CONTRACTION AND RETRACTION OF MUSCULAR FIBRES, WITH SPECIAL REFERENCE TO THE UTERUS.

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Muscular fibre is either voluntary or involuntary; the former is striated, and the latter unstriated, the exception being the fibres of the heart, which, though striated, are involuntary.

Striped or unstriped, voluntary or involuntary, the great and essential characteristic of muscular fibre is its power of contraction —*i.e.*, its power of shortening so as to draw its extremities nearer together.

Thus, when the biceps muscle of the arm contracts, its insertion into the forearm draws the latter upwards towards its origin from the shoulder, and the result is flexion of the forearm on the arm. Again, the triceps muscle contracts and pulls up the olecranon process of the ulna towards the shoulder, producing extension of the forearm.

But contraction is not quite so simple as this, and if one were to define it as a shortening of the fibres, whereby the ends were drawn nearer together, we should find that such a definition would not always hold good, inasmuch as a muscle may contract and yet its extremities may not be approximated at all. Thus, supposing the left forearm be flexed by the right hand as far as possible, so that the origin and insertion of the biceps are as near together as they can be, it will be found that the biceps can be made to contract or relax at will; each contraction causes the shape of the muscle to alter, and each relaxation causes it to pass into its previous condition, and yet the ends of the muscle (origin and insertion) are unaltered so far as nearness to one another is concerned.

Hence, contraction of a muscular fibre may be defined as the power to alter its condition so as actively to pull on its attachments (origin and insertion), and so bring them, or tend to bring them, nearer together. Doubtless in the great majority of instances they are brought nearer together, but occasionally, as in the example just given, this is not the case, simply because they are already as near as they can be. And yet the muscle contracts. It is thus seen that the word *contraction* as applied to a muscular fibre must not be

limited to a mere shrinking in length—that is, shortening—as was perhaps the original intention of the earliest physiologists who gave it this name.

Moreover, when a muscular fibre contracts, and its attachments are approximated, then it not only shortens, but it thickens, and, in

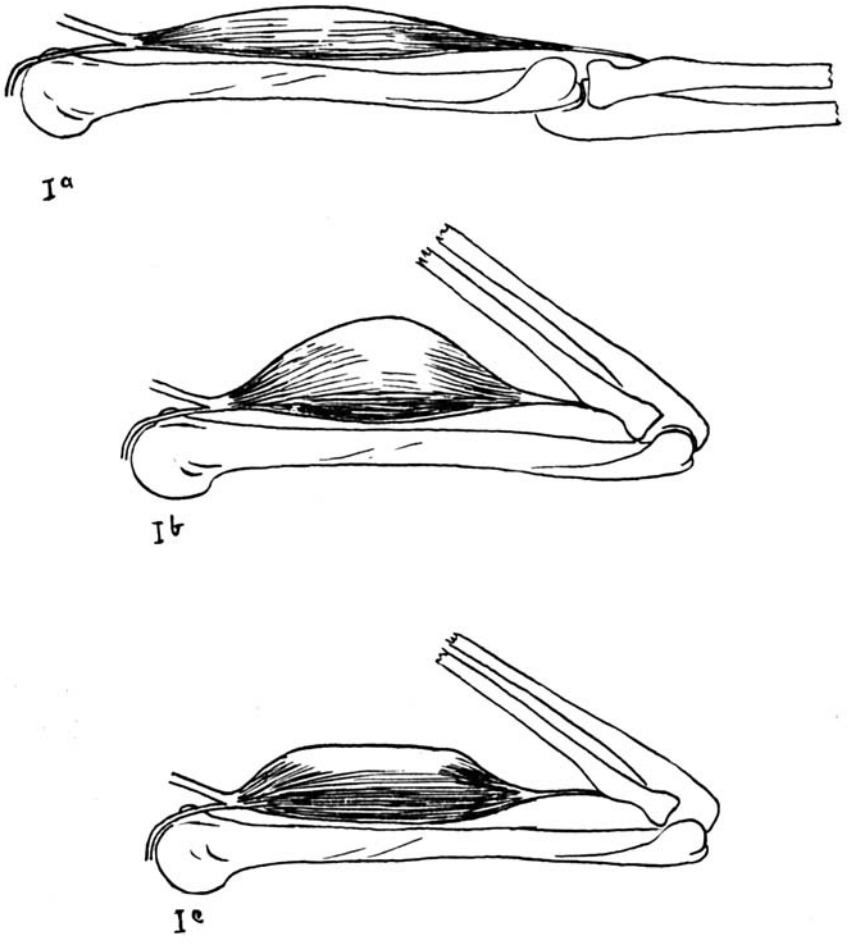

FIG. 1.—(*a*) SHOWS BICEPS EXTENDED TO THE FULLEST EXTENT; (*b*) SHOWS BICEPS IN ACTIVE FULL CONTRACTION; (*c*) SHOWS BICEPS IN PASSIVE FULL RELAXATION (RETRACTION).

fact, it thickens in exact proportion to the amount of shortening, and therefore, it is found that no matter how much it shortens in its contraction, there is no diminution of bulk.

This has been proved by causing a muscle to contract in a fluid, like water; the height of the water in the vessel is just the same before and after contraction. Again, when a muscle, whose ends are

already as near together as they can be, contracts, it alters its shape, and becomes more spheroidal, and at the same time harder. This fact can be illustrated by the biceps muscle again. Let its attachments be approximated as much as possible by flexing the arm on the forearm with the other hand. Now, if the biceps of the flexed limb be felt, it feels soft, and its shape varies according to its size, but is somewhat cylindrical. Now let the biceps be thrown into activity, and it assumes a more or less spheroidal shape, and feels hard.

Doubtless the arrangement of the fibres is different according to the state of the muscle in extension, active contraction, and passive relaxation respectively, but the exact nature of this difference of arrangement has not yet been determined.

Almost all text-books on physiology describe a simple muscular contraction as consisting of—

1. The latent period.
2. The shortening or contraction.
3. The relaxation or return to the original length.

In order to understand what is to follow, it is necessary to state exactly what is meant by these three phases.

1. *The Latent Period.*—When a muscle is stimulated to contract, it is found that a certain length of time—generally about a hundredth of a second—elapses before contraction begins. This is called the *latent period*, and during this period certain changes are undoubtedly taking place. For instance, there is a negative variation in the electric current.

The most modern investigations seem to show that the latent period is much shorter than a hundredth of a second.

2. *The Shortening or Contraction.*—All the books on physiology look upon contraction as synonymous with shortening, and if this were true, then whenever a muscle contracted it would become shorter, and therefore its extremities would be approximated.

In the example given of the biceps, there is a muscle which contracted and yet which did not become shorter, because its ends were already as near together as they could be got. It is possible that an explanation may be found in this, namely, that the individual fibres contract and actually shorten, and that it is this combined shortening which causes the belly of the muscle to alter its shape towards a sphere, although the tendinous ends of the muscle are not approximated.

3. *The Relaxation or Return to the Original Length.*—The phenomena of a contracting muscle have been observed chiefly in the frog. One

of the thigh muscles is used, and one end is cut away from the bone and a weight is attached. The muscle is now made to contract by a stimulus of some sort. When the active contraction is over, the weight attached to the muscle pulls upon it, and draws it out to its original length. This is called the *relaxation or return to the original length.* Now, if there were no weight attached to the muscle it would not return to its original length, although the activity of the contraction would pass away. Thus, in the example already given, the ends of the biceps can be kept as near together as it is possible to

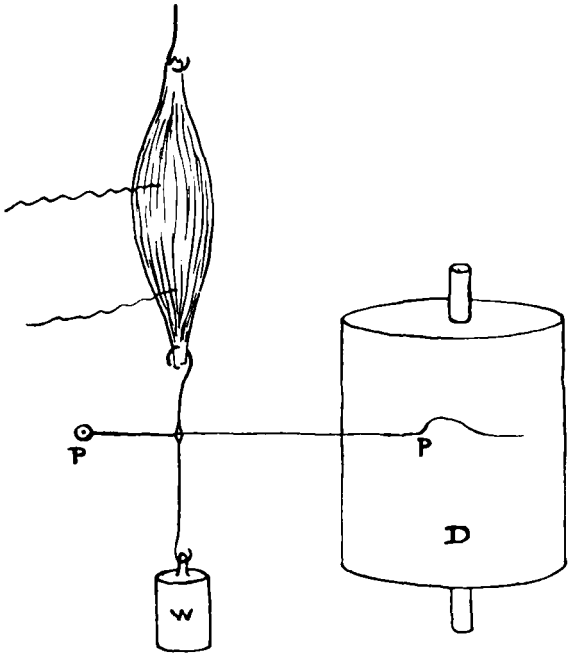

FIG. 2.--SHOWS SIMPLE APPARATUS FOR RECORDING A MUSCLE CONTRACTION.

W, Weight; *D*, drum; *P*, pivot with writing point.

bring them by means of the other hand. The biceps can be made to actively contract without shortening, as already described, and can be allowed to relax without lengthening. It may be argued that it would lengthen if it were not for the fact that the forearm is being held in a state of flexion by the other hand. To perceive that this is not true needs very little thought. If it were so, then the biceps would not only be a *flexor*, but also an *extensor* of the forearm.

It will be noticed that the word *relaxation* is used in most works on physiology to connote not merely the passing off of the state of active contraction, but also the lengthening out again to its former

extended condition. Now, inasmuch as the muscle can relax simply and yet remain short, and the word *relaxation* is used to mean this only, great confusion has arisen in the minds of many students. In order to be as clear as possible, it will be necessary to define precisely what is meant when this word is used.

It is probable that no muscular fibre, of whatever kind, is capable by itself of returning to its former lengthened condition. If this be true, it is a fact of the greatest importance. The following evidence is offered to support the theory:

Dr. ——* placed a fresh muscle cut from the thigh of a newly-killed frog upon a layer of quicksilver, in order to reduce friction as much as possible. He then sent an electric current into this muscle, and it contracted actively, and became short and thick. The current was applied in sufficient strength to make the muscle contract and shorten to its fullest extent. When the effect of the stimulus had passed off, the muscle *relaxed*—that is, it became softer, and its shape altered, becoming more cylindrical and less spheroidal, but its length remained the same.

I have repeated this experiment with the help of Dr. Starling, at one time physiologist at Guy's Hospital, and now Professor of Physiology in University College, placing the muscle on quicksilver with a layer of oil floating on the surface, in order to reduce friction to a minimum, and the result has fully confirmed Dr. ——'s. A strong electric current from a Ruhmkorff's coil caused the muscle to contract forcibly, and to shorten as far as possible. When the current was withdrawn the muscle soon relaxed, but it remained short, and merely altered its shape, becoming less spheroidal.

Another fact which points in the same direction is that every muscle in the body has an opponent. This is not always another muscle. The flexors of the body are opposed by the extensors, and *vice versâ*. When the biceps contracts and shortens, it is drawn out again to its former length by the contraction and shortening of its opponent, the triceps, and *vice versâ*.

Some have asserted that extension of a muscular fibre is brought about in certain muscles by means of other muscular fibres curling round them in a spiral manner, as seen in Fig. 3. When the fibre contracts the spiral is widened, and so stretched. When the spiral fibre contracts, it lengthens or stretches the contained fibre.

In some instances the opponent is not a muscle. It may be the

* I have been unable to find the name of the first experimenter, but it is referred to in Rosenthal's 'General Physiology of Muscle and Nerve,' and was described by Prevost and Dumas.

recoil of an elastic substance, such as the elastic ligaments, or it may be hydrostatic pressure. Thus, when the heart contracts it drives the blood out of its cavities into the pulmonary artery and aorta respectively, and when the active contraction passes off, and the fibres relax, they are stretched out again by the blood pouring into the cavities through the vena cava and pulmonary veins respectively. But the most interesting example of this hydrostatic action is the pregnant uterus. When the muscular fibres of the uterus contract, the effect is to bring pressure to bear upon the contained liquor amnii. If it were possible to have the bulb of a barometer inside the cavity, the mercury would rise in the barometer according to the strength of the contraction.

The late Dr. Matthews Duncan found experimentally that, on an

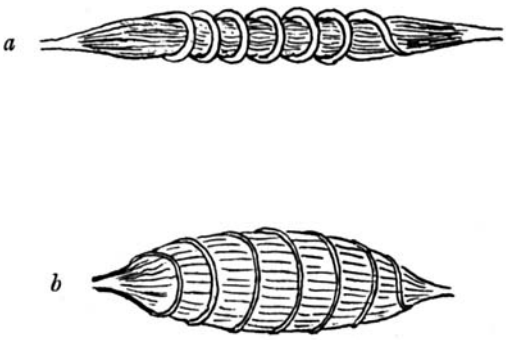

FIG. 3.—DIAGRAM TO SHOW MUSCLE FIBRE WITH HYPOTHETICAL SPIRAL FIBRE AROUND.

a, Muscle fibre stretched, spiral fibre contracted; *b*, muscle fibre contracted, spiral fibre stretched.

average, it required a force of 15 pounds to rupture the membranes, and from other facts made by different observers it is certain that the pressure exerted is often greater than this. Now, there is a law in hydrostatics that, whenever a fluid like water is submitted to a given pressure, this pressure is transmitted equally to all parts of the fluid. If the pressure caused by the contraction of the uterus be 15 pounds to the square inch, then every square inch touched by the amnion has this pressure upon it. Hence, when the active contraction of the fibres passes off, and they become relaxed, this 15-pound pressure to the square inch comes into play, and forces out the uterine cavity in all directions, thereby stretching or extending the muscular fibres to their previous length. In other words, this hydrostatic pressure is the opponent of the contracting fibres of the uterus, and they have no other, so far as is known.

The uterus is made up almost entirely of muscular fibres, and they are all unstriped and involuntary. The uterus contracts at varying intervals throughout pregnancy. The late Dr. Braxton Hicks wrote papers in the *Obstetrical Transactions of London*, vol. xiii., and in the *Medical Press and Circular* for 1894, on these contractions. They are quite palpable in the later months of pregnancy, although the patient is unconscious of them; in fact, they are painless uterine contractions. In all probability they go on, not only throughout pregnancy, but also in the non-pregnant state.

In the Guy's Hospital Reports for 1881 I showed that the muscular fibres of the iris were constantly contracting and relaxing,

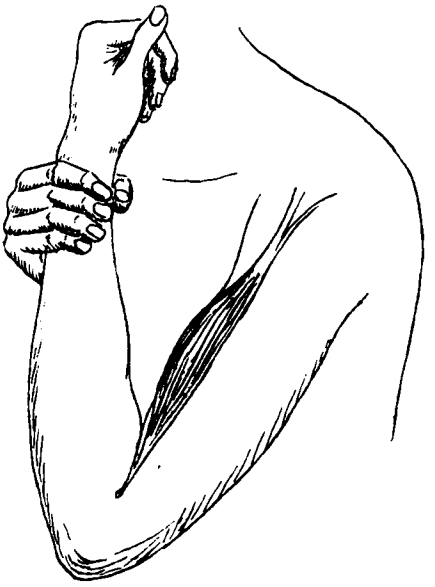

FIG. 4.—RIGHT HAND HOLDING LEFT FOREARM IN A CONDITION OF COMPLETE FLEXION; THE BICEPS IS SEEN WITH ITS ATTACHMENTS APPROXIMATED AS MUCH AS POSSIBLE, ALTHOUGH IT IS NOT IN ACTIVE CONTRACTION.

causing slight alterations in the size of the pupil, independently of light or accommodation, and it is extremely probable that every muscular fibre in the body during healthy life is undergoing these constant changes. Be that as it may, the painless contractions and relaxations of the uterus described by the late Dr. Braxton Hicks can be observed by anyone who will take the trouble, and they are of very great importance in diagnosis, because no other condition is like it. It is true that a soft fibroid of the uterus which is made of muscular fibre is said to undergo similar contractions and relaxations, yet it is so different in degree that anyone who has had

experience can appreciate the difference in a moment. In fact, so slight is this contraction of a fibroid tumour that it is extremely difficult to detect, whereas the painless contraction of an enlarged uterus, when felt, is distinct and unmistakable. Hence, it serves to show that it is the uterus, and not a tumour. Of course, it may not be a pregnant uterus, because if a uterus were enlarged by an intra-uterine polypus these contractions could be felt, though, as a rule, they are then painful, like ordinary labour pains.

Sometimes the uterus can be felt to contract in cases of extra-uterine gestation, but in such a case it is a comparatively small body, owing to the absence of fœtus and membranes and the liquor amnii from its cavity. Sometimes the contractions of the uterus in a non-pregnant state are felt by the individual, especially during menstruation, and the pain produced is often great, and forms one of the commonest and best-known kinds of dysmenorrhœa.

Hitherto contraction of muscular fibre has been spoken of, and the difference between simple relaxation and stretching or extension has been pointed out. To return again to the biceps muscle. First of all it is in a state of rest, and extended to its utmost length (*vide* Fig. 1, *a*). Now it is thrown into active contraction, with the result that the forearm is flexed on the arm by the shortening of the fibres, and the approximation of the attached tendinous ends of the muscle (*vide* Fig. 1, *b*). It is seen that the belly of the muscle is more or less spherical. Now, whilst keeping the forearm completely flexed by holding it with the other hand, the active contraction of the biceps is allowed to cease; in other words, it is allowed simply to relax. It is noticed that the belly of the muscle becomes less spheroidal and more oblong—in fact, it is wider from side to side, and not so thick from before backwards as it was; and yet the muscle as a whole is just as short from tendon to tendon (origin to insertion) as it was when the fibres were in active contraction (*vide* Fig. 5). This condition is called *retraction*, which may be defined as the condition of a living healthy muscle, with its nervous reflex loop intact, when a *contraction* is followed by simple *relaxation*, but not by *extension*. If the biceps contracts until the forearm is only partly flexed, and then relaxes, the condition is *partial retraction*. The *retraction* is *complete* when the muscle relaxes after having contracted until it has shortened to its utmost capacity.

The late Matthews Duncan (*vide Obstetrical Transactions of London*, 1886) thought that retraction might go on without contraction, for he says: 'It is a separate and distinct function—that is, it may go on without contractions.' But he added, 'That retraction

is not dependent on contraction is difficult to prove.' The general opinion was that retraction was dependent upon contraction, and was the permanent shortened condition of the muscle after contraction, when the active contraction had passed off—in other words, that the fibres were not stretched out again to their original length (*op. cit.* Galabin, Horrocks, Champneys, and Roper).

Every living muscle in a state of health, and with its nervous mechanism intact, possesses a certain tone or slight contraction, even when in a state of rest. The difference between muscles with tone and the same muscles without is seen when the spinal cord is destroyed. Just before, all the muscles are in this condition of tone, and easily thrown into co-ordinated reflex action; just after, they

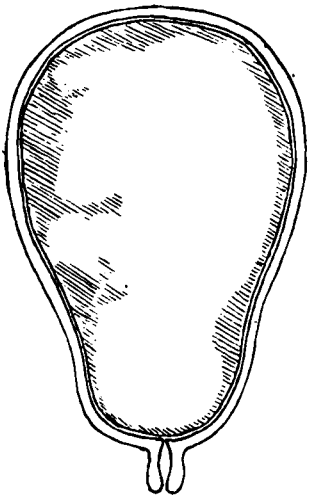

FIG. 5.—DIAGRAM SHOWING SECTION OF PREGNANT UTERUS AT FULL TERM.

are flabby and toneless, and incapable of being stimulated to reflex action.

The combined effect of this tonicity in all the detrusor fibres of a recently-delivered uterus is enough to account for the arrest of hæmorrhage, without seeking for some force special to uterine muscular fibres which is not possessed by other fibres, voluntary as well as involuntary. For it must be remembered that the uterus just after delivery at term is the thickest involuntary muscle in the human body.

Here is a section of the gravid uterus (Fig. 5) near the full term. The fœtus is left out for the sake of clearness. The uterus is at rest; its fibres are relaxed, but stretched out to their fullest

extent, corresponding to the biceps when the forearm is extended (Fig. 1, *a*).

First take a painless contraction occurring a week or two before abour begins. The result of the contraction is to cause the uterus to assume a more spherical shape, the pressure within the uterine cavity is increased, but there is little actual shortening of individual fibres, and practically no diminution in the size of the uterus. When the contraction passes off, the pressure of the liquor amnii forces the fibres back to their original position, and the uterus is no longer quite so spherical, and its walls are felt to be softer and more doughy.

When labour actually begins, the uterine contractions are felt by the patient, and she begins to have pains. The exact cause of the onset of labour is still a vexed question, but, whatever its cause, we know that the internal os begins to open,* and the amnion is driven into it, and each succeeding pain causes pressure upon the liquor amnii, which pressure drives the amnion into the cervical canal and finally against the external os uteri, gradually opening up the neck of the womb until the first stage of labour is complete.

This opening up of the neck of the womb is accompanied by a relaxation of the fibres in the lower zone of the uterus and in the cervix uteri, so that the hydrostatic pressure within the amniotic cavity, which, by the law already alluded to, acts all over the interior of the uterus, finds in these relaxed parts yielding tissues, and as they yield the pressure, of course, lessens, so that when the active contraction passes off there is not enough force left to stretch the contracting shortened fibres back to their original length: for the uterine wall, or, at all events, that portion of it which expels the child, is in a state of *partial retraction* in between the pains, and, as is seen in Fig. 6, the walls are rather thicker. At last the membranes rupture, and there is an escape of more or less liquor amnii, and all pressure within at once ceases. The moment the membranes rupture, the hydrostatic pressure previously exerted by the liquor amnii upon the interior of the uterus ceases, and the uterine contraction which causes the rupture is followed by a con-

* According to some, the internal os is pulled open by the longitudinal fibres which radiate from it up into the wall of the uterus (*vide* Fig. 11). When it is open a little, it is much easier to increase the dilatation, because the resistance of any circular ring to any dilating force acting from within, the tension of the edge remaining the same, varies inversely as the radius of the ring (*vide* Galabin, *Obstetrical Transactions*, 1886, p. 103).

siderable increase in *retraction*, because, as soon as the pain has passed off, the fibres remain as short as that contraction has made them, owing to the absence of the normal hydrostatic extending force (*vide* Fig. 7).

This absolute, complete, and immediate cessation of hydrostatic pressure is made use of in the testing of boilers for steam-engines, etc. The boilers are filled with water, which is subjected to whatever pressure the boiler is expected to withstand, amounting in some cases to hundreds of pounds to the square inch. If there is a flaw in any portion of the boiler, rendering it unable to withstand this trial-pressure, it bursts, but there is no explosion, and no injury

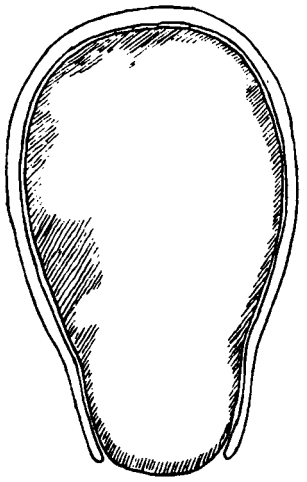

FIG. 6.—SHOWS SECTION OF UTERUS WITH PARTIAL RETRACTION AT END OF FIRST STAGE OF LABOUR.

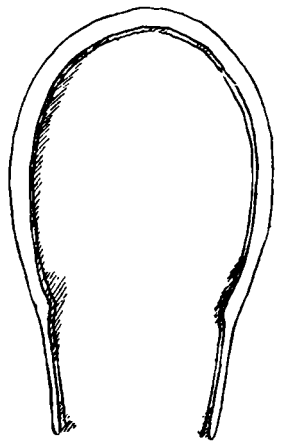

FIG. 7.—SECTION OF UTERUS WITH MORE RETRACTION AFTER RUPTURE OF MEMBRANES.

to anyone, because the hydrostatic pressure is so instantaneously lost. It is different, of course, with steam, which is expansive, and so causes disastrous effects by still exerting enormous pressure even when the boiler has burst.

It is a well-known fact that the uterus immediately after the rupture of the membranes is much smaller than it was just before the commencement of that uterine contraction which ruptured them. How far the elastic recoil of the tissues in the uterine wall assists in this reduction of size, and also in the expulsive powers of the uterus, is questionable. Certainly it is in all probability but little, for muscular fibre, which forms the chief bulk of the wall, possesses very slight, though perfect, elasticity—*i.e.*, it will not stretch much

without breaking, but it returns completely to its former length when the stretching force is removed. Matthews Duncan (*op. cit.*) says that 'the elasticity of the peritoneal covering of the uterus is probably the chief element in the elasticity of the uterus generally.' Very little is known of the elasticity of mucous membranes, but in all probability it is insignificant as a force. Hence, the combined force of elastic recoil in all the constituents of the wall of the uterus is so small that, as Duncan says (*op. cit.*), 'it is not sufficient to keep the uterus taut.' At the same time, when the amnion ruptures and allows the fluid to escape, the pressure on the uterine walls is taken off instantaneously, and thus whatever elastic recoil the walls possess is allowed to come into play.

Of course, if the child's head or other presenting part has become wedged so as to act like a ball-valve, then the conditions are different, and the forewaters—that is, those in front of the presenting part—are cut off from the rest, and so do not behave precisely in the way mentioned, and the afterwaters—or those inside the uterus—are still under pressure after rupture of the membranes. But this could act only momentarily.

After rupturing the membranes there is generally a pause for a short time before active contractions begin again. Each contraction now tends to drive the child through the parturient canal, and, as it descends, the fibres get shorter and shorter. Each shortening, although followed by relaxation, is not followed by extension, as there is no extending force in action. When the child is expelled, the walls of the uterus have become very greatly increased in thickness, as is seen in Fig. 8.

Again there is a pause, lasting for a period varying from a few minutes to several hours, *i.e.*, in a case left to Nature without any artificial aid. The uterus seems to be resting, as it were, from its work. Finally it begins to contract again, and the placenta is detached and expelled, the uterine fibres are shortened to their utmost capacity, and there is *complete retraction* (*vide* Fig. 9). Every now and then the uterus actively contracts, and becomes more or less spheroidal, and feels hard, like a cricket-ball (*vide* Fig. 10); but there is nothing to expel from its cavity, and it is already as short as it can be, and when the active contraction subsides it is less spheroidal, and feels soft and indefinable, although it is in a state of complete retraction. The sum total of the tone of the fibres of the retracted (relaxed) uterus is enough to secure the bleeding vessels, and so to prevent excessive post-partum hæmorrhage.

The active contraction of the empty uterus when it is hard and

spheroidal and easily felt, like a cricket-ball, is only one phase, which is followed soon by the soft, less spheroidal, and impalpable phase, when the fibres are relaxed, though possessing tone. Sometimes during this perfectly natural phase of retraction great efforts are made to alter it to the active state of contraction by kneading and rubbing the uterus as much as possible, even when there is no excessive hæmorrhage and the pulse is good, strong, and normal in frequency. Fear and apprehension is caused unless the uterus can be felt hard like a cricket-ball *all the time.* Such a condition would be a tetanic contraction and would be abnormal, probably continuously painful, and might be accompanied by excessive hæmorrhage.

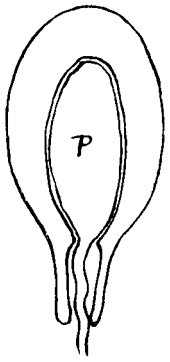

FIG. 8.—SECTION OF UTERUS WITH NEARLY COMPLETE RETRACTION AFTER EXPULSION OF FŒTUS.
P, Placenta.

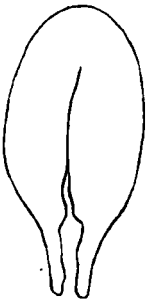

FIG. 9.—SECTION OF UTERUS WITH COMPLETE RETRACTION AFTER EXPULSION OF PLACENTA.

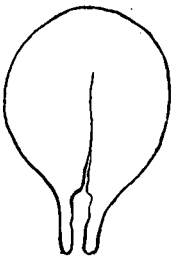

FIG. 10.—SECTION OF COMPLETELY RETRACTED UTERUS IN ACTIVE CONTRACTION.

The condition of the uterus just after the delivery of the placenta is very much like that of a turtle's heart beating after it has been cut out of the body and when it is empty of blood, the difference being that the contractions of the uterus are slower, stronger, and at longer intervals. At first they occur every few minutes and are often painless. Later they are less frequent and often painful—the so-called 'after pains'—the amount of these being very variable in different women, and even in the same woman in different pregnancies. No doubt they are felt when the contractions are very vigorous, or when the patient is hyperæsthetic, and especially when retained clots or fœtal membranes or decidua have to be expelled.

It can be shown that on the whole it is scientifically better to let the patient alone in natural labours, which constitute the majority

of cases. Some strongly recommend that the hand should be placed on the abdomen in order to follow the uterus down during the actual delivery of the child, as well as during the expulsion of the placenta. Possibly such a procedure, when done skilfully, does no harm, but certainly it is quite unnecessary. To touch the abdomen during the second stage of labour, assuming that satisfactory progress is being made and the patient is in good condition, is equally needless.

After the child is born, it is very bad practice in normal cases to try and expel the placenta by external pressure immediately.

Crédé himself recommended that fifteen to twenty minutes should elapse before attempting to express the placenta, and this seems in order to allow of such changes as retraction, clotting, etc., to take place before the final effort is made. And, indeed, it will be seen that when the third stage of labour is left to Nature, she nearly always waits for a longer or shorter period, and then uterine contractions begin again, and these contractions not only expel the placenta, but result in the maximum amount of shortening of the fibres, and therefore the maximum amount of retraction. Inasmuch as sometimes the uterus remains inert for a very long time, it is perhaps quite justifiable after, say, twenty minutes, to express the placenta.

In the light of what has been already stated, it will be recognised it is better that after waiting twenty minutes, to try by rubbing and kneading the uterus to set up a contraction rather than to expel it one's self by absolute pressure on the uterus. Also, in an adherent placenta, where it is necessary to detach it with the fingers, it is better after completely detaching it to try and start a uterine contraction, or, failing that, to expel it by expression, instead of pulling it out.

After the labour is over, the child and the placenta born, it is quite unnecessary to trouble about the condition of the uterus if everything is satisfactory. If the amount of visible hæmorrhage is not excessive, and if the pulse is full, strong, and not more than 80 or 90 per minute, and there is no pallor, one can assume that there is no abnormal hæmorrhage going on, and the patient may be left alone. If, however, an attempt is made to feel the uterus through the abdominal wall, there need be no alarm even if it cannot be made out. For in such a case it is indefinable because it is soft, relaxed, and, in fact, in a state of retraction. Very likely, if the hand be kept on for a short time, the uterus will contract actively, and will then be felt as a hard, more or less spherical, well-defined body aptly compared to a cricket-ball.

Of course, where there is unusual hæmorrhage, or where the

patient's pulse is too quick, or where she is pale, or in other abnormal conditions suggestive of internal hæmorrhage, then it becomes a matter of grave anxiety if the uterus cannot be felt. Fortunately more than 90 per cent. of labours are normal, and it is to these only that the above remarks apply.

A cricket-ball is a very good simile for the active contracting phase of the uterus just after labour is over. As felt through the abdominal wall, it is about the size and consistence of a cricket-ball, but one obtains a far more complete idea of its condition by thinking of it as a slowly-beating heart now in active systolic contraction, and now in passive diastolic relaxation (complete retraction).

The contraction, relaxation, retraction, and extension of muscular fibre are of great importance in many other conditions—for instance, in the case of the heart and the diseases connected with it. But two conditions that are more immediately connected with midwifery and diseases of women may be mentioned. One is rupture of the perinæum. The circular fibres which surround the anus are called the sphincter ani. Now, if the perinæum is torn completely through into the rectum, all these circular fibres are severed; they contract and then relax, remaining in this shortened condition in a state of retraction. There is no extending power, and the broken ends of the fibres can be felt quite distinctly on each side of the lacerated perinæum. It is the object of an operator to draw out these fibres again, to extend them, in fact, and sew them together so that when they have united they shall be capable, not only of contracting, but also of shortening.

Another use made of our knowledge of retraction of muscular fibres is in the operation on fibroid tumours of the uterus when they are polypoid. We can cut pieces out of a large fibroid so as to make it smaller, and we can cut through the pedicle with scissors or a knife without fear of hæmorrhage, because the structure is muscular fibre, which, on being cut, at once contracts and closes the severed bloodvessels. Moreover, even when relaxed there is retraction, which still stops hæmorrhage, and there is no extending force to draw out the fibres.

The Law of Polarity.—Stated briefly, it is this: 'When a muscle contracts, its opponent relaxes.' Thus when the flexors of the fore-arm contract, the extensors relax; and *vice versâ*, when the extensors contract, the flexors relax. When the circular fibres of the iris contract, the radiating fibres relax, and the result is that the pupil of the eye gets smaller. When the radiating fibres contract, the circular fibres relax, and the pupil dilates.

In the case of hollow organs, such as the bladder, heart, uterus, etc., strictly speaking the pressure of the contents of these cavities act as opponents to the contracting fibres. Thus the urine as it accumulates in the bladder gradually distends the walls and so stretches the muscular fibres.

The sphincter muscles assist, however, inasmuch as they keep the orifice closed. If it were not for this, the fluid would run out, and so there would be no hydrostatic pressure within the cavity, and so no extension or lengthening out of the muscular fibres of the walls of the cavity.

In the bladder the expelling fibres, called *detrusor* fibres, are arranged in such a way that when they contract they tend to drive the contents out through the urethra.

The internal orifice of the urethra is kept closed by the retraction of the circular fibres arranged round the neck of the bladder, and called the 'sphincter vesicæ.' They act as opponents of the detrusor fibres in the way already described; when they relax the pressure of the urine causes them to stretch, so as to open the internal urethral orifice and allow of the expulsion of the urine. It is possible that there may be fibres radiating from the internal orifice of the urethra, contraction of which help to open the orifice.

Similarly the lower zone of the uterus and the cervix uteri form practically a kind of sphincter muscle of the uterus, and when the expelling or detrusor fibres of the body and fundus of the uterus contract, these sphincteric fibres relax, and the result is that they are stretched or extended by the pressure brought to bear upon the liquor amnii and amnion by the contracting detrusor fibres.

If the amnion is ruptured, then these relaxed fibres are stretched by the presenting part of the child, which is driven down by the pressure from above. In this case the pressure is unequal, and hence is apt to be less satisfactory.

One of the commonest mistakes made by students when asked to state the law of uterine polarity is to say that when the body and fundus of the uterus contract, the lower zone and cervix *dilate*. It is true they are often dilated, but not unless there is something to dilate them. Possibly the radiating fibres may assist in dilating. The law is, that when the body and fundus contract, the lower zone and cervix uteri *relax*, and hence whilst in this state of relaxation they are capable of easy extension, that is, dilatation by an extending force, such as that exerted by the pressure of the liquor amnii on the amnion, or by the pressure of the presenting part.

Nevertheless, it would appear that there is a mechanism whereby

the cervical canal and lower zone of the uterus can be expanded and dilated independently of pressure by the liquor amnii or the presenting part of a child; for it must be the experience of most accoucheurs to occasionally meet with cases where the first stage of labour is completed in the absence of both of these agencies. For instance, I have myself seen the cervical canal completely dilated, and the os uteri expanded and capable of admitting several fingers in a case of hydatid mole before the mole had come down into the cervical canal, and so before it could have exercised any dilating pressure. This is to be explained, I think, by the longitudinal fibres found in the lower zone of the uterus and in the cervix uteri. I have tried to depict in this diagram (Fig. 11) the numerous expelling or detrusor fibres of the uterus which actually expel the child, and also the less numerous longitudinal fibres which run down to the external os. Obviously the contraction of these fibres would tend to open the os uteri and the cervical canal and the lower zone

FIG. 11.—CERVIX UTERI SHOWING HYPOTHETICAL ARRANGEMENT OF CIRCULAR AND LONGITUDINAL MUSCLE FIBRES.

of the uterus quite independently of the dilating wedge of amnion and liquor amnii, or fœtal skull or other presenting part. In sphincter muscles generally there may be radiating muscular fibres to assist dilatation. Should the circular fibres of the lower zone and of the cervix uteri remain in a state of contraction the result is what is known as a *rigid os* and *rigid cervix*, one of the most troublesome things in midwifery. Whether it is due to a flaw in the working of the law of polarity or not has not been determined, but it is very probable, and this may also be the explanation of the condition of 'hour-glass contraction,' or, as the late Matthews Duncan preferred to call it, 'hour-glass relaxation' (*vide* Champneys in *Obstetrical Journal*, 1879-80). Naturally the walls of the lower zone, and of the cervix uteri and of the vagina, become thinner as they get stretched by the child's head. This is seen in Fig. 12.

When labour is over there is a certain amount of elastic recoil, particularly in the vaginal walls, which are much more elastic than those of the uterus. The muscular fibres are apparently paralyzed

for a time, and indeed, as is well known, there is nearly always a certain amount of laceration. After a time, however, they recover themselves, and begin to contract and retract. The circular fibres of the lower (dilating) zone of the uterus contract and retract before those of the cervix.

When labour is obstructed and the uterine contractions are maintained, there is formed a distinct ring of demarcation, which is believed by most observers to represent the place of meeting of the ends of the detrusor or expulsive fibres with the circular relaxed

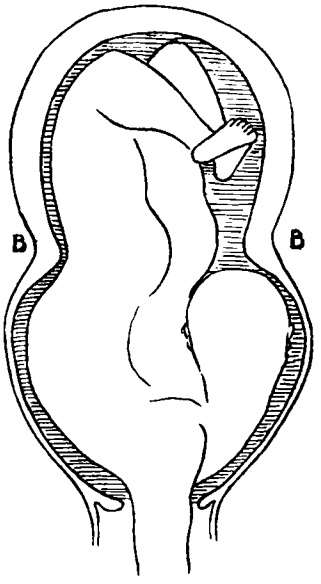

FIG. 12.—SECTION OF UTERUS SHOWING PATHOLOGICAL EFFECT OF RETRACTION IN AN OBSTRUCTED LABOUR.

BB, Bandl's ring.

fibres in the lower zone of the uterus. When well formed this so-called ring of Bandl presents a groove on the surface of the uterus, and a projection within its cavity (*vide* Fig. 12). At all events, the detrusor contracting fibres above the ring contract and shorten as much as they are able to with the child still unexpelled. Hence the walls of the fundus and upper two-thirds of the body of the uterus are seen to form a thick cap over the child (Fig. 12).

A study of the action of the uterus in pregnancy and labour points unerringly to the fact that the fibres are under obedience to certain laws. And a comparison of their actions with those of muscular fibres in other parts of the body leads to the conclusion that the nervous system is intimately associated with the carrying

out of these laws. Many think that parturition is a reflex act. As before mentioned, for a reflex act are required a stimulus, an afferent nerve, a nerve centre, an efferent nerve, and a muscular fibre or other agent. As to the stimulus, it is still a vexed question, but it seems to be most probable that the actual labour pains are brought about by the gradually increasing strength of the painless uterine contractions, associated maybe with gradual relaxation of the sphincter fibres around the internal os, which permits the liquor amnii to force the amnion slightly into the internal os, which causes an irritation of the nerve endings in that neighbourhood. These are the afferent or sensory nerves which carry the stimulus to the nerve centre. This centre is supposed to be in the lumbar portion of the spinal cord, and the stimulus is reflected from this centre down the efferent or motor nerves to the muscular fibres of the uterus, causing those of the fundus and body of the uterus to contract, and those of the lower zone and cervix uteri to relax. Certain it is that parturition can take place during unconsciousness, proving that the will-power is not essential. No doubt voluntary efforts are helpful, but they are not essential, and they could not of themselves expel the uterine contents. Again, in certain paralytic conditions where the spinal cord is diseased so as to cause an absolute loss of both sensation and power below the seat of the disease, it has been found that parturition goes on almost as well as where there is no such disease. Whether it would do so if the nerve connections between the uterus and the spinal cord and the sympathetic nerve system were severed, is an open question. Some think the uterus contains its own ganglia and nerve connections like the heart, and hence it could act quite independently of the general nerve system. Be that as it may, it is quite certain that in ordinary normal labour in a healthy woman the uterus is supplied with nerves which are connected with the sympathetic and spinal systems.

Moreover, we utilize our knowledge of reflex acts when we want to induce labour. The plan recommended in text-books is to pass a bougie into the uterus between the membranes and the uterine wall. This acts as a stimulus, and the irritation causes the uterus to contract by reflex action. If the stimulus be applied in the neighbourhood of the internal os, the reflex act is more speedy and certain.

It was for this reason I advocated the use of small indiarubber bags fixed on the end of a gum-elastic catheter, and introduced just within the uterus, so as to be close to the internal os, and then filled with fluid, with the object of inducing miscarriage or labour. The

nerve-endings are irritated, and so reflex uterine contractions ensue, and by the time the little bag is expelled the bag of waters (liquor amnii) has descended, and so labour is carried on in the natural way. I have tried many different fluids, such as diluted carbolic acid, perchloride of mercury, boracic acid solution, lysol, etc., but the most potent in speed and certainty is a solution of tincture of iodine in the proportion of 2 drachms to 1 pint of water. On the reflex theory, this is only what might have been expected, because tincture of iodine is a very penetrating and irritating fluid, and one generally finds that the contents of the little bag are quite colourless when the bag is expelled, showing that the iodine has somehow escaped or has been neutralized. Moreover, the onset of uterine pains is much quicker when this solution is used.

Again, if one considers for a moment the progress of labour, one sees that at first the nerve-fibres about the internal os, the lower zone and cervix uteri, are irritated, and the resulting pains are of a certain magnitude. Then, when the head of the child is expelled into the vagina, one has, in addition, the nerve-endings in the vagina irritated, with a consequent increase in the strength of the reflex muscular contractions, and at last, when the perinæum is stretched, and the vaginal orifice widely dilated, one gets the sensory nerves of these parts stimulated, and so there is a mighty result in the strong expulsive uterine contractions so characteristic of that stage of labour. The afferent impulses increase in number as the child's head descends, and as a consequence the reflex act—that is, contraction of the expulsive fibres and relaxation of the sphincteric fibres—correspondingly increase. Possibly a time will come when we shall be able to regulate uterine contractions and relaxations as easily as switching on and off an electric light, but if ever that time comes, it is to be hoped there will come with it an adequate knowledge of when it is necessary or justifiable to set these fibres into action, or to cause them to relax.

When one studies the action of muscular fibre, and the laws which govern its action, and the structure and arrangement of the fibres in the uterus, and all the mechanism concerned, one sees how greatly superior Nature's method is to any artificial plan yet invented. Consider, for instance, the method adopted by Nature in completing the first stage of labour, or dilatation of the os uteri and cervical canal. In the first place, the force used is water-pressure; secondly, whilst the pressure is brought into play, the fibres which have to be stretched are at the same time physiologically relaxed; thirdly, the pressure is intermittent; fourthly, the force of the pressure gradually

increases in amount. Compare this with the best method we know for artificially dilating the same parts—namely, a Champetier de Ribes bag. Certainly it is water-pressure, but whilst it is in action we have no means of relaxing the fibres to be stretched. Not only so, but the pressure is constant, and as the fibres yield it gradually lessens in amount. It is best to imitate Nature's plan as nearly as possible, viz., to occasionally let the fluid out of the bag, in order to give the parts a rest, then to inject rather more fluid than before, in order to exert more pressure, and to make up for the amount of yielding or stretching that the fibres have already undergone.

As a summary, the following points may be stated:

1. Contraction of a muscle is generally, but not always, accompanied by an approximation of its two ends.

2. When a muscle is shortened to its fullest extent, it can relax or contract without becoming longer or shorter.

3. When a muscle contracts, it is unable of itself to return to its former condition; some other muscle or force is required to pull it out or extend it.

4. When a muscle contracts, and then simply relaxes, it is in a condition called retraction.

5. Retraction is the condition of a muscle which having been shortened by contraction, the active contraction has given place to simple relaxation without extension.

6. In a state of retraction there is a slight and constant contraction called tone.

7. Retraction may be partial or complete, according to the amount of preceding contraction. If the muscle has contracted to its fullest extent before relaxing, the retraction is complete; if anything less than its fullest extent, it is only partial.

8. Retraction of the uterus in labour affects only the expulsive fibres of the fundus and upper two-thirds of the body of the uterus. It keeps the sinuses and broken bloodvessels of the placental site closed, and is therefore of the greatest importance.

9. After the third stage of labour, the uterus sometimes is in an active state of contraction, when it is more or less spherical, and feels hard and well defined in outline, and sometimes in a state of relaxation, when it is less spherical, softer, and not so defined in outline; but such a condition is quite normal, and in no way indicative of danger.

10. Labour pains are in all probability reflex acts.

11. The less they are interfered with the better.

12. Complete retraction of the uterus is the safest condition for the prevention of post-partum hæmorrhage.

13. Complete retraction is obtained by complete contraction followed by relaxation.

14. The law of polarity, as applied to the uterus, is that when the expulsive fibres contract the sphincteric fibres relax, and permit themselves to be stretched or extended.

15. The cervical canal can be opened up apart from pressure from within, and this is accomplished probably by relaxation of the circular fibres, and contraction of the longitudinal fibres in the cervix and lower zone of the body of the uterus.

16. The painless uterine contractions taking place during pregnancy are not followed by retraction, because the fibres are stretched out again by the hydrostatic pressure of the liquor amnii.

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