The Croonian Lectures

ON

MUSCULAR MOVEMENTS AND THEIR REPRESENTATION IN THE CENTRAL NERVOUS SYSTEM.

Delivered before the Royal College of Physicians of London.

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LECTURE I. METHODS.

[AFTER expressing his sense of the honour done to him by his selection as Croonian lecturer, Dr. Beever proceeded to consider the methods by which it had been sought to determine the action of a muscle:

1. *The anatomical method*, by which (a) the muscle was dissected out and pulled up, the resultant motion being taken to be the action of the muscle during life; or (b) by which its action was deduced from its origin and insertion. The objections to this method were that it gave the action of the individual muscle alone, gave all the possible motions of a muscle, and postulated that it took part in all, whereas there was hardly an instance of movement in which only one muscle took part; and it did not follow that, because a certain movement could be produced by traction on a dissected muscle, it must take part in that movement during life.

2. *The electrical method*, employed with such great success by Duchenne. Its results were valuable, and where the muscles were superficial enough to be reached by the current was preferable to the anatomical method, but it was open to the same objection that it showed the action of the individual muscle alone and not in association.

3. *The physiological or natural method*, which he had himself employed. In it a living person was told to perform a definite movement, and the muscles taking part in it were observed.

Dr. Beever continued to the following effect:—]

Certain precautions have to be taken in using this method, the most important being that the person shall perform by fixation of the limb only that movement which is required, so that if told to pronate the forearm he must not at the same time abduct the shoulder and thereby bring into action other muscles than those concerned directly with pronation. The means which I have used for determining whether a muscle is taking part in any given movement are inspection and palpation either of the muscle as a whole or of its tendon. I have examined both normal persons and patients who have lost the use of some of their muscles. The movements have been performed in three ways:

1. By moving the limb only without any extra weight.
2. By moving the limb loaded with different weights.
3. By attempting to move the limb which is fixed by an opposing force.

The first procedure gives the minimum work which the muscles entering into any movement are called upon to do. The least possible work that a group of muscles can do is to overcome the inertia of a joint. This can be accomplished in the elbow by placing the upper arm on a support in a horizontal position and then flexing or extending the forearm on it in a horizontal plane; by this means the action of gravity can be neutralized. Or with the upper arm resting horizontally the forearm can be placed vertically and the movement of pronation and supination can be carried out. The next degree of work is that afforded by lifting the limb against gravity as in flexing the forearm when the humerus is in the vertical position alongside the trunk.

The third procedure gives the strongest work that the muscles can perform; and as by reason of the fixation of the limb, there is no alteration in the angle of the joint the error is avoided of assuming that the tightening of a tendon from the stretching of a passive muscle is evidence of contraction of the muscle.

The second method would give the intermediate conditions between the two extremes of maximum and minimum work.

The amount of work done by the muscles was measured by spring balances or by the traction scale of a clinical dynamometer.

With the exception of Winslow and Duchenne I am unable to find that writers on anatomy as a rule take their knowledge

of the action of muscles from the living subject. James Benignus Winslow, whom Duchenne rightly styles the Admirable Winslow, and who, although his name has an English sound, was Professor of Physick, Anatomy, and Surgery in the University of Paris in the eighteenth century, speaks with no uncertain note when he writes that "the experiments made on dead bodies, by pulling the muscles after they have been raised, are very fallacious." To be sure, list of muscles are given under the different heads of flexors, extensors, rotators, abductors, adductors, etc., but these lists are made by putting into one category, for instance, all the single muscles which are called flexors, etc., and such a list does not express a combination which has been verified by actual inspection during life. I venture to think that, if all the muscles contained in some of these lists contracted, the movement produced would not be the one which is expected.

In examining a case of muscular atrophy the chief difficulty consists in knowing what movements to ask the patient to perform in order to find out whether a particular muscle is acting or not. I trust the time will come when the actions of muscles will be taught on the living subject, together with the part which they take in the performance of simple movements.

MOVEMENTS OF THE FINGERS.

Taking first some of the movements of the upper limb and first those of the fingers, I would recall that the first phalanges of the fingers are flexed on the metacarpal bones by the interossei and lumbricales, an anatomical discovery made by Columbus and Fallopius in 1559 and 1561, which, according to Duchenne, was lost sight of till he (Duchenne) again called attention to it, but this is hardly correct, as it was mentioned by Winslow,² and John Hunter³ refers to it in his Croonian lecture delivered before the Royal Society in 1777. The first phalanges are also flexed by the tendons of the flexores digitorum on their way to the terminal digits. If, however, it is required to flex the two last phalanges of each digit but not the first, the extensor communis digitorum is brought into action, a muscle which extends the first phalanx more than the last two phalanges. If the movement of flexion of the fingers is required without any movement of the wrist, then along with the flexores digitorum the extensores carpi radialis longior and brevior and ulnaris contract.

The extension of the second and third phalanges is as is well known produced by the two sets of muscles, the extensor communis digitorum and the interossei and lumbricales which are inserted into the common extensor tendons. The action, therefore, of these small muscles is to flex the first phalanx and to extend the second and third phalanges. Duchenne⁴ is strongly in favour of the theory that the action of the extensor communis digitorum on the last phalanges is exceedingly limited, and that it is not an extensor of all the phalanges, but that it only has a true action on the first phalanx and he proposes to call it the extensor of the first phalanx. He also states that the interossei and lumbricales are in reality the sole extensors of the two last phalanges and the sole flexors of the first phalanx. It is no doubt true that when the extensor digitorum is paralysed, the last two phalanges can be extended by the interossei and lumbricales, and also that in the "claw hand" there is inability to extend the last digits when these small muscles are paralysed. In the latter cases if the first phalanges be kept passively flexed on the metacarpus the person is able to extend the terminal digits, so that it seems probable that the inability of the extensor digitorum to extend the terminal phalanges is due to its energy being expended on the first phalanges, which are not prevented from extending by the interossei and lumbricales which are now paralysed.

The extension of the proximal phalanges on the metacarpal bones by the extensor communis digitorum is accompanied, as Duchenne⁵ pointed out, by contraction of the flexors of the carpus, namely, the flexores carpi radialis and ulnaris and palmaris longus. In lead poisoning, where there is paralysis of the extensor communis digitorum and not of the extensores carpi "the patient can, if he keeps his fingers flexed, extend the hand on the forearm. But if he wishes to extend his fingers, his first phalanges remain immovable and his hand is flexed on the forearm with as much energy as he makes in his greatest effort to obtain extension of the fingers." The explanation of this combination will be discussed later when we consider the synergic action of muscles.

The lateral movements of the fingers are adduction toward the middle finger, and abduction away from the line of the middle finger. Adduction is performed by the palmar

interossei and abduction of the three large fingers by the dorsal interossei, but with abduction of the index finger and the little finger other muscles come into action. It is exceedingly difficult to abduct the index finger without adducting or flexing the thumb, from the fact that the first dorsal interosseus or abductor indicis arises from the metacarpal bone of the thumb as well as from that of the index finger, so that if it is required to abduct the index finger alone the extensores ossis metacarpi and primi internodii of the thumb are called into action to prevent the thumb moving. Abduction of the little finger is performed by the special abductor minimi digiti, but as this arises from the pisiform bone, this latter has to be fixed by the flexor carpi ulnaris, and to obviate the special action of the flexor carpi ulnaris on the wrist, the extensor ossis metacarpi pollicis contracts, and when the hand is in a line with the forearm it is apparently impossible to abduct the little finger without the extensor ossis metacarpi contracting; if, however, the hand be first adducted to the ulnar side the contraction is less marked.

THE MOVEMENTS OF THE THUMB.

Flexion and extension take place in a plane parallel to the palm of the hand, of all three joints of the thumb, and abduction and adduction of the metacarpo-carpal joint in a plane at right angles to the one just mentioned. In addition there is opposition of the thumb to the fingers.

With regard to the movements of the first metacarpus on the carpus, in the movements of flexion and extension which take place in a plane parallel to that of the palm of the hand the palmar surface of the thumb is at right angles to the palm of the hand, but in the movement of abduction it seems to me that it is difficult to perform this movement without rotating the thumb inward, so that the palmar surface of the thumb is opposed to that of the fingers. Therefore in abducting the thumb it passes naturally into the position of opposition, and from that position it can be advanced towards the tips of the fingers in succession, but more rotation will be required to oppose it to the index finger than to the fourth finger.

Taking the terminal phalangeal joint of the thumb first, flexion, as is well known, is performed by the flexor longus pollicis, and if this movement alone be required the extensor primi internodii contracts to prevent the first phalanx being flexed on the metacarpus. Extension of the last phalanx is performed by the extensor secundi internodii pollicis, but, as was pointed out by Duchenne, this simple movement cannot be performed without also calling in the action of the abductor pollicis, the flexor brevis pollicis, and the adductor pollicis, as these small muscles send prolongations to the tendon of the extensor secundi internodii (Sabatier, Bouvier, and Duchenne), so that by the action of these small muscles the last phalanx can be extended without extending the first phalanx.

The movements of the metacarpo-carpal joint of the thumb are more complicated, and, besides flexion and extension, there is opposition.

Flexion of the metacarpal bone of the thumb is caused by the opponens pollicis and by the abductor flexor brevis and adductor pollicis—transversus and obliquus, as they are now called—when flexion of the first phalanx is also required; but when flexion of the metacarpal bone is required, with extension of the phalanges, there is also some action of the extensores primi internodii pollicis. Flexion of the metacarpal bone is also affected by the flexor longus pollicis after the metacarpal joints are flexed.

Extension of the metacarpal bone is performed by the extensor ossis metacarpi, and also by the extensor primi internodii. At the same time, as was pointed out by Duchenne, it is not possible to extend the metacarpal bone and the first phalanx of the thumb without putting into action the extensor carpi ulnaris, and also, I would add, the flexor carpi ulnaris, which, however, does not come into action so soon as the extensor. The reason why these muscles are brought in will be discussed later on; at present I would lay stress on the impossibility of extending the thumb without putting these other two muscles into action, and also that this action occurs in all positions of the wrist, even when it is in that of extreme abduction, a position in which it would not be possible for the extensor ossis metacarpi to move the wrist further in the direction of abduction.

Abduction of the thumb is performed by the small thumb muscles, namely, the abductor pollicis, opponens pollicis, and outer head of the flexor brevis, and also by the extensor ossis metacarpi and primi internodii. This is not in accord-

ance with Duchenne,⁶ who from electrical observations states that the extensor ossis metacarpi is one of the opposing muscles of the thumb and not its abductor, while the extensor primi internodii is not an extensor of the first metacarpal, but is the only direct abductor. If by abduction is meant carrying the thumb away from the first finger in a plane at right angles to the palm, I think that there is no doubt that the tendons of both these two extensors of the thumb can be felt to contract. There is one important point with regard to this movement, and that is that though it is possible to abduct the thumb when the extensors of the thumb are paralysed, it is quite impossible for the extensors of the thumb to abduct in the slightest degree when the small thumb muscles are paralysed; in fact inability to abduct the thumb is one of the best tests for the absence of the small muscles of the thumb.

In adduction of the thumb from the position of abduction it rotates from within outwards, and this movement is performed by the adductor transversus and probably the obliquus and by the extensor secundi internodii, as shown by Duchenne. When, however, the thumb has passed the middle point of its movement, I find that the flexor carpi ulnaris, also contracts, probably to counteract the extension of the wrist by the extensor secundi internodii.

Opposition is best performed after abducting the thumb, and from that position advancing it to meet the fingers; the muscles which take part in this movement are the abductor pollicis, the opponens pollicis, the flexor brevis, the adductores pollicis.

According to Duchenne,⁷ the abductor chiefly opposes the thumb to the two first fingers, and the flexor brevis to all the fingers, while he also includes among the opposers the extensor ossis metacarpi, which, according to him, is one of the chief opposers of the metacarpal bone and not its abductor; but it seems to me that although it does act in abducting the thumb and putting it in the position of opposition it ceases to act as soon as any resistance is made to the opposition. The movement of opposition is therefore preserved when the extensor ossis metacarpi is paralysed and lost when the thenar muscles are paralysed.

It is interesting to note that Duchenne⁸ from electrical observations ascribes to the adductor pollicis four different actions on the metacarpal bone of the thumb—namely, adduction, abduction, extension, and flexion. With this I am unable to agree, as I cannot find that the muscle takes part in abduction or extension, in any position of the bone, and I think it is an instance where the actions obtained by electrical stimulation of a muscle do not find their counterpart in the voluntary movements in the living body. It postulates that a muscle may act as a primary mover in two movements which are diametrically opposed to each other, a condition which I believe does not exist in the human body, and which I shall refer to later.

COMBINED MOVEMENTS OF THE FINGERS AND THUMB.

In grasping all the muscles which flex the different joints of the fingers and thumb come into action, and, in addition to these muscles, the extensors of the wrist take part in the action just as they take part in that of flexion of the first phalanges of the fingers. This combination was definitely pointed out by Duchenne,⁹ who stated "that the synergic action of the extensors of the wrist is absolutely necessary to the flexion of the fingers, and the force of their contraction is then proportional to the energy of this flexion."

THE MOVEMENTS OF THE WRIST.

Flexion—In addition to the definite flexors of the wrist—namely, flexor carpi radialis, flexor carpi ulnaris, and palmaris longus—the flexors of the fingers become also flexors of the wrist, but this depends on where the resistance is made. If the resistance is made against the phalanges, then the flexors digitorum do flex the wrist after they have flexed the fingers, but if resistance is made against the metacarpal bones so that only pure flexion of the wrist is required, then I do not think that the flexors of the digits contract. With regard to the thumb muscles, the extensor ossis metacarpi, as stated by Duchenne,¹⁰ is a flexor of the wrist.

Extension of the wrist is performed by the three extensors of the wrist, and also by the extensor secundi internodii to a slight degree, but not by the other two extensors of the thumb. The question of the part played by the extensors digitorum will be discussed presently.

Abduction is performed by the flexor carpi radialis, the three extensors of the thumb, and the extensor radialis longior.

Adduction by the flexor carpi ulnaris and the extensor carpi ulnaris. It is interesting to note that Duchenne¹¹ from electrical stimulation denies that the flexor carpi ulnaris is an adductor or that the flexor carpi radialis is an abductor of the wrist. In reply to that I would say that in performing the movement of adduction and abduction these muscles can be felt to contract, and it shows how important it is that results obtained by electric testings should be verified by reference to the living body. The action obtained by electrical stimulation is that of the muscle acting alone, a condition which does not exist in the body unless all the other muscles are paralysed. In passing round from flexion of the wrist to adduction the flexor carpi ulnaris is either contracting with the palmaris longus in flexion or with the extensor carpi ulnaris in adduction. It is quite possible that if this last muscle, the extensor carpi ulnaris, were absent, the flexor carpi ulnaris would not be able to adduct the wrist alone. Now, according to Duchenne,¹² faradization of the extensor carpi radialis longior and of the extensor carpi ulnaris alone produces extension with abduction and adduction respectively, so that these two muscles acting alone could not produce pure abduction or adduction; to do so each must act with the flexor carpi radialis and ulnaris respectively.

In reference to the movements of extension and flexion of the wrist, an important question arises as to the part taken by the extensors and flexors of the fingers in this movement. It is mentioned by Duchenne¹³—and whether he was the first to point it out I do not know, but it is an observation which has been frequently confirmed, and I have already referred to it in speaking of the synergic action of the fingers and the flexors of the wrist—that in lead paralysis affecting the extensor communis digitorum but not the extensores carpi, as long as the person keeps his fingers flexed, he can extend with force his hand on the forearm; but if he should wish to extend his fingers, his first phalanges remain immovable, and his hand is flexed on the forearm with as much energy as the efforts he makes to produce extension of the fingers. Sir William Gowers,¹⁴ in his work on *Diseases of the Nervous System*, states, in speaking of lead paralysis, in which the extensores digitorum are paralysed but not the extensores carpi, that “as long as the special extensors of the wrist retain power this joint can still be extended when the fingers are flexed so as to close the fist, although the wrist cannot be extended when the fingers are also extended. The reason for this seems to be physiological. When in health the hand and fingers are both extended, the special extensors of the wrist act very little if at all; the movement at the wrist-joint is effected by the long extensor of the fingers; if, however, the fingers are flexed the extension of the wrist is effected by the special extensors.” So that, according to Duchenne, if a person with paralysis of the extensor digitorum tries to perform the movement of extending his fingers, the only result he obtains is flexion of the wrist; and, according to the extract just given from Sir W. Gowers, a patient with paralysis of the extensor digitorum has no power to extend the wrist as long as he tries to do it with the fingers straight. These conditions are frequently met with in cases of lead paralysis.

The problem before us (which has, as far as I know, never been explained) is—Why do not the extensors of the wrist, which in this case are healthy, come to the rescue, and help the paralysed extensors of the fingers to extend the wrist? They certainly do not contract, and there must be some explanation of the inability of the person to make them do so.

Let us observe what happens in the normal condition? With the fingers flexed so as to form a fist, if the wrist is to be extended, the work is done by the three extensores carpi and their tendons at the wrist and especially the extensores carpi radialis longior and ulnaris can be felt to contract. If now in the course of this extension the fingers be suddenly extended, the extensors of the carpus immediately cease to contract and the work of extension is done by the extensors of the fingers. But the extensors of the fingers cannot act without at the same time causing the flexors of the wrist to contract, and by putting one's thumb and finger on the tendons respectively of the extensor carpi radialis and the flexor carpi ulnaris, it will be found that when the fingers are extended the extensor carpi can be felt to relax and the flexor carpi ulnaris to contract. The wrist can therefore be extended fully by the extensors of the fingers without the help of the extensors of the wrist, but as the extensors of the fingers have to do this against the contraction of the flexors of the wrist there is a feeling of constraint. Now what will happen if strong resistance be made to the extension of the wrist by

the extensors of the fingers, which are weak muscles, will the extensors of the wrist—so to say—come to the rescue and take part in the movement of extending the wrist. As a matter of observation I have found that they will come and help. But, and I think that this is a most important point and one which I believe has not been shown before, as long as the fingers remain extended the extensors of the wrist will not help until a certain resistance has been reached and when this amount of resistance is reached the extensor tendons of the wrist will be felt to contract. On the other hand if the extensors of the fingers retire from the contest and let the fingers flex, the extensors of the wrist instantly contract no matter how slight the resistance may be. It, therefore, seemed to me important in extending the wrist by means of the extensors of the fingers to find out: first, the amount of resistance necessary to cause the extensores carpi to contract; secondly, the amount of resistance necessary to cause the flexores carpi to cease contracting.

The experiment was made with the forearm placed on the flat surface of a table, with the palm downwards, and with the hand projecting beyond the edge of the table, and with the hand in a line with the forearm, and with the fingers extended. Resistance was applied in one of two ways:—in the one by passing a broad band over the extended fingers, taking care to keep it beyond or peripherally to the metacarpo-phalangeal joint, and then to attach this band to a fixed point, with a dynamometer interposed. Against this fixed point the person extended the wrist-joint, while the finger of the observer was placed on the tendon of the extensor carpi radialis longior. The other method consisted in keeping the fingers extended, and by means of an assistant increasing the traction on the band until the tendon of the extensor carpi could be felt contracting. The latter was found to be the better method, as the wrist being fixed it was more easy to ensure that other movements should not be made which would prevent the tendon being felt.

The result of several examinations gave in my own case that the pressure of 3 lb. to 4 lb. was required to be applied to the extended fingers before the extensor carpi radialis longior could be felt to act.

It might be thought that the flexores carpi would cease to contract as soon as the extensores carpi took up the work. But this was not found to be the case, and in some instances more pressure was required, as much as 10 lb. having to be applied before the tendons of the flexores carpi relaxed. The relaxation of the flexors of the carpus is a much more difficult matter to determine, as in some trials they seemed to leave off contracting at once, while in others they were still contracting even with a pressure strong enough to overcome the resistance of the wrist. I think that the following is the explanation:

If the fingers be actively extended to the full amount, or if they be quickly extended, the flexors of the wrist are felt to contract synergically, and if in this condition pressure be made against extension of the wrist, the flexors of the wrist will not relax; but if the extension of the fingers be made very slowly and not to the full degree, the flexors of the wrist will hardly be felt to contract, or very slightly, and in that condition very little pressure against the extension of the wrist suffices to relax them altogether. It therefore appears that if the predominant idea is extension of the fingers, then the flexors of the wrist contract, and remain contracted if this combination be required to take part in the superadded movement of extension of the wrist. Now, if the movement of extension of the fingers is not made to the full extent, and the superadded movement of extension of the wrist becomes the predominant one, the flexors of the wrist cease acting as soon as pressure is applied to the dorsum of the first phalanges, although the extensor communis digitorum is taking part in the movement and its tendons can be seen to stand out.

I think these experiments show that if the movement of extending the wrist be performed with the fingers extended, the extensors of the fingers have to do all the work themselves, and against the contraction of the flexores carpi until the amount of work done amounts, as in my own case, to 3 lb. to 4 lb., when the extensores carpi will join in and help them.

Now to apply this to what we find in lead paralysis. In paralysis of the extensors of the fingers due to lead, if the movement of extension of the wrist be started by that of attempting to extend the fingers, the extensores digitorum, being paralysed, cannot move at all and so cannot possibly reach the amount of 3 lb., which, as we have seen, is required for them to attain before the extensores carpi will come in and help them. The important point is that the patient has no power to make the extensors of the carpus contract, and the only resulting movement is flexion of the wrist due to the synergic action of the flexores carpi. It rather reminds one

of some highly-organized establishments where if one of the servants is incapacitated it is no one's place to do the work, which is consequently left undone.

I have already mentioned that the flexors of the fingers take part in the flexion of the wrist, and they do so very readily. It is also to be noted that when the flexores digitorum act as flexors of the wrist the synergic action of the extensores carpi does not occur. When, however, we cause the fingers and thumb to contract powerfully, as in grasping, and while this is occurring we flex the wrist, we get an entirely different condition. Here we have taking part in the movement of grasping the flexors of the thumb and fingers, and also the synergic action of the extensores of the wrist, and the question is, What will happen if we now flex the wrist? Will the movement be done by the flexors of the fingers, or will the flexors of the wrist come and help? And, lastly, will the extensores of the wrist relax? It will be observed that if this movement be attempted while a strong grasp is maintained, and also if the flexion of the wrist be made slowly, there is a considerable feeling of strain, and a certain amount of tremor due to the antagonism between the acting muscles.

To determine the three above-mentioned points the following method was used:

1. It was first necessary to ensure that the grasp of the hand was being maintained throughout the observation, and this was done by means of a dynamometer, which was grasped in the hand, and the index of which could be watched, for I found that in flexing the wrist against resistance as soon as the grasp was relaxed the flexors of the wrist immediately contracted, even in the slightest degree of flexion, and, as I have already mentioned, the whole experiment depended on the grasp being maintained.

2. The forearm was put in the position midway between supination and pronation, and a band was passed round the metacarpal bones, and either traction was made horizontally in the direction opposed to flexion of the wrist, or flexion was made by the wrist against a fixed point; a spring balance was attached to the band, and the amount of traction was read off at which the tendons of the flexors of the wrist were felt contracting, and also the amount of traction required to make the tendon of the extensor carpi radialis relax.

In my own case I found that the tendon of the palmaris longus could be felt first when the balance measured 3 lb., whereas the tendons of the flexores carpi radialis and ulnaris were not felt till 5 to 6 lb. traction was made. On the other hand, the tendon of the extensor carpi radialis was not felt to relax till as much as from 14 to 16 lb. traction had been made.

The strained feeling would therefore seem to be due to the antagonism between the extensores of the wrist and the flexors of the wrist.

These experiments show that the combination between the extensores digitorum and flexores carpi, and also between the flexores digitorum and extensores carpi, is so strong that the muscles which flex and extend the wrist will oppose each other rather than sever their connexion with the finger muscles, when the wrist is being extended or flexed in conjunction with extending the fingers or flexing the fingers and thumbs.

While discussing the question of the action of the extensores of the wrist with the flexors of the fingers, it will be advisable to say a few words about the nature of this combination. Duchenne calls attention to the definite association between the above-mentioned muscles, as well as that of the extensores of the fingers and flexors of the wrist, and that of the extensor ossis metacarpi pollicis and the extensor carpi ulnaris. He speaks¹ of the "moderating synergy," and he describes

that the synergic contraction of the flexors of the hand on the forearm is inseparable from the muscular function which ought to produce voluntary extension of the first digital phalanges. To place the common and special extensores of the fingers in the greatest elongation in order to augment their dynamical power: such is the useful end of this instinctive combination of the flexors of the hand during extension of the fingers.

He refers to the over-extension of the wrist which occurs in extending the fingers when the flexors of the wrist are paralysed, and the explanation which he gives is that "the common extensores of the fingers, being up to a certain point at the same time extensores of the hand on the arm, their contraction renders necessary the moderating synergy of the flexors of the wrist." One of the earliest mentions that I can find about a muscle passing over two or more joints is that of William Cowper who¹⁶ reproduces Bidloo's splendid anatomical plates. He gives various reasons for this occurrence, but he does not mention the bringing in of other muscles. John Hunter¹⁷ in his second Croonian lecture delivered before the Royal Society in 1777, was, as far as I can ascertain, the first to enunciate the doctrine of synergic muscles. He says: "Muscles often go over two, three, or four joints, and only

move the third and fourth, as the flexors of the last joints of the fingers; but to prevent the first and second joints being moved by this action the extensores of the intermediate joints are obliged to interfere and keep them bending." This is really the use of these synergic muscles, and although the flexors of the wrist do act in placing the extensores of the fingers in the greatest elongation in order to augment their dynamical power, and to such a degree that when the wrist is flexed to a right angle the grasp is about one-half what it is when the hand is in a line with the forearm, that I think is not their object. For if the wrist be extended passively as far as it will go, and if then the fingers be actively extended, the flexor carpi ulnaris will still be felt to contract without remedying the position of the wrist-joint, even though the extensores of the fingers are working at a great disadvantage. Surely if the function of the synergic muscles was to put the extensores of the fingers in the most advantageous position, they would flex the wrist and bring the hand into the position in a line with the forearm. Their function appears to be to fix the wrist in whatever position it is required to be, so that the fingers will have a secure basis to work upon. Following the opinion cited above of John Hunter, I think the condition may be stated thus: When a muscle by passing over two or more joints has two or more different actions, then, if only one of these actions is required, other muscles are brought into the movement whose actions are antagonistic to those of the muscle which are not required. In the above quoted case the extensores of the fingers, by passing over the wrist, are extensores of the wrist as well as extensores of the fingers, and as extension of the wrist is not required the antagonists to this action, namely, the flexors of the wrist, are brought into the movement, and the resultant movement is extension of the fingers without extension of the wrist. This rule applies, as far as I have been able to observe, throughout the muscular system. These muscles, which are brought into action to neutralize an action which is not required, I should propose to call "synergic muscles," a term used by Duchenne.

REFERENCES.

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Observations

ON

THE TREATMENT OF CANCER OF THE RECTUM.

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THE treatment of cancer of the rectum practically resolves itself into three alternatives, namely, (1) to leave the disease alone; (2) to perform colotomy; or (3) to remove the affected portion of the bowel. I may say a few words on each of these points.

1. Where the disease is left alone, the treatment consists in the relief of symptoms as they arise, and the adoption of a variety of palliative expedients, such as local injections to keep the part clean, laxatives to keep the bowels open, scraping away the fungating masses if they are causing obstruction, opium, etc. There is no doubt that a certain number of cases get on very well on these lines; and so long as the disease has not spread to neighbouring organs or involved nerves, such as the sacral plexus, the patient is in many ways more comfortable than with colotomy, because he still retains his sphincter and is able to go about. The cases suitable for this kind of treatment are those where there are fungating masses, chiefly growing from one side of the rectum, as distinguished from those in which there is an encircling and constricting growth.

2. Colotomy. This removes the risk of obstruction. It may also relieve some of the symptoms, such as tenesmus and the pain due to the passage of faecal material over the