EFFECT OF ACETYLCHOLINE, ADRENALIN, POTASSIUM CHLORIDE AND CALCIUM CHLORIDE ON CONTRACTIONS OF THE LEFT DIVISION OF THE BUNDLE OF HIS WITH FUNCTIONAL CONNECTIONS WITH THE LEFT VENTRICULAR MYOCARDIUM INTACT AND INTERRUPTED

Yu. G. Starinskii

UDC 612.178.3.014.46

In experiments on isolated hearts of rabbits with functional connection between the specific muscle of the left ventricle and the myocardium of this ventricle intact or interrupted (in the same heart), it was shown that acetylcholine, adrenalin, potassium chloride, and calcium chloride have a direct action on the contractile activity of the specific muscle when injected into the coronary vessels. The action of these substances on the strength and rhythm of contractions of the left division of the bundle of His after interruption of its functional connection with the myocardium resembles their action on the whole heart when this connection is intact.

The specific muscle and myocardium are connected functionally in performance of the contractile activity of the heart. The connection between the two muscle systems may be disturbed under certain conditions. In Professor A. I. Smirnov's laboratory, for instance, work has shown that hypothermia and hypoxia interrupt functional connection between these muscular structures in the isolated heart of the warm-blooded animal [1, 2, 6]. After complete interruption of functional connection the specific muscle contracts while the myocardium does not receive these contractions [4, 5]. Smirnov and Vinokurova [7, 8] have shown that contractions of these specific muscles continue for several days longer than contractions of the myocardium.

The object of the present investigation was to demonstrate the action of acetylcholine, adrenalin, potassium chloride, and calcium chloride on contractions of the left division of the bundle of His (LDBH) with its functional connnection with the left ventricular myocardium intact or interrupted.

EXPERIMENTAL METHOD

Two series of experiments were carried out: series I of 11 experiments and series II of 14 experiments. Under intravenous urethane anesthesia the heart was removed from 2 male rabbits weighing 2.5-3 kg and perfused by Langendorf's method with Ringer's solution (38°C) with oxygenation. The wall of the left ventricle was excised above the interventricular septum to obtain a good view of the branches of the LDBH. Acetylcholine (0.3 ml of a 2% solution), adrenalin (0.3 ml of a 0.1% solution), potassium chloride (1 ml of a 10% solution), and calcium chloride (1 ml of a 10% solution) were injected into the perfusion system 5 cm away from the base of the aorta. The time between injection of one substance and injection of another was 10 min. In the experiments of series I the test substances were injected only during synchronous contractions of the LDBH after interruption of its functional connection with the left ventricular myocardium. This interruption was produced by perfusing originally with Ringer's solution (22°C) without oxygenation for 5-6 h. In the experiments of series II the test substances were injected when functional connection between

Physiological Group, Academy of Medical Sciences of the USSR, Institute of Normal and Pathological Physiology, Academy of Medical Sciences of the USSR, Moscow. (Presented by Academician of the Academy of Medical Sciences of the USSR N. A. Fedorov.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 74, No. 7, pp. 22-25, July, 1972. Original article submitted December 2, 1971.

TABLE 1. Effect of Test Substances on Left Division of Bundle of His with Its Functional Connection with the Left Ventricular Myocardium Intact or Interrupted in the Same Heart (experiments of series II)

Substance tested	Functional connection of left division with myocardium intact			Functional connection of left division with myocardium intact		
	original frequency of contractions	frequency of contractions after 5 min	frequency of contractions after 10 min	original frequency of contractions	frequency of contractions after 5 min	frequency of contractions after 10 min
Acetylcholine	103	68	96	75	39	64
Adrenalin	101	149	128	46	89	81
Potassium chloride	121	82	80	72	51	55
Calcium chloride	88	80	82	51	45	59

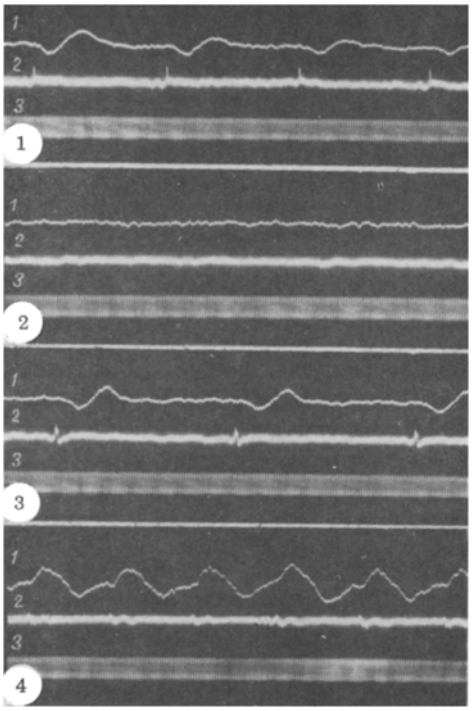

Fig. 1. Electrical and mechanical activity of the LDBH after interruption of its connection with the left ventricular myocardium and during the action of the test substances: A) Initial moment after injection of acetylcholine: decrease in amplitude of waves of mechanical activity; B) subsequent action of acetylcholine 20 sec after injection: disappearance of waves of mechanical and electrical activity; C) mechanical and electrical activity 3 min after injection of potassium chloride; D) increase in amplitude and frequency of contractions of left division after injection of calcium chloride. 1) Mechanical, 2) electrical activity; 3) time marker (50 msec).

the LDBH and left ventricular myocardium was intact or was interrupted in the same heart. Connection was interrupted by perfusion for 1 h 30 min. The frequency of contractions of the LDBH 5 min after injection of each test substance was compared by statistical analysis using the difference method, with the original frequency in both series of experiments. Visual observations of the strength and frequency of contraction of the LDBH were made with the MBS-2 microscope (magnification 20 ×). Mechanical and electrical activity of the LDBH was recorded simultaneously. Electrodes for recording its electrical activity were inserted into a branch of the LDBH leading to the anterior papillary muscle. The detector for recording mechanical activity was placed above the same zone of the contracting surface of the LDBH. Full details of the method were given previously [3]. The ECG of the isolated heart also was recorded.

In the experiments of series I and II, the effect of the test substances on its contractions was identical. Acetylcholine caused weakening of the LDBH contractions, followed by their cessation (Fig. 1A, B). As the test substance was rinsed out the contrations reappeared. After 5 min the frequency and amplitude of the contractions were lower ($P > 0.01$) than initially.

Adrenalin caused an initial increase in the frequency and strength of the contractions, which were clearly visible after 5 min ($P > 0.01$). Potassium chloride weakened and slowed the contractions of the LDBH, after which they ceased altogether and then recommenced, but after 5 min they were still weaker and slower than initially ($P > 0.01$; Fig. 1C).

Calcium chloride produced responses of the LDBH which varied from fibrillation to arrest, but if contractions were observed after administration of calcium chloride they were always strong (Fig. 1D; Table 1).

If the functional connection between the LDBH and left ventricular myocardium was intact, initially acetylcholine and potassium chloride weakened and stopped the contractions of the LDBH and left ventricular

myocardium. Adrenalin increased both the strength and the frequency of contraction. With a slow rate of contractions of LDBH, the myocardium also contracted infrequently. On the onset of fibrillation in the LDBH, the myocardium also fibrillated. Calcium chloride led to arrhythmic contractions of the LDBH and not infrequently to fibrillation.

A short time after coronary perfusion the original action continued but the characteristic effects of each substance appeared after 5 min on the contractions of the LDBH and left ventricular myocardium. After 5 min acetylcholine reduced ($P > 0.01$), adrenalin increased ($P > 0.001$), while potassium chloride reduced ($P > 0.01$) the frequency of the contractions.

It is clear from these experiments that, after interruption of connections with the myocardium, the test substances gave rise to changes in contractions of the LDBH similar to those produced by them when the connections was intact.

The experiments demonstrated the direct effect of adrenalin, acetylcholine, potassium chloride, and calcium chloride on changes in the contractile activity of the LDBH when its functional connection with the left ventricular myocardium is interputed.

LITERATURE CITED

1. A. G. Artuyunova, Fiziol. Zh. SSSR, 23, No. 1, 3 (1937).
2. I. Yu. Vinokurova, Fiziol. Zh. SSSR, No. 9, 1045 (1968).
3. V. F. Eroshkin, I. Yu. Vinokurova, and S. I. Anikeeva, Byull. Éksperim. Biol. i Med., No. 5, 121 (1969).
4. A. I. Smirnov, Klin. Med., No. 11-12, 1619 (1934).
5. A. I. Smirnov, Byull. Éksperim. Biol. i Med., 2, No. 6, 421 (1936).
6. A. I. Smirnov, Kardiologiya, No. 3, 74 (1970).
7. A. I. Smirnov, and I. Yu. Vinokurova, Byull. Éksperim. Biol. i Med., No. 9, 6 (1967).
8. A. I. Smirnov, and I. Yu. Vinokurova, Byull. Éksperim. Biol. i Med., No. 2, 7 (1970).