Effect of Double Suprarenalectomy on the Fatigability of the Nerve-Muscle Preparation in situ.

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Studies *rê* the question whether or not double removal of the suprarenal capsules has some bearings upon the development of fatigue in animals is to be classified into three groups, namely (1) studies of the fatigability of the animal as the whole, or of the voluntary activity, (2) that of muscle on exciting it through its nerve, or on the indirect stimulation, and (3) that on the direct stimulation.

In studying the question it is rather superfluous to say here that utmost care should be paid in order to avoid any mingling of influence of the operation itself besides that of the loss of the suprarenal capsules itself upon the experimental results.

With this kind of precautions Shoji¹⁾ was able in the tread mill experiment to see the equality in the velocity with which the fatigue develops between the normal rabbit and the doubly decapsulated and indefinitely well living one.

It is then a further question whether or not a similar outcome will be obtainable if a nerve-muscle preparation in situ will be stimulated indirectly or directly instead of the tread mill experiment.

While all the reports²⁻¹³⁾ agree in noting a remarkable inferiority of the work capacity of the muscle preparation such as the gastrocnemic in rats or guinea-pigs doubly decapsulated or even unilaterally operated on, they are based upon the experiments carried out immediately after the decapsulation or a few days or weeks later. It is unquestionable that most of the animals were suffering from some weakness.

In the present work, which was carried out about five years ago, was used the rabbit, the animal which possesses invariably accessory cortical

tissue, is capable of surviving indefinitely double removal of suprarenals if properly operated,¹⁴ and really proved by Shoji¹⁵ of non-inferiority of the work capacity of doubly decapsulated, indefinitely surviving ones to the normal controls in the tread mill experiment, as above referred to. The latter work is fairly comparable to the present, given in the following pages.

METHODS.

Male and female rabbits of good nutrition were experimented on, without giving any narcosis throughout.

The peripheral cut end of the sciatic nerve was stimulated electrically, and the contraction of the gastrocnemius muscle was recorded, the calcaneus tendon being attached to the lever. The muscle was afterloaded with a lead weight of 50–100 grms.

All the arrangement and the operative procedure of exposing the nerve and muscle, inserting drills and fixing the animal were carried out in the manner much practised in the laboratory of Professor C. S. Sherrington, such as described in his text-book of practical exercise.¹⁶ The Sherrington glass-sheathed electrode was used in an earlier form.¹⁶ The stimulation was given automatically at 5 second intervals by means of a faradic current, using break shocks only. In the primary circuit of the induction apparatus a battery of 2 volts and a metronom were placed, and in the secondary a rectifier, a condenser of $2 \mu F$ and a Sherrington electrode.

Registration of muscle contractions on a slow revolving extensometer kymograph was made from time to time, the intervals being taken properly; when thought necessary it was done without interruption for some length of time. The total amount of work done was calculated by multiplying the summated height of the contraction by the weight lifted.

DATA.

3 normal rabbits and 7 doubly suprarenalectomized, long surviving ones were used in the fatigue experiment of the ischiadicus-gastrocnemius preparation *in situ*. The results are given graphically below.

As well known, the body temperature of rabbits falls, if they are fastened on an experiment table, for example. When rabbits, 4 in number, were fastened in the supine position for 8 hrs., the length of time in which the nerve-muscle preparation *in situ* of the doubly decapsulated rabbits becomes incapable of reacting against the electric stimulant, the body temperature fell by $1.8-3.4^{\circ}$ in 3–5 hrs., followed by a very slow recovery. The room temperature was there $18-23^{\circ}$.

In the fatigue experiment this fall was guarded against properly by heating electrically the upper copper plate of the experiment table. The fall in the body

temperature as well as overheating may interfere with the results in such a kind of experiment.

In the figure the work capacity is given on the ordinate with grms. cm. and the time on the abscissa with hours. The capacities from the normal, control rabbits are given with light circles connected with dash lines and those from the decapsulated with heavy circles with solid lines. The circles are those actually determined. When those determined successively were different from each other, the lines are drawn as passing the mean value, indicated by a small circle.

Some words may be spent for the experiments in which some peculiarities were observed. Rabbit L: At terminal (+), the gastrocnemius contracted only occasionally, but on stronger stimuli it was capable of responding with 744 grms. cm., but ten minutes later no more response. Rabbit M: At + the animal became exhausted, irregular responses against stimuli, about ten minutes later only scant reactions were observable. Rabbit N: At O small and irregular responses only. Rabbit O: At + the coil-distance was shortened to zero, then a work 336 grm. cm. was performed. Rabbit P: At + the responses irregular, at ++ almost exhausted, and at +++ on coil-distance 7 cm. the work capacity was almost same as the initial, ten minutes later it reduced by a half, about ten minutes later almost no responses. Rabbit R: At + responses irregular, sometimes no responses, sometimes a pretty large ones. Rabbit S: At + the animal unquiet, & contractions irregular, at ++ contractions smaller and much irregular.

Lead weight: For normal animals:—H 730 g, J 560 g, K 560 g. For decapsulated animals:—L 620 g, M 710 g, N 420 g, O 420 g, P 520 g, Q 570 g, R 670 g, S 650 g.

In none of the decapsulated rabbits, was found at autopsy any fragment of both the supra-renal glands. The accessory cortical tissues found on that occasion were as follows: Rabbit L ♀: 1×0.9 mm. on inf. cava vein below R liver, 2×1.5 mm. & 1.5×1.0 mm. on inf. cava v., near R renal vessels. 0.7×0.8 mm. on R ovary. Rabbit M ♀: $4.2 \times 4.6 \times 3.2$ mm. on R. ovary, $2 \times 1.5 \times 1.5$ mm. near R kidney. Rabbit N ♂: $2.6 \times 1.2 \times 0.9$ mm. & $2.2 \times 1.5 \times 0.9$ mm. on L epididymis, $1.8 \times 1.5 \times 1.2$ mm. on R epididymis. Rabbit O ♂: $2.2 \times 2 \times 1.5$ mm. & $2 \times 2 \times 1$ mm. on head of L epididymis, 2 pieces of $1.3 \times 1.2 \times 1$ mm. on R. epididymis. Rabbit P ♂: $1 \times 1 \times 0.8$ mm. on front of L kidney, $3.5 \times 2 \times 3$ mm. & $2.2 \times 1.5 \times 1.5$ mm. on L epididymis. Rabbit Q ♀: 1 piece under L kidney, $2.2 \times 2 \times 1.5$ mm. & $3.2 \times 2 \times 2$ mm. on L ovary. Rabbit R ♀: $3.5 \times 3 \times 3$ mm., $2 \times 1 \times 1$ mm. & $1 \times 1 \times 1$ mm. on L ovary, $2.5 \times 1.5 \times 1$ mm., $2.5 \times 2.5 \times 2$ mm. & $1.5 \times 1 \times 1$ mm. on R ovary. Rabbit S ♂: $3.5 \times 3 \times 2.5$ mm., $2 \times 1.5 \times 1.5$ mm. & $1.5 \times 1 \times 1$ mm. on L epididymis, 1 poppy-seed sized on R epididymis.

The above figure clearly shows a remarkable difference in the fatigability of the sciatic-gastrocnemic-preparation *in situ* between the normal rabbits and the long surviving, doubly decapsulated ones. An individual, Rabbit M, of the latter group makes a single exception. This will be explained below.

Three normal animals (H ♂, J ♂, K ♂) were capable of responding against rhythmical electric stimuli applied to the peripheral end of sciatic nerve with contractions of the gastrocnemic muscle for a long duration of time such as 16–49 hours. Contrary to the normal controls, the decapsulated ones gave no more response when stimuli were given interruptedly with regular intervals for 2–8 hours. The differences are decided.

Only Rabbit M, doubly decapsulated, behaved just as the normal, 28 hours being noted as needed for the total exhaustion of the nerve-muscle preparation in situ. This was found having possessed a large accessory cortical tissue, such as $4.2 \times 4.6 \times 3.2$ mm. on the right ovary, besides an accessory of usual size. This rather abnormally large accessory mass might be taken as responsible for an abnormally large resistance of the nerve-muscle preparation in situ of this rabbit (Rabbit M).

It may be noted in passing that the contraction height was in some decapsulated animals (R, S, Q, P & M) was incomparatively great at the start of stimulating in comparison with the normal controls:

On the whole, it may be justifiable to assume that the nerve-muscle preparation of rabbits in situ shows a larger fatigability on the rhythmic stimuli if the suprarenal glands are removed beforehand. The animals were surviving very well the decapsulation.

This conclusion coincides well with the results of the previous experiments above quoted, those of Ferreira and Fontes,⁶ who carried out the experiments on the rabbits surviving over two months being excepted.

When they previously conducted the stimulations a few days after double decapsulation, a much quicker fatigability was noted in rabbits; those results check well with what was also based on acute experiments.

The present data, which were performed when the decapsulated rabbits were well, indefinitely surviving, don't harmonize with the similar kinds of experiment of Ferreira and Fontes, and rather with the data from acute experiments.

The view of Shoji,¹ that work capacity of the rabbit is not influenced by depriving it of the suprarenals, their medulla or the splanchnic nerves, is based on the experiments in which voluntary movements were tested, and the time when fatigue sets in all the kinds of animals was about sixty minutes on an average for each group of animals. The experiments of such a kind are related to the fatigability of the central nervous system, and further the time when the fatigue sets in is undoubtedly shorter than the present experiments; there are therefore no disharmony between the outcome of Shoji's experiment and that in the present investigation.

SUMMARY.

Of the rapidity with which fatigue develops by ergographic test of the sciatic-gastrocnemic preparation in situ, test was made on the normal rabbits and those which were indefinitely (1-3 months), well surviving after double

suprenalectomy. No anesthesia was used, and the body temperature was protected from lowering.

In the so-operated rabbits a complete fatigue sets in much quicker than the normal controls. The velocity with which it develops is about one eighth of that of their controls.

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