph. Isometric contractions were induced with current from a square-wave stimulator, and the developed tension transmitted to the strain gage. The stimulating current was monitored through an oscilloscope and, by means of a separate output from the stimulator, was simultaneously recorded on the oscillograph with the developed tension. A time signal was also simultaneously recorded.

The rate of oxygen consumption was determined for the remaining 15 preparations, using the standard direct Warburg technique at 37 C. with 100 per cent oxygen. A constant resting tension of 1 Gm. was maintained on the muscle.

Results and Discussion

Excitability Characteristics. The mean strength-duration curve for the 20 muscle columns is shown in figure 2. The rheobase taken from the curve is 0.12 ma. and the chronaxie 1.30 msec. These results are comparable to those which have been obtained by others from cat and dog heart muscle preparations under similar but not identical experimental conditions.

The mean refractory period, i.e., shortest interval between the driving and test stimuli which just produced an extra systole, was found to be 71 ± 2 msec., while stimulating the heart at a rate of 60/min. The test stimulus used was 6 msec. in duration and 4 ma. in intensity. The refractory period is shorter than that reported for either the cat or dog heart.

Length-Tension Diagrams. In figure 3 the mean resting and developed tension for the 20 muscle preparations are plotted as a function of the per cent increase in equilibrium length. This is defined as that length at which further
Fig. 1. Interior of left ventricle of rat heart, showing location of the trabecula carnea used in the experiment.

Fig. 2. Mean strength-duration curve for 20 heart muscle preparations. Ordinate, threshold in m&. a. Rheobase, stimulus duration in msec.

stretching of the muscle just begins to produce tension, and is indicated in the figure as 100 per cent. It approximates the in situ diastolic resting length. Tension is expressed as grams (resting tension) or milligrams (developed tension, i.e., total minus resting) per millimeter of equilibrium length of the muscle.

Figure 3 shows that the increase in resting tension of the heart muscle is approximately a linear function of its length over the range measured. The general shape of the developed length-tension diagram for the rat heart preparation was similar to that obtained for skeletal muscle. The maximum tension for heart muscle was developed at 105 per cent of the equilibrium length, compared to skeletal muscle in which the maximum tension has been shown to develop at the in situ resting length. According to Lundin, the maximum tension of amphibian cardiac muscle developed at 175 to 200 per cent of the equilibrium length. This may indicate differences between mammalian and amphibian cardiac muscle. It is possible, however, that in Lundin’s work the equilibrium length did not correspond to the in situ diastolic length of the cardiac fibers, or that his preparation was composed of nonparallel muscle fibers.
Histologic sections of the rat heart preparation reported here show essentially parallel muscle fibers running the length of the preparation.

Oxygen Consumption. The mean oxygen consumption ($Q_{O_2}$) of the 15 heart muscle preparations was $12.1 \pm 0.8 \mu l./hr./mg.$ dry weight of tissue. This is slightly higher than respiratory rates generally found for rat ventricle slices. The difference may lie in the fact that the muscle columns were not sliced and therefore contained relatively lesser amounts of injured tissue, which presumably would not contribute substantially to the total respiratory rate. In addition, stretching may enhance the respiratory rate.

Summary

A muscle preparation from the left ventricle of the rat heart has been described. Data on excitability, extensibility, tension development and oxygen consumption are reported which are in agreement with previous ones, from other preparations. The technic offers a convenient, economical and consistent method for the study of in vitro properties of mammalian cardiac muscle.

Summario in Interlingua

Es describite un preparato muscular ab le ventriculo sinistre del corde del rato. Es reportate datos relative a excitabilitate, extensibilitate, disveloppamento tensional, e consumpotion de oxygeno. Isto ses de accordo con datos obtenite previemente ab altere preparatos. Le technica representata un practic, economic, e invariabile methodo pro le studio del qualitatis in vitro de musculos cardiac de mammalibus.

REFERENCES

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