

The Influence of Castration on the Constituents of Rat's Liver*

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Houssay and coworkers showed that the incidence of diabetes in castrated male rats induced by subtotal pancreatectomy is less than in normal ones. Female rats were more resistant to diabetes than male ones, the resistance itself being decreased by castration. The increased resistance of male castrated rats was ascribed to the removal of testicular hormones. The ovarian hormones produced in subtotally depancreatized rats hypertrophy of insular tissue in which dominated the number of β -cells i. e. the insulinogenic cells.

If there is more insulinogenic tissue in castrated males it must be supposed that this hypertrophy would be reflected in the metabolism of the liver.

Having this in view, the castration of male and female rats was carried out. The content of water, fat, proteins and glycogen in liver of normal and castrated rats was estimated and compared with normals. It was shown that castration produced in male rats a decrease in liver weight, liver fat and protein content and an increase in liver glycogen. No changes were observed in castrated females.

Many investigators have reported a hypertrophy of insular tissue following castration^{1, 2, 3, 4}, others, on the contrary, could not observe such an affect^{5, 6}.

Houssay⁷ and his school dealt with this problem too. They showed that the castration lowers the incidence of diabetes in subtotally depancreatized male rats. It is probable that castration in this experiments induced hypertrophy of residual insular tissue, the diabetes hastening factor of testes being removed. By giving estrogens to the male castrated rats incidence of diabetes further decreased. The ovarian hormones produced in subtotally depancreatized rats of both sexes hypertrophy of islets, and decreased the incidence of diabetes in castrated animals of both sex. Testosterone on the contrary increased the incidence of diabetes in castrated male and female rats.

Szego and White⁸ investigated the liver metabolism in normal and castrated fed and fasting mice. Their results showed that gonadectomy in mice elicited enlargement of liver owing to the increased content of water and lipid. They found also that the protein content in liver was decreased. It is regrettable that they did not determine liver fat, but calculated it by difference neglecting the liver glycogen.

If one supposes a hypertrophy of insular tissue in castrated mice it is difficult to believe the liver fat would be increased.

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TABLE I.
The influence of castration on liver weight and water, fat, protein and glycogen content in male rats

Group	No of rats	Body weight	Liver weight		Liver
			gm	gm/100 gm B. W.	%
Intact	5	241.5 ± 24.5*	9.194 ± 0.303	3.695 ± 0.0408	71.15 ± 1.822
Castrated	6	232.4 ± 27.g*	6.945 ± 0.545	2.985 ± 0.0175	68.95 ± 2.813
		p	< 0.01	< 0.001	> 0.05

For this purpose we performed the following investigations with normal and castrated, male and female rats.

METHODS

Male and female albino rats were used. Male rats were gonadectomized by incision in the scrotum, female ones by paravertebral incision.

The rats were fed with common laboratory food ad libitum prior and after castration. The food supply consisted of: 5 g yellow maize, 1.5 g white flour, 0.7 g casein, 0.4 g dried brewer's yeast, 0.04 g sodium chloride, 0.04 g calcium carbonate, 1.5 g dried milk, 0.008 g ferric chloride and 0.008 g potassium iodide. The animals were also given water ad libitum.

Seven weeks after the castration the weighed animals were sacrificed by recapitulation end exsanguination in slight ether narcosis.

The liver was weighed and slices were taken for fat and protein analysis. The rest was used for determination of water content.

TABLE II.
The influence of castration on liver weight and water, fat protein and glycogen content in female rats

Group	No of rats	Body weight	Liver weight		Liver
			gm	gm/100 gm B. W.	%
Intact	5	220.04 ± 27.1*	7.293 ± 0.292	3.314 ± 0.0887	69.60 ± 1.529
Castrated	4	217.25 ± 53.33*	6.552 ± 0.707	3.014 ± 0.097	70.51 ± 0.197
		p	> 0.05	> 0.05	> 0.05

Fat was determined by the method of Roberts and Samuels⁹ as total lipids. Protein analysis was performed by Kjeldahl method, total nitrogen being multiplied by the factor 6.25.

TABLE I
(Continuation)

water	Liver fat		Liver protein		Liver glycogen	
	gm/100 gm B. W.	%	gm/100 gm B.W.	%	gm/100 gm B. W.	%
2.607 ± 0.0601	5.78 ± 0.918	0.212 ± 0.033	16.74 ± 0.157	0.645 ± 0.0277	6.33	0.231
2.074 ± 0.168	2.74 ± 0.363	0.083 ± 0.014	13.43 ± 2.168	0.401 ± 0.00734	14.88	0.427
< 0.5	< 0.5	< 0.01	< 0.05	< 0.001		

* Standard deviation
All other ± indicate standard error of the mean

Water was determined by desiccating the liver tissue in a dry oven at 80—90°C until the weight at the two successive weighings remained constant.

The animals were divided in four groups: male normals, male castrated, female normals and female castrated. All the animals were killed in the fed state.

RESULTS

The results of liver analysis are presented in the following Tables.

As seen from the Table I the castration in male rats resulted in a highly significant ($p < 0.001$) decrease in the liver weight and liver weight calculated per 100 g of the body weight. No change in water content was observed. The decrease of fat content and protein content calculated per 100 g. of body weight

TABLE II
(Continuation)

water	Liver fat		Liver protein		Liver glycogen	
	gm/100 gm B. W.	%	gm/100 gm B.W.	%	gm/100 gm B. W.	%
2.321 ± 0.083	5.87 ± 0.694	0.198 ± 0.024	17.49 ± 0.219	0.609 ± 0.337	7.04	0.189
2.125 ± 0.0619	5.27 ± 0.657	0.169 ± 0.00973	16.15 ± 0.391	0.486 ± 0.0174	8.07	0.234
> 0,05	> 0,05	> 0,05	< 0,05	> 0,05		

* Standard deviation
All other ± indicate standard error of the mean

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was also significant ($p < 0,01$ resp. $p < 0,001$). The increase in glycogen content — obtained by difference — could thus be considered as significant.

Table II present the results obtained by castrating female rats. There is no influence of female gonads on the constituents of the liver.

Statistical evaluation of the results did not always show a parallelism between the values calculated per 100 g of liver weight and those per 100 g of body weight.

DISCUSSION

Hypertrophy of insular tissue as a result of the castration of male animals was earlier observed^{1, 2, 3, 4}. The relations between the gonades and the islets of pancreas are more ascertained and explained by means of studies of the incidence of diabetes in subtotally depancreatized, intact and castrated male and female rats⁷. It is evident that testes inhibit the function of insulinogenic apparatus and that the ovaries stimulate it.

Hypertrophy of insular tissue may be caused by scurvy^{10, 11}. This is expressed by relative increase in number of α -cells. In this case liver glycogen is diminished. Houssay and coworkers produced hypertrophy of islets in the remnant of pancreas by the administration of oestrogens to the subtotally depancreatized rats. Hypertrophy was expressed as an increase in number of β -cells.

The results of the above described experiments indicate an increased function of insulinogenic apparatus, especially regarding the fall of the content and the increase of glycogen content in liver of castrated males. The fall in liver weight in castrated males could be ascribed to the fall in fat and in protein content. There is a discrepancy with the results of Szego and White, wich could also be ascribed to the differences in species.

György and coworkers¹² observed an accelerated mobilisation of fat from the liver of rats when estrogen was added to animals receiving a diet otherwise low in lipotropic factors (the testosterone was ineffective under the same conditions). Szego and White claim that this fact is in agreement with their observations, i. e. that the fat was accumulating in liver of intact female non fasted mice as a result of increased metabolism of fat. It seems, however, that in this case, i. e. when rats were treated with estrogen, the stimulation of insulinogenic apparatus occured and the fall of fat was probably due to the increase of glycogen. They also recognized the impossibility of reconciling their results with work of Nyda and coworkers¹³, »who observed a relative and absolute increase in total body fat of ovariectomized rats treated chronically with estradiol benzoate«. On the contrary it may be considered that these results, as well as those of present study, speak for Houssay's thesis. The well known fact that it is useful to treat meagre people with insulin speaks also in favour of Houssay's statement. Therefore the altered metabolism of fat in liver of castrated rats more related to insular tissue than to altered secretion of gonadotrophins and ACTH wich occurs in castrated animals.

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IZVOD

Utjecaj kastracije na sastav jetara štakora

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U ovoj studiji promatran je utjecaj kastracije na sastav jetara muških i ženskih štakora albinaca s obzirom na vodu, masti, bjelančevine i glikogen.

Pokazalo se, da kastracija muških štakora dovodi do pada težine jetara i sadržaja masti i bjelančevina — u odnosu na 100 g tjelesne težine — i do porasta glikogena. Kastracija ženskih štakora ne uzrokuje nikakvih promjena u jetrima s obzirom na gornje metabolite.

Ovi rezultati dovode se u vezu s poznatom hipertrofijom insularnog aparata nakon kastracije mužjaka. Veća produkcija insulina zbog većeg broja insulinogenih stanica bila bi uzrokom porasta sadržaja glikogena i pada sadržaja masti u jetrima kastriranih muških štakora.

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