
By Robert Kennedy, M.A., D.Sc., M.D., St. Mungo Professor of Surgery in the University of Glasgow.

(Communicated by Prof. J. G. McKendrick, F.R.S. Received November 25, 1913,—Read January 22, 1914.)

(Abstract.)

The part of the research into the anastomosis of nerves dealt with in this paper has reference to the restoration of function of a group of muscles in the limb. Following the early experiment of Flourens, several workers (Rawa, Stefani, Howell and Huber, Cunningham, and the author) published investigations on the effects of nerve crossing, or the division of two nerves in the limb and cross suture of the ends.

These investigations, while showing that restoration of function can take place through the composite nerve, and that even in the cerebral cortex the areas associated with flexion and extension become interchanged, left it doubtful whether in the event of one nerve being eliminated, the muscles supplied by it could be innervated by a neighbouring motor nerve, which at the same time could continue also to supply the muscles proper to it, performing thus a double function.

The subject was investigated from this point of view by Kilvington, who published a series of experiments in which the external popliteal nerve was cut and the peripheral segment anastomosed to the internal popliteal, and vice versa. He reports recovery of function after this procedure.

Doubt, however, still remains as to the possibility of an extensor and flexor group of muscles recovering the capacity of performing co-ordinated movements under such conditions, as in the case of the hind limb of the dog even when the sciatic nerve cut high in the thigh has not united, the animal is able to use the leg in walking, the chief defect being that it walks on the dorsum of the paw. Also, in these circumstances, the foot is sometimes, possibly by accident, placed plantar surface down. Therefore the reported recoveries after such experiments leave doubt whether the recovery is real or apparent. In addition, it is impossible to investigate the changes in the

* The expense of this research has been defrayed by a Government Grant from the Royal Society.

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cortical representation in the case of the hind limb, as in the dog this is represented by a single centre.

The author has performed five experiments in dogs on the right fore-limb, which has the advantage, in the first place, that section of the nerves above the elbow paralyses the limb in such a way that it is impossible for the animal to use it for walking until recovery of co-ordinated movements occurs. This is then a very severe test. In the second place, the fore-limb of the dog is represented by two separate and distinct centres, one for flexion and one for extension, which are only exceptionally defective.

The experiments are of two kinds, but are the same in so far that in all the musculo-cutaneous, median, ulnar, and musculo-spiral nerves were each divided above the elbow, and the limb thus completely paralysed below the elbow. Then the four distal segments were united to the proximal end of the musculo-spiral nerve, and the three remaining proximal ends left ununited; or, on the other hand, the four distal segments were united to the proximal ends of the musculo-cutaneous, median, and ulnar, and the one remaining proximal end (musculo-spiral) left ununited. The limb was fixed in plaster of Paris as long as necessary.

The following results were obtained:—

A. Where the central supply was that proper to the flexor muscles (musculo-cutaneous, median, and ulnar), the first sign of recovery of the muscles was shown at 96 and 93 days respectively after the operation, and a satisfactory recovery, enabling the dog to run about, and in one case to be taken for exercise into the streets, was reached at 126 and 123 days respectively. In the first case no interruption of the excellent recovery occurred as long as the animal was allowed to live, namely, 225 days, but in the latter case there was some trouble by the development of a slight flexor contracture which hindered the recovery up till the animal was killed at 187 days.

B. Where the central supply was that proper to the extensor muscles (musculo-spiral), the first sign of recovery was at 81 and 59 days respectively in the two which showed recovery. In the first case a pressure sore interfered with further progress, but in the second case at 79 days the animal ran about normally, and was able to be taken out for exercise in the streets without any fear of attracting notice. It may be noted that although in this form of experiment the muscles of the limb were supplied by the lesser number of nerve fibres, namely, those contained in the musculo-spiral, the recovery commenced earlier than when the three nerves normally supplying flexors formed the sole central supply, although in that case the greater number of nerve fibres were available for the supply. This is explained as due probably to the earlier recovery of the extensors when the musculo-spiral...
was the common source of supply, thus enabling the leg to be earlier held extended, and therefore useful for walking.

Each experiment was investigated before the animal was killed, as follows:—

A. *Examination of the Nerves.*—In every case the union of the nerves had taken place as intended, i.e. no reunion of any nerve intended to be eliminated had occurred. Also it was found that when the musculo-spiral trunk was supplying both flexors and extensors, it conveyed the fibres for the flexors and those for the extensors along different sides of the nerve, where they could be separately stimulated.

B. *Examination of the Brain.*—In every case in which this examination was able to be made, namely, in one of the first type of experiment and in two of the second, the centre at which stimulation normally produces contraction in the muscles of the eliminated nerve supply was inexitable, and in the other centre (either the normal flexion or the normal extension centre according to the type of the experiment) both flexion and extension were evoked, and at no point in the centre could separation of these movements be obtained.

The operation which Nicoladoni introduced for cases in which infantile paralysis has destroyed the function of a group of muscles presents the same problem as do cases of nerve anastomosis. This operation consisted of substituting for the lost muscles a portion of a neighbouring muscle so as to regain some of the lost function, and if the lost function or a part of it can be thus regained, it can only be by the nerve supply of the muscle from which the substitute is taken altering its function so as to cause the movement proper to the paralysed muscle instead of that normally belonging to it.

A case in which the author performed this operation was carefully examined in order to exclude sources of fallacy. The function of the extensors in the leg was lost and a talipes equinus by contraction of the gastrocnemius was present. This was in a girl aged 7, and had lasted for six years. The extensor muscles gave no reactions to electrical tests. At the operation the gastrocnemius was lengthened to overcome the talipes, and one-third was taken from the outer part of that muscle and attached in front to the tendons of the paralysed muscles. Sixty-nine days after the operation the patient had power to extend the foot voluntarily, some eversion being produced at the same time owing to the line of action of the new muscle. The new muscle also stood out as a tense band while the voluntary movement was being performed. The two separate movements were also able to be evoked by galvanic or faradic stimulation over the two separate parts of the gastrocnemius. After the recovery of voluntary extension a further examination
of the extensor muscles was made, and this showed that the movement of extension was not made by the extensor muscles, as they were not able to be stimulated. A platinum electrode was also inserted into the extensor muscles through the skin, but no contractions could be produced in them either by the galvanic or by the faradic current.

The following are the conclusions from the research:—

(1) In the limb of the dog when the nerve supply of one group of muscles is eliminated, the nerve supply of its antagonistic group may be used to supply both groups, and under these conditions co-ordinated movements may be restored.

(2) When two antagonistic groups of muscles in the limb of the dog have their nerve supplies cut and both groups then made to derive their supply from that of the one group, the group whose nerve supply is utilised probably will be the first to recover.

(3) Recovery of function of antagonistic muscles is slower to occur when one nerve supply is eliminated than in the case of nerve-crossing experiments where no nerve is eliminated, but where the supply of the two groups is crossed: and this delay is caused by reduction in the former case of the total volume of the nerves supplying the limb, and possibly by greater difficulties of adaptation in the brain to the new conditions.

(4) Where in the dog one nerve has been made to supply not only its own but also the antagonist of its own muscle, the nerve fibres passing to the two muscles in the nerve trunk proximal to the junction may be so completely separated that it may be possible to stimulate each group without affecting the other, producing thus at will contraction either of the one or of the other muscle, both being now supplied by a single central trunk.

(5) When two groups of antagonistic muscles in the limb of the dog are represented by separate cortical areas, and when the nerve supply of one of the groups is eliminated, both groups being caused to be innervated by the remaining nerve supply, the cortical area corresponding to the eliminated nerve supply becomes inexcitable, while the other cortical area on stimulation causes contraction in both groups of muscles.

(6) Where one group of muscles is paralysed, and a portion of an antagonist muscle is detached from its insertion and attached to the tendons of the paralysed group, this substitute for the paralysed group may enable the function of that group to be performed to a certain extent, and the function recovered by means of this procedure is probably controlled by the same adaptation in the central nervous system as occurs in the case of nerve anastomosis.

(7) The adaptation in the central nervous system which allows restoration
Variations in the Sex Ratio of Mus rattus.

of function to take place after nerve anastomosis is not due to a simple re-education process, as there is no evidence of this during recovery, but is probably due to an alteration in the centres under the influence of altered afferent impulses from the muscles, the brain thus having the capacity quickly to adapt itself to such alteration.

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Variations in the Sex Ratio of Mus rattus Associated with an Unusual Mortality of Adult Females.

By F. Norman White, M.D. (Lond.), Capt. I.M.S.

(Communicated by Prof. C. J. Martin, F.R.S. Received November 28, 1913,—Read January 22, 1914.)

At the commencement of June, 1911, whilst engaged on plague epidemiological observations in the United Provinces my attention was drawn to the fact that nearly all the young Mus rattus that were being trapped and examined by our staff in Lucknow were females. It was this strange phenomenon, the parallel of which I had never encountered during a five years' experience of plague research in India, that prompted the inquiry, the results of which are briefly set forth in this paper.

A few words explanatory of the methods employed in the daily routine examination of rats will show the nature of the material at my disposal. The prime object in trapping and examining large numbers of rats was, of course, to ascertain how far facts thus collected would assist us in solving the plague epidemiological problems with which we were faced. The species, sex, and weight in grammes of each rat caught were noted; the address of the house in which the rat was trapped and the number and species of fleas found on it were recorded. The sex of each rat was noted after dissection of the animal, and if it were female a further note was made as to the existence of pregnancy. If pregnant the number of foetuses was likewise written down. Finally, any pathological or other condition calling for comment was fully described.

All this information, which was in the first place recorded on cards, one card for each rat, was at the end of the day's work entered in a register. Weighing the rat was done in a specially constructed spring balance, by means of which the weight in grammes to the nearest multiple of 10 could be readily and accurately ascertained. I wish to emphasise the fact that the sex of the animal was noted only after dissection, so that