KINETOCARDIOGRAPHIC STUDY OF CONTRACTIONS OF THE LEFT AND RIGHT VENTRICLES DURING THE DEVELOPMENT OF RENOVASCULAR HYPERTENSION IN DOGS OF DIFFERENT AGES

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Kinetocardiograms of the left and right ventricles were recorded in puppies and adult dogs during development of experimental renovascular hypertension. The development of hypertension in adult dogs led to shortening of the expulsion period, but to its lengthening in puppies. Vector analysis of the kinetocardiograms showed that a syndrome of hypodynamia of the left ventricle, followed by a syndrome of high diastolic pressure, is observed in adult dogs; in puppies a phasic syndrome of high diastolic pressure, followed by a syndrome of stenosis of the outlet tract. The phase structure of the right ventricular cycle was marked by the appearance of a syndrome of hyperdynamia as detected previously in the adult dogs.

KEY WORDS: renovascular hypertension; age differences; kinetocardiography.

Until recently the character of changes in cardiac function during the development and subsequent course of renovascular hypertension remained unexplained. It was suggested [12] that in the early stages of its formation changes take place in the cardiac output in connection with a disturbance of sodium metabolism [15]. One important characteristic of the contractility of the myocardium is the duration of the phases of the cardiac cycle, but no information on changes in the phase structure of contractions of the right and left ventricles during the development of experimental renovascular hypertension can be found in the literature. Cardiac activity is known to differ in the intensity of functioning of the myocardial structures [4], in the character of nervous and humoral regulation [1], and in the phase structure of the cycle [2, 7, 10], at different age periods.

Accordingly, in the investigation described below the structure of the cycle of the right and left ventricles was compared during the period of formation of renovascular hypertension in puppies and adult dogs.

EXPERIMENTAL METHOD

Experiments were carried out on 21 puppies aged 2-3 months and 15 adult (3-5 years) dogs. Renovascular hypertension [13] was produced by simultaneous measured constriction of the lumen of both renal arteries. The arterial blood pressure (BP) was recorded by the direct method in the femoral artery. Kinetocardiograms (KCGs) were recorded by means of a special detector [5] in the fourth intercostal space on the right for the right ventricle and on the left for the left ventricle. Recording was carried out on the "Elcar" electrocardiograph with the animals at rest and fixed in the supine position (paper winding speed 100 mm/sec). The ECG in lead II was recorded synchronously with the KCG. Investigations were carried out in the initial state and on the 3rd and 14th days after renal ischemia. Control experiments were carried out

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on five adult dogs 3 days after a mock operation. For a more accurate interpretation of the phase shifts during the development of hypertension, vector analysis of the KCG was used [9].

TABLE 1. Changes in Phase Structure of Cardiac Cycle of Right and Left Ventricles during Development of Renovascular Hypertension in Adult Dogs and Puppies (M ± m)

Index studied (sec)	Left ventricle			Right ventricle		
	initially	3rd day	14th day	initially	3rd day	14th day
Adult dogs						
Period of contraction	0,063±0,002	0,059±0,003	0,063±0,038	0,062±0,002	0,053±0,003*	0,063±0,003
Phase of transformation	0,040±0,002	0,030±0,001*	0,036±0,029	0,040±0,001	0,031±0,003*	0,034±0,001*
Phase of isometric contraction	0,023±0,001	0,029±0,002*	0,027±0,001*	0,024±0,001	0,024±0,001	0,030±0,002*
Period of ejection	0,155±0,003	0,136±0,008*	0,154±0,007	0,159±0,004	0,150±0,005	0,153±0,008
Mechanical systole	0,166±0,005	0,172±0,006	0,188±0,007*	0,181±0,038	0,179±0,005	0,196±0,005
Mechanical diastole	0,432±0,030	0,314±0,027*	0,397±0,032	0,401±0,029	0,300±0,026*	0,388±0,042
Puppies aged 2-3 months						
Period of contraction	0,050±0,001	0,048±0,002	0,053±0,002	0,051±0,001	0,047±0,001*	0,049±0,002
Phase of transformation	0,025±0,001	0,025±0,001	0,026±0,003	0,027±0,001	0,026±0,001	0,027±0,002
Phase of isometric contraction	0,024±0,001	0,021±0,001*	0,027±0,003	0,024±0,001	0,022±0,001	0,026±0,003
Period of ejection	0,124±0,003	0,130±0,005	0,145±0,003*	0,129±0,004	0,134±0,007	0,141±0,005
Mechanical systole	0,151±0,003	0,154±0,006	0,165±0,006*	0,155±0,04	0,161±0,059	0,170±0,006*
Mechanical diastole	0,209±0,005	0,116±0,012*	0,198±0,017	0,206±0,0110	0,118±0,012*	0,189±0,014

* $P < 0.05$.

EXPERIMENTAL RESULTS

Simultaneous constriction of the renal arteries caused the BP to rise in the animals of both age groups. In puppies after 3 days BP reached 133.6 ± 2.6 mm, and by the 14th day it was 156.0 ± 8.4 mm compared with its initial level of 105.6 ± 1.9 mm. The increase in BP of the adult dogs was somewhat less: from 152.6 ± 1.65 mm initially to 184.5 ± 3.91 on the 3rd day and 198.3 ± 2.75 mm 2 weeks after renal ischemia. The duration of the cardiac cycle in the puppies by the 3rd day of renal ischemia was reduced to 0.288 ± 0.014 sec compared with an initial 0.366 ± 0.007 sec ($P < 0.001$), and by the 14th day it was back to normal. In adult dogs the duration of the cardiac cycle on the 3rd day also was reduced (0.541 ± 0.007 compared with an initial 0.615 ± 0.014 sec; $P < 0.001$), and on the 14th day its initial level was restored. The increased heart rate in the adult dogs was the result of shortening of the expulsion period and of diastole, but in the puppies it was entirely the result of shortening of diastole (Table 1).

Vector analysis of the KCG of the left ventricle of the adult dogs on the 3rd day after renal ischemia revealed a marked syndrome of hypodynamia, but on the 14th day a syndrome of high diastolic pressure was the predominant feature. In the right ventricle evidence of hyperdynamia was followed on the 14th day by a syndrome of hypodynamia.

On the 3rd day after renal ischemia the cardiac activity of the puppies was characterized by a phasic syndrome of stenosis of the outlet tract of the left ventricle, followed on the 14th day by a syndrome of high diastolic pressure and by certain features of hyperdynamia of the right ventricle.

Some investigators [8, 11] have observed clear evidence of a disturbance of the coronary circulation in the early stages of development of renovascular hypertension in adult dogs. Such a disturbance was evidently connected in these experiments with the appearance of the hypodynamic syndrome [3, 6]. The slight lengthening of the expulsion period in the puppies with a raised arterial pressure could reflect an increase in the cardiac output [14, 16].

In the animals undergoing mock operations no changes were found in the phase structure of the cycle. The blood pressure and heart rate remained the same as before.

It can be concluded from these results that the myocardium of the left ventricle possesses less mobility of its compensatory reactions to increased resistance

to ejection in adult dogs than in puppies. The changes detected in the phase structure of the right ventricle suggest that the development of renovascular hypertension considerably modifies the circulation in the pulmonary system also.

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