CHANGES IN THE PROTEIN COMPOSITION OF SKELETAL, CARDIAC, AND SMOOTH MUSCLE AFTER CASTRATION

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The effect of castration on the metabolism and chemical composition of muscle tissue has received only little study, except for the muscle of the uterus, which has been the subject of several biochemical investigations [7-10]. These have shown that ovariectomy is followed by appreciable changes in the protein composition of the myometrium.

Since the motor function of muscle is closely related to its protein composition [1, 2, 6], changes in the muscle protein fractions can be used to define the functional state of muscles after castration. In the present paper we describe the results of an experimental study of the protein composition of skeletal, cardiac, and smooth muscle in animals after bilateral ovariectomy.

EXPERIMENTAL METHOD

Bilateral ovariectomy was performed (by N. I. Mirovich) on adult female rabbits of approximately the same age and weight (about 3 kg). The animals were sacrificed 150-180 days after castration by air embolism, and were exsanguinated. The muscle tissue – myometrium, skeletal muscle, myocardium, and muscle of the stomach – was freed from connective and adipose tissue. The muscular layer of the stomach was carefully separated from the mucous membrane, and the myometrium from the endometrium.

The muscle proteins were fractionated by a technique described previously [1, 2]. As a result of fractionation, sarcoplasmic proteins, total myofibrillary proteins, myofibrillary proteins soluble at high (AM) and low (T) ionic strengths, and stromal proteins were obtained.

The total nitrogen of the tissue, the nonprotein nitrogen, and the protein nitrogen in all the fractions were determined by Kjeldahl's micromethod. We give below the typical results for each series of experiments.

EXPERIMENTAL RESULTS

After bilateral ovariectomy, the protein composition of the skeletal muscles and of the gastric and uterine muscle was significantly modified, especially as regards the total nitrogen, the nitrogen of myofibrillary proteins, and the stromal proteins (see table).

Skeletal muscle. It will be clear from the table that the total nitrogen in 1 g of fresh muscle tissue of the castrated animals was slightly greater than normal. This presumably indicated some degree of dehydration of the muscles after castration.

The percentages of nonprotein nitrogen and nitrogen of sarcoplasmic proteins in the skeletal muscle of the normal and castrated rabbits differed only very slightly (Fig. 1). The total myofibrillary proteins fell sharply, and the proportion of myofibrillary proteins soluble in salt solutions of low ionic strength increased. The content of stromal proteins in the skeletal muscle of the castrated animals was almost doubled by comparison with the muscle of the normal rabbits. These changes were similar in character to those taking place in disturbances of the contractile function of the skeletal muscles [3, 4].

Myocardium. The protein composition of the heart muscle after castration remained practically unchanged. The very slight differences in the content of the nitrogen fractions could be attributed to individual variations among the experimental animals.

Fractional Composition of Muscle Proteins in Normal and Castrated Animals* (in mg nitrogen in 1 g fresh tissue)

Type of muscle	Total nitrogen	Nonprotein nitrogen	Sarcoplasmic protein	Nitrogen of myofibrillary proteins				Stroma
				total	*AM*	*T*	*AM/T*	
Skeletal								
normal	34,5	4,29	9,67	17,31	13,5	3,83	3,5:1	3,48
castration	38,0	5,12	10,34	13,61	8,4	5,21	1,6:1	8,98
Myocardium								
normal	25,86	2,23	8,85	7,32	4,40	2,92	1,5:1	7,30
castration	25,6	2,17	9,67	7,42	4,19	2,67	1,5:1	6,37
Stomach								
normal	24,65	1,60	8,67	6,97	2,78	4,19	1:1,5	7,16
castration	28,62	2,05	12,13	6,11	1,74	4,78	0,4:1	9,14
Uterus								
normal	22,14	1,84	7,66	3,70	0,93	2,77	1:3	8,90
castration	28,38	1,3	6,99	6,59	4,72	1,8	2,6:1	13,5

*The figures for the protein composition of the muscles in various species of normal animals were taken from reports by other workers [1, 2].

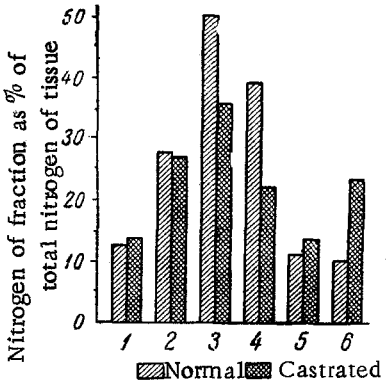

Fig. 1

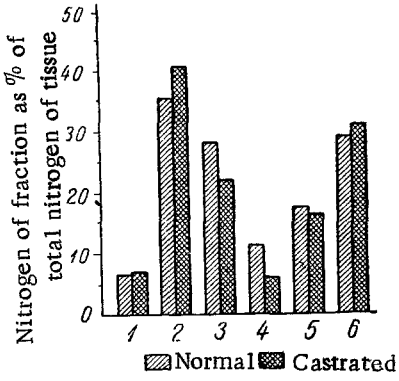

Fig. 2

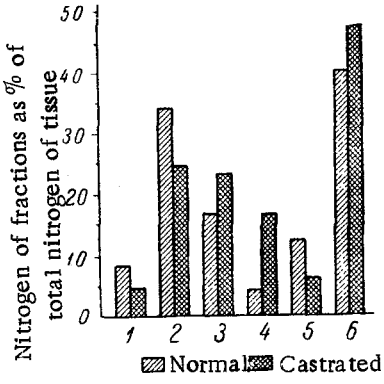

Fig. 3

Fig. 1. Fractional composition of skeletal muscle proteins of normal (lightly shaded columns) and castrated (cross-hatched columns) rabbits. 1) nonprotein nitrogen; 2) sarcoplasmic proteins; 3) myofibrillary proteins; 4) fraction AM; 5) fraction T; 6) stromal proteins.

Fig. 2. Fractional composition of proteins of gastric muscle of normal and castrated rabbits. Legend as in Fig. 1.

Fig. 3. Fractional composition of muscle proteins of the uterus of normal and castrated rabbits. Legend as in Fig. 1.

Stomach. Comparison of the data showing the fractional composition of the gastric muscle of normal and castrated animals (Fig. 2 and table) shows that in the latter the total nitrogen and the nitrogen of the sarcoplasmic proteins were increased and the content of total myofibrillary proteins appreciably decreased. Considerable variations were observed in the content of stromal proteins in different castrated animals. In most cases there was a slight increase in their content. The changes found in the protein composition of the gastric muscle, especially the decrease in the content of myofibrillary proteins accompanied by changes in the relative proportion of their fractions soluble in solutions of high and low ionic strength, suggest that after castration the motor function of the smooth muscle of the alimentary tract is impaired.

Myometrium. Other investigations [7-10] have shown that after castration considerable disturbances take place in the protein composition of the myometrium: the contents of actomyosin, nucleoproteins, stromal proteins, etc. are modified. According to N. I. Mirovich [5], castration of animals is accompanied by changes in the protein composition of the uterine muscle of a similar character to those observed after division of the spinal cord in the lumbar region. This suggests some degree of similarity between dystrophy of the myometrium of neurogenic and hormonal origin.

Our results also showed that for a long period after castration there were considerable changes in the protein composition of the myometrium. It may be seen from the table and from Fig. 3 that the total nitrogen and the content of stromal proteins increased in the myometrium, as in the skeletal and gastric muscle. The content of sarcoplasmic proteins in the myometrium fell appreciably after castration. In contrast to the other types of muscle, the myometrium showed no decrease in the percentage of myofibrillary proteins, with the possible exception of a slight increase in their total content. The protein composition of this fraction showed considerable changes, and as a rule there was an increase in the content of the myofibrillary proteins soluble at a high ionic strength. It is difficult to say whether this resulted from a true increase in the proteins of the actomyosin complex or whether it merely indicated qualitative changes in the myofibrillary proteins of the myocardium after castration. Nevertheless, the fact that marked changes occurred in the composition and, probably, in the properties of the muscle proteins of the uterus after castration cannot be doubted.

The results demonstrate that disturbance of the hormonal balance by castration leads to profound biochemical changes in the muscles and, hence, to disturbances of their functional state. An exception to this statement is the heart muscle.

These results are of considerable interest in connection with the clinical manifestations of certain forms of hormonal disturbance.

SUMMARY

Bilateral ovariectomy in adult rabbits was accompanied by significant changes in the fractional composition of muscular proteins in the skeletal muscles, stomach, and uterus. These changes were especially marked in respect to total nitrogen, nitrogen of myofibrillary proteins, and stroma proteins. The shifts revealed in the protein composition of the muscular tissue of castrated animals may evidently serve as one of the significant causes of a disturbed motor function of the muscles.

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