4

ANATOMICAL

AND

PHYSIOLOGICAL OBSERVATIONS.

(*Continued.*)

DR JOHN STRUTHERS.

XVII.

ON JUGULAR VENESECTION IN ASPHYXIA,

ANATOMICALLY AND EXPERIMENTALLY CONSIDERED,

INCLUDING THE

DEMONSTRATION OF VALVES IN THE VEINS OF THE NECK.

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THE question, whether resuscitation can be assisted by jugular venesection, has not received that attention which it deserves. The practice has been looked on as preferable to venesection at the arm, as, perhaps, also affording special relief to the brain; but the true principle on which it has been proposed does not seem to have been generally appreciated. This may be in part due to the fact, that the proposal has as yet only a physiological foundation, from experiments on the lower animals. That similar relief would or could follow in man, has not been yet demonstrated.

The practice can be useful chiefly, if not entirely, by regurgitation, on the principle of disgorging the right side of the heart. In asphyxia, the action of the pulmonic heart is arrested by distension, is paralysed by this mechanical cause, which remains, or may remain, notwithstanding artificial respiration, unless relieved by regurgitation.

The experiments of Drs Reid,[1] Cormack,[2] and Lonsdale,[3] satisfactorily show—1, That in animals—dogs, cats, and rabbits—the right side of the heart may be disgorged by jugular venesection; and, 2, that the effect of this is to increase the action of the heart

[1] On the Effects of Venesection in Renewing and Increasing the Heart's Action under certain circumstances.—*Edin. Med. and Surg. Journal*, 1836.

[2] *Treatise on Creosote* 1836—*and Inaugural Dissertation on the Entrance of Air into the Organs of Circulation*, 1837.

[3] An Experimental Inquiry into the Physiological Action, etc., of Hydrocyanic Acid.—*Edinburgh Medical and Surgical Journal*, 1839.

when it had become feeble, or to renew it when the action had altogether ceased. The animals in these experiments, had been previously killed, or all but killed, variously, by hanging, by blows on the head, by poisonous doses of hydrocyanic acid, creosote, strychnia, and by injection of air into the veins. The principle of relief is the same in all these circumstances; whether, as in asphyxia, the heart has been distended by impediment at the lungs, or whether, as in the case of the poisons, it has become engorged during its temporary arrest under the action of the poison; or whether it has simply become mechanically distended by the air—in all there is the mechanical distension to be got quit of by regurgitation.

In these experiments, it was found, first, that the exposed pulmonic heart, although pricked and scratched with the knife, will not act, but as soon as the auricle, or one of the great veins, is punctured, allowing the blood to escape, the auricle and ventricle become emptied or relaxed, and spontaneously resume their action. Then, by farther experiment it was found that the same object could be accomplished by jugular venesection. For the details of these experiments the reader is referred to the above mentioned papers, especially to that of Dr Reid, which, together with masterly articles on asphyxia and on the entrance of air into the veins, may be consulted in his volume of collected papers.[1] The object of my paper is to inquire, through anatomy and experiment, whether these results, obtained by experiment on the lower animals, are attainable on the human subject, or likely to be so. The circumstances on which the successful result depends may not be similar. In the animals mentioned, the external jugular vein is relatively much larger, being the principal vein of the neck. And again, do valves offer any obstruction to regurgitation in man?

Let me first say that it has long been well known that the right ventricle may disgorge itself backwards into the auricle. This was demonstrated by the late Mr T. W. King,[2] in an able and complete paper, entitled "On the Safety-valve of the Human Heart." Mr King showed, by injecting water down the aorta and pulmonary artery—1*st*, That the mitral valve acts perfectly, and, even in the distended state of the left ventricle, prevents regurgitation; and 2*d*, That the tricuspid valve allows of free regurgitation, in a flat or

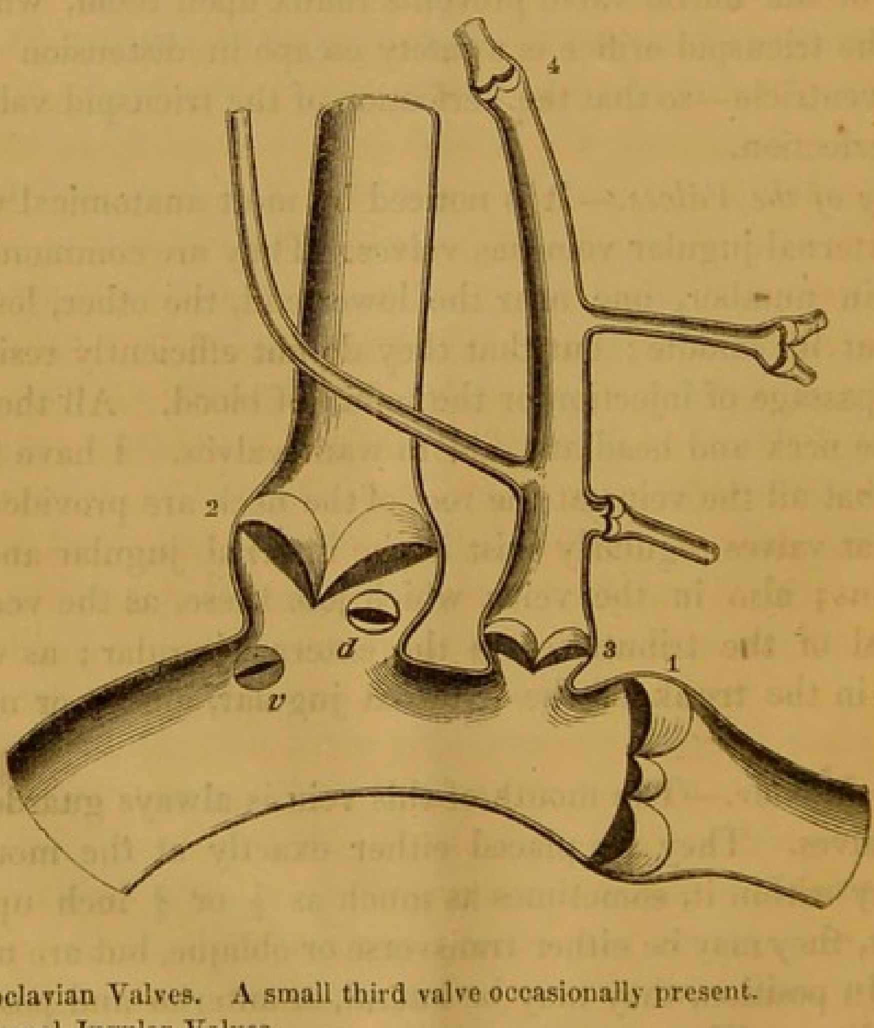
[1] *Physiological, Pathological, and Anatomical Researches.* Edinburgh, 1848.
[2] *Guy's Hospital Reports*, 1837.

tape like stream; and this in all conditions of the ventricle, but more especially when it is distended. The conditions of the living and dead hearts no doubt are not similar, as muscle is concerned in the action of the living valves; but the distended and paralysed condition of the pulmonic heart in asphyxia reduces it very much to the condition of the heart in Mr King's experiments, which at any rate show satisfactorily that the tricuspid is a less complete valve than the mitral, especially in the distended state of the ventricle, and will allow of regurgitation sufficient to relieve the ventricle. The same occurs in the lower animals; and it is well known to all experimenters, as Dr Reid particularly remarked, that when the veins or right auricle are punctured, the distended right ventricle at once empties itself backwards into the auricle. This is evidently a double provision of nature for the protection of the lungs; the perfection of the mitral valve prevents reflux upon them, while the reflux at the tricuspid orifice is a safety escape in distension of the pulmonic ventricle—so that the perfection of the tricuspid valve lies in its imperfection.

Anatomy of the Valves.—It is noticed by most anatomical writers that the external jugular vein has valves. They are commonly said to be two in number, one near the lower end, the other, less constant, about its middle; but that they do not efficiently resist the backward passage of injection or the reflux of blood. All the other veins in the neck and head are said to want valves. I have found, however, that all the veins at the root of the neck are provided with valves; that valves regularly exist in the internal jugular and subclavian veins; also in the veins which join these, as the vertebral and several of the tributaries to the external jugular; as well as constantly in the trunk of the external jugular, and at or near its mouth.

Internal Jugular.—The mouth of this vein is always guarded by a pair of valves. They are placed either exactly at the mouth or a little way within it, sometimes as much as $\frac{1}{2}$ or $\frac{3}{4}$ inch up. In attachment, they may be either transverse or oblique, but are usually oblique. In position, they may be lateral, or anterior and posterior, or intermediate. They are most commonly oblique, with a position chiefly lateral, the posterior horns meeting at the posterior and inner part of the mouth, while the anterior horns stretch upwards and outwards to their point of meeting. One may be larger than the other, and occasionally there is a frænum at one end, formed by the confluence of the anterior horns, giving somewhat the appearance of one large valve. Various anatomists have noticed a dilatation or ampulla at the lower end of the internal jugular vein immediately above its termination, and M. Cruveilhier states that "this oblong dilatation in some asthmatic persons is very large," but the reason for it, in the existence of valves, does not seem to have been noticed. All valves have a sinus, as necessary to their mechanical action, on the same principle as the sinuses of Valsalva at the aortic valves. The occasional swelling, noticed by Cruveilhier, will be the natural result of regurgitating force in obstructed respiration.

Subclavian.—This vein is always provided with valves at about an inch from its termination, and immediately external to the point of entrance of the external jugular. Like those of the internal jugular, they may be transversely or obliquely attached; or in position,



1. Subclavian Valves. A small third valve occasionally present.
2. Internal Jugular Valves.
3. Lower or Terminal Valves of External Jugular.
4. Higher or Trunk Valves of External Jugular.

d. Occasional Valves across Entrance of Thoracic Duct.

v. Valves across Mouth of Vertebral Vein.

Valves are seen in the posterior tributaries to the external jugular, but none in the anterior jugular, which joins it from before.

either anterior and posterior, or superior and inferior; but they are most frequently transverse and placed one before, the other behind. When oblique, they are usually superior and inferior, the posterior horns, long and pointed, reaching inwards as far as opposite the mouth of the external jugular, the anterior horns attached farther out, and sometimes meeting in a frænum, and giving the appearance of one large valve or partial diaphragm. When transversely fixed, they are generally anterior and posterior. The arrangement of the parts of this valve varies much; there may be two of equal, or of very unequal size; or there may be three, or the appearance of one only. The appearance of one only may be due to a broad frænum uniting the anterior horns of two obliquely placed flaps, or to the anterior flap or valve having been divided in slitting the vein, as is very apt to happen. Every one who has been accustomed to slit veins in search of valves, knows how readily a divided valve is apt to be overlooked, although a careful examination at the horns usually shows the remains of the divided flap. When of unequal size, the larger is a posterior transverse valve, with a very deep sinus, the valve being large and loose enough, when floated up, to close the vein. This is not to be confounded with two oblique valves confluent at one end, both sinus and valve being differently placed. Occasionally a third valve or flap occurs here, smaller than the other two, and placed between the posterior horns of two transverse or oblique flaps, which may or may not be united by a frænum at their anterior attachment. The sinus of this little valve may be very deep. A valve across the entrance of a small vein or divided thoracic duct near the subclavian valves, must be distinguished from a true third flap. The occurrence of three valves is said to be rare in the human veins; I have seen it only here, and in two subjects, in one of which it was present on both sides. Here, however, one of the valves in each case was diminutive. A similar condition may occur at the aortic valves, apparently from arrested growth of one of the three.[1]

Whatever the variety, there is constantly an efficient valve in the subclavian vein, placed immediately external to the entrance of the external jugular. This valve therefore checks regurgitation towards the arm, but not along the external jugular. It is the only one contained in the subclavian vein, nor are there any in the axillary until usually opposite the lower edge of the subscapularis muscle, after a

[1] See the paper on Malformation of the Semi-lunar Valves of the Heart *Anatomical and Physiological Observations*. Part I. P 109.

distance of about five inches, where a double valve is constant, and another may occur soon, between this and the commencement of the humeral vein proper. A valve of one or of two flaps, generally exists at or within the termination of the cephalic and subscapular veins in the axillary trunk.

External Jugular.—As generally mentioned by authors, this vein has valves at two parts—in its course and near its termination. There are always two pairs, in one subject only have I found three pairs. By pair of valves, I mean a valve consisting of two distinct portions. The first pair (lower or terminal) guard the mouth of the vein, placed either exactly at the mouth, or a little way within it, but sometimes half an inch up. They may vary, as usual: be either oblique or transverse; sometimes placed antero-posteriorly, sometimes laterally. When at the mouth, and oblique, the posterior horn is the lowest, and may run down a little into the subclavian, while the anterior horns meet some distance up the vein, and may be confluent in a frænum. The external jugular vein terminates in the subclavian usually about $\frac{1}{2}$ to $\frac{3}{4}$ inch from the commencement of the brachio-cephalic. The subclavian valves are never placed internal to the jugular opening, so that the valves of the external jugular itself offer the only check to regurgitation along this vein. Only once have I found the external jugular end in the internal jugular; it was close to its lower end, guarded as usual by a pair of valves, and the internal jugular valves were shifted up a little so as to be placed above the entrance of the external jugular. On the other side of the same neck, the external jugular ended in the subclavian as usual.

The other valve is placed in the course of the vein (higher or trunk valve) below the middle of the neck, usually at about $1\frac{1}{2}$ inch above the clavicle; after the vein has crossed the posterior border of the sterno-mastoid, but it may be while it still lies on the back part of the muscle. This deserves attention in determining the point for venesection if regurgitation is desired. Regurgitation will usually occur freely from an opening below, but not above this valve. When the whole vein has been dissected and stretched, this valve appears as if higher up the neck, but in the natural position of the vein, it is usually not more than the $1\frac{1}{2}$ inch above the clavicle. It forms the upper limit of the large part of the vein which some have called its sinus. The vein is seen to swell up to this point, and then regurgitation is more or less arrested; and when the vein is naturally distended in the living body, it appears large for about an inch above the clavicle. This is not, however, a sinus proper; it is merely the commencement of a large part of the vein, which here receives several large tributaries from behind, the *transversales colli* and *humeri*, and other smaller veins; and this increase in size goes on as the vein proceeds downwards and inwards to end in the subclavian. In some old subjects, this part of the vein appears very much distended, compared with the part above, the terminal valves allowing of regurgitation and dilatation, which is checked above by the second pair of valves. This trunk valve I have always found to be a double one, although one is apt to be slit and escape notice, the two flaps being attached either obliquely or transversely, and sometimes lateral, sometimes antero-posterior.

When the vein is divided into two, as not unfrequently occurs, then both divisions are guarded by a pair of valves, at or a little way above the point of division. The larger tributaries to the external jugular are also provided with valves; except the anterior jugular in which, though sometimes a large vein, joining the lower part of the external jugular, I have never been able to find valves. The two principal posterior tributaries to the external jugular,—the *transversalis colli*, joining a little way above the clavicle, and the *transversalis humeri*, joining behind the clavicle,—have valves; either a single fold or a pair at their termination, or half an inch to an inch along, where their divisions may be guarded by single crescentic valves.

The only instance in which I have met with three successive pairs of valves in the external jugular, is that referred to in experiment IV. The usual trunk valves existed above the lancet opening; they could not be very satisfactorily examined on the left side, but on the right side, the vein had divided, and each division had its valve. On both sides below the lancet opening, there were two pairs of valves, one terminal or nearly so, the other about $\frac{3}{4}$ inch higher up.

In one subject only have I found valves in the higher veins of the neck; on one side, a pair in a large communicating branch between the external and anterior jugular veins; on the other side, a pair in the anterior jugular, where it terminated early in the internal jugular about the middle of the neck. I have not, however, examined the higher veins so frequently or with so much interest as those at the root of the neck.

The *vertebral* vein is also guarded by a pair of valves, or by one large crescentic valve at its usual termination in the back of the early part of the brachio-cephalic trunk; the valves being generally at the mouth, but sometimes a little way within the vein. These, and valves across the occasional termination of other small veins near the junction of the subclavian and internal jugular trunks, must not be mistaken for lymphatic valves. The *thoracic duct*, I have found usually to enter just at the root of the internal jugular vein, almost in the sinus of one of the internal jugular valves, though not covered by the valve, and to be without valves at its very mouth. The duct has a funnel-like opening, and when this contracts into the duct proper, the first valve or valves are seen and catch the probe. I have, however, seen very distinct valves across the mouth of the duct, though still somewhat sunk in a depression; the upper considerably larger than the lower; not forming valves with sinuses like those of the veins, and like the succeeding valves of the duct, but more transversely placed, though still capable of closing the duct, like the two flaps of the ileo-colic valve on a small scale, but without fræna. The duct may enter divided, one near the internal jugular, the other near the subclavian valves, and in such a case I have found both lymphatic orifices to be without valves.

It now remains to be seen whether, notwithstanding the obstacle presented by these valves, fluid will regurgitate by an opening in the external jugular vein, so as to unload the right side of the heart.

With this view I performed the following experiments.

A pipe was introduced into the femoral vein, and tepid water was thrown freely upwards by a syringe. The effect of this would be, to fill the venous systems of the abdomen and thorax, and the right side of the heart and pulmonary artery, as in asphyxia; and, when these parts became distended, there would be the tendency to regurgitation upon the veins of the neck. As the experiments proceeded, we continued to throw in the fluid at the groin, and moderate force was exerted by the syringe so as to imitate the over-distended condition of the veins in asphyxia.

The points to be noticed were—whether the external jugular veins became distended; if so, whether from above or from below; and whether, when the opening was made, the fluid would regurgitate. The subsequent dissection of the veins will be also noticed, as the result might have been influenced by variety of connection, or by position of valves.

Experiment I.—On a young female subject. The right external jugular vein was laid bare, about an inch above the clavicle. Soon after the fluid was thrown in at the groin, the vein became distended, and appeared large. The vein was pressed at the middle of the neck, and then emptied downwards. It immediately filled again from below, evidently by regurgitation.

I now opened the vein at about an inch above the clavicle. The fluid came freely, not in a jet, but in an active stream across the neck. By renewing the injection at the groin, the same result followed. The flow became more active when pressure was made on the abdomen, or across the root of the neck.

On dissection I found a pair of well formed lateral valves at the mouth of the external jugular at its opening into the subclavian; the opening was about two inches up from these, and half an inch above it, the vein divided into two, each being guarded by a pair of valves. The opening was thus made between the high and low valves, and the fluid had overcome the latter.

Experiment II.—An aged male subject. The external jugular vein speedily became distended on both sides. The distension at first ceased at about an inch and a half above the clavicle, but soon the entire vein became distended, previous to which the internal jugulars were seen to rise.

The vein (external jugular) was now emptied upwards by pressure, and immediately became again distended by downward flow. It was next emptied downwards, and did not again fill, higher than the sinus, as long as pressure was kept on above. It was the same on both sides. The right appeared larger than the left.

The right vein was now exposed, tied with a ligature, and opened below the ligature, an inch above the clavicle. At first the fluid spouted out with force, and then came as an active stream running across the neck. In order to ascertain how much fluid would flow spontaneously, the wound was closed until the veins were re-distended from the groin. On letting go the opening, $1\frac{1}{4}$ oz. of fluid flowed spontaneously. After it had ceased, the flow was renewed by pressure on the chest and abdomen.

The vein was now tied below the opening, and another opening made above the first ligature. The fluid being again thrown in at the groin, the internal jugulars rose, and the fluid, descending the external jugular, flowed freely from the upper opening.

On removing the lower ligature, the fluid again regurgitated in an active stream. It could not however, be made to spout. Even although the lips of the opening in the vein were held aside with forceps, the fluid still came, as if overcoming obstruction, with a wriggling motion, flowing over the neck in an active stream.

To ascertain, whether this impediment arose from the valves, I now introduced a catheter. The catheter was passed down into the subclavian vein, and thence to the vena cava and right auricle. It is not difficult to pass a catheter to the heart, if the proper direction be attended to. The fluid now came through the catheter, as freely and forcibly as in relieving a distended bladder. No fluid came until the catheter had passed, as we supposed, to the subclavian vein ; the effect of the valves was evident ; when the catheter was withdrawn to a certain point, the fluid came slowly and with little force ; but as soon as the catheter passed this point, the fluid again poured out in an active stream. No advantage was gained by passing the catheter farther ; as there are no valves between the termination of the external jugular and the heart, it is enough if the catheter has entered the subclavian or innominate vein.

On dissection, a pair of oblique valves, placed laterally, were found in the trunk of the vein, about an inch above the lancet opening ; and midway between the opening and the mouth of the vein, a pair of large transverse valves, anterior and posterior. A very large anterior jugular vein opened into the external jugular immediately above these valves. Thus, the regurgitating fluid had either overcome the inferior pair of valves of the external jugular, or had entered above these valves from the anterior jugular, in which case, however, it must previously have overcome the valves at the mouth of the internal jugular, from which the anterior had become filled. The three jugular veins all communicated freely at the upper part of the neck.

Experiment III.—On an aged male subject. Soon after the fluid began to be thrown in by the femoral vein, all the jugular veins became distended, the internal apparently first. The external jugular filled by regurgitation up to the top of its sinus, about 1½ inch above the clavicle; the higher part of the vein became filled by a descending current.

An opening was made with the lancet, as in venesection, into the right external jugular, an inch above the clavicle. The blood spouted out freely in a jet, for a little, and then continued to run actively and freely across the neck, in a large stream.

To ascertain how much of this came from above, a ligature was applied above the opening, and a second opening made higher up. From this orifice the fluid also flowed freely, but the stream was smaller.

I now tried the effect of introduction of the probe and catheter towards the heart. The probe was introduced, and held so as to push aside one of the valves, but this had little effect in increasing the regurgitating flow. As soon as the catheter passed into the subclavian, the fluid came by it in an active jet, as from a distended bladder; but as soon as the catheter was withdrawn a little, so as to be within the external jugular, the flow through the instrument ceased, and the fluid came in moderate quantity by the side of the catheter. This was repeated several times.

I may remark that some difficulty was experienced in this case, in the introduction of the probe and catheter, first at the orifice, and then in passing them on to the heart; but after I understood the proper direction in which to pass them—viz., obliquely inwards and downwards, and also backwards, as if deeply behind the head of the clavicle, they passed easily.

The external jugular on the right side was now tied, and the experiment repeated on the left side. More fluid was thrown in, and the left external jugular became distended. An opening was made with the lancet, as on the right side, at the upper part of the sinus, as in performing venesection on the living body. The fluid gushed out actively, first springing, and then flowing over the neck. It was received into a measure jar, and two ounces escaped (a quantity fully equal to the capacity of the natural auricle or ventricle). This escape was free and spontaneous, due alone to the elastic reaction of the distended veins and heart, as the injection at the groin was discontinued before the lancet opening was made. By pressure on the chest and abdomen, other two ounces escaped. We saw that here commenced the danger of entrance of air into the veins; that as long as they were allowed to empty themselves spontaneously, the air could not enter, as they were occupied by regurgitating fluid; but that if artificially emptied by forcible compression of the chest, the removal of this compression was apt to suck in the air.

Before opening the jugular, the experiment of opening a vein at the elbow and axilla was tried. No fluid whatever escaped by the opening in the median-basilic vein; and although the axillary vein seemed partially distended, and a little fluid escaped by the opening made opposite the conjoined tendon, yet an active stream could not be obtained. This shows that bleeding from the arm can be of no use whatever on the principle of regurgitation; the only principle on which it could have been expected to be useful.

I had not the opportunity of making a satisfactory dissection of the external jugulars in this subject. The termination of the left vein was, however, examined, and found to be provided at its mouth with the usual pair of valves, transversely placed, anterior and posterior. The right axillary vein was examined, and presented only one pair of valves above the lancet opening, placed at the upper edge of the conjoined tendon. These valves, along with the pair of subclavian valves, which existed as usual, had therefore prevented regurgitation to the opening in the axillary vein; while the one pair of valves at the mouth of the external jugular had allowed of free regurgitation.

Experiment IV.—On an aged female subject. The cranium had been opened for the removal of the brain, and the fluid, thrown in at the groin, poured freely out at the cranial sinuses, and also at the foramen magnum. Although we endeavoured to plug the cranial sinuses, the fluid still flowed there. The external jugular veins could not be distended, the right became slightly so, the left not at all. By pressure with the finger the fluid in the right jugular could be made to pass readily up, as if there were no trunk valves. We attributed the non-descent of the fluid in this case, as well as our inability to distend the jugulars by regurgitation, to the free outlet at the cranium.

An opening was made with the lancet in the lower part of the right external jugular. No fluid escaped, although thrown freely in at the groin. A free escape continued from the cranial sinuses.

The probe and catheter were now tried. The introduction of the probe into the subclavian, held so as to lift aside a valve, was followed by a free escape of fluid, not in a jet, but wriggling out in an active stream, as occurred in the previous experiments without the probe. This flow stopped immediately and completely when the probe was withdrawn. The catheter was now introduced, and easily passed to the vena cava. As soon as it entered the subclavian, the fluid came by it as freely as from a distended bladder; but ceased completely when the catheter was withdrawn from the subclavian.

It is necessary in these experiments to guard against obstruction from clots of blood. They may fill the eye of the catheter, and also obstruct the opening in the vein, as occurred in this experiment. After these were removed, a little fluid came spontaneously, but very little. This obstruction by clots applies, of course, only to experiment on the dead subject.

We inferred from this experiment that regurgitation by the external jugular vein will not take place unless it is distended, so as to overcome the action of its terminal valves, the distension being, in this experiment, prevented by the open state of the cranial sinuses. The free escape from these showed, however, that the fluid had regurgitated past the pair of valves at the mouth of the internal jugulars; and on dissection we found a more sufficient reason for non-regurgitation by the external jugulars, in the presence of two pairs of valves between its mouth and the lancet opening. In this case, then, the external jugular had three successive pairs of valves. The lowest at the mouth, or a little within it, as usual; the next midway between these and the lancet opening. The fluid, therefore, had been unable to overcome the second pair of valves; but came freely as soon as the probe was introduced to hold them aside.

Resuscitating means must be founded on a clear understanding of the physiology of asphyxia. We know that, in asphyxia, dark blood at first passes through the lungs, and is circulated in the arteries, as Dr Reid's experiments show, with undiminished force. And that, as the result of this, under the influence of venous blood, or from want of the stimulus of arterial blood, the functions of the cerebrum, and afterwards those of the medulla oblongata, become suspended. It is for this reason that after only a short immersion in the water, respiration does not recommence although the lungs and air are restored to their natural relation; the brain is poisoned, is unaware of the state of the lungs, and does not perform the respiratory movement. But this consideration need not influence our treatment of asphyxia, farther than reminding us that it is only after continued artificial respiration that a current of arterial blood can be sent to the brain,—that we must therefore persevere with artificial respiration with the view of arterialising the brain, and that when this is accomplished, but not sooner, the natural movements of the chest will commence.

Shortly after the functions of the brain are suspended, the second cessation of the vital actions occurs in the arrest of the pulmonary circulation. The proximate cause of this stagnation is not evident or demonstrable. It is not simply or mechanically due to cessation of the movements of the chest, for these movements have been arrested from the very beginning, and Dr Alison has shown that in animals confined in nitrogen, and breathing up to the time when they were suddenly killed, the same arrest of the pulmonary circulation takes place. Whether this arrest is due, as Drs Alison and Reid suppose, to the cessation of the chemical changes, when the supply of oxygen previously in the air cells is at length exhausted, or as Mr Erichsen and others suppose, to spasm of the capillaries, matters not in a practical point of view. The facts will suit either theory, and the practical consideration is, that before the circulation can be renewed, the respiratory function must be renewed by getting the poisoned air out and fresh air in. The great resuscitating means to which anatomy and physiology point is artificial respiration. This, in the first place, renews the function or chemical changes in the lungs, setting loose and restoring the pulmonary circulation,—second, it at length furnishes a supply of arterial blood for the brain,—and third, it tends to relieve the right side of the heart—the latter in two ways, by removing the obstruction at the pulmonic capillaries, and, as in an ordinary and still more in a forced expiration, as Dr Reid's experiments show, by mechanically forcing on the blood.

The remaining indication in the treatment of asphyxia, is specially to restore the action of the heart. The stagnation at the lungs produces accumulation of blood in the right side of the heart, distending and at length paralysing it, the action of the heart continuing a short time after respiration has ceased. It may be asked, Why does restoration not quickly follow well performed artificial respiration, after a short immersion? The natural relation between the lungs and the air has been restored, and respiration is going on. All that would seem to be now wanting is the forcing power of the heart to drive the blood onwards ; but the pulmonic heart is paralysed by a mechanical cause, which, unless removed by regurgitation, must or may render fruitless all attempts at resuscitation.

In regard to this important indication I infer, from these experiments on the human subject, and from the general view I have presented of this inquiry—1, That it is generally possible to disgorge the right side of the heart by jugular venesection; and 2, That there is every reason to believe that jugular venesection will prove a useful means in resuscitation.

In jugular venesection under other circumstances we make pressure below the opening, and the blood flows from above. This proceeding is to be regarded as a general bloodletting, as in bleeding at the arm, and in addition, as a local bloodletting to the head; as a more direct and rapid means of relieving congestion of the head generally, and pressure on the brain from venous obstruction. In asphyxia, jugular venesection may possibly be useful on this principle also, as well as on the much more important principle of regurgitation; but it is to be borne in mind, as my experiments show, that the blood which comes from above may still be a regurgitating current from the internal jugular, on account of the very free communication which always exists at the upper part of the neck between the various jugular veins of the same side, enabling injections to pass readily from one to the other.

There is one danger attending this procedure—that of entrance of air into the veins. This accident is especially apt to occur at the root of the neck, where the veins do not collapse easily, but are kept open, or "canalised," by their relation to the bones; so that, during the act of inspiration, air is very liable to enter. To leave a wound in the external jugular vein in an open condition during the performance of artificial respiration, would therefore place the patient in very dangerous circumstances. It is, however, evident that air cannot enter as long as the veins are distended or full. The danger then may be obviated by closing the wound as soon as the blood ceases to regurgitate actively. Recollecting that our object is not to empty, but only to relieve the over-distension of the auricle and ventricle, the escape, by regurgitation, of even 1 oz., should afford very material relief. As, however, part comes from above, the safe plan is not to close the wound until the blood ceases to flow actively.

In conclusion let me state precisely what I recommend in regard to jugular venesection.

We know that in the great majority of the drowned, although the body is early recovered from the water, the vital actions have ceased; that means of rescuscitation are usually continued for perhaps an hour or more; and that the means commonly had recourse to, after stripping and drying the body, are warmth and friction, and attempts to restore respiration by artificial means, or by galvanism.

I would recommend jugular venesection to be performed *as early as possible;* that the vein should be opened at about an inch above the clavicle; that the veins be simply allowed to disgorge themselves; and as soon as the active flow ceases, not waiting too long, that the wound should be carefully closed, and artificial respiration immediately commenced.

With regard to assisting the regurgitation, I would not be disposed to interfere if the blood came with even moderate freedom. If it did not, it might then be advisable to introduce a probe, or blow pipe, or instrument like a female catheter, and slip it gently in the direction already mentioned, for about a couple of inches. If this be not succeeded by a regurgitating current, then abandon the procedure, and close the wound. The patient has had all the chance which the surgeon can give of the benefit which I believe jugular venesection will generally confer.

5.

XVIII.

DEMONSTRATION

ON THE

USE OF THE ROUND LIGAMENT OF THE HIP JOINT.

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PREVIOUS WRITERS have erred regarding the use of this important ligament, from not employing a right method. By removing more or less of the capsular ligament, they destroyed a structure which naturally prevents several motions from going so far as to put the round ligament on the stretch. They have therefore attributed to it uses which it has not; while, from not seeing it in its natural position, they have unavoidably failed to recognise its true use.

If we sit down to examine it in a preparation in which the capsular ligament has been completely divided, the matter becomes extremely puzzling, and we hardly wonder at the conclusion of our own time-honoured Dr Barclay, that the use of the round ligament seemed "the restoring the head of the bone to a right direction, when it had partially quitted, or was disposed to quit, the cavity of the acetabulum, and the maintaining it in that direction, so as to replace the head of the femur readily in its socket, under a variety of circumstances." On further examination, we might agree with Mr Mayo, that it checks rotation inwards; next with Dr Knox, that it checks all the rotatory movements, simple or combined. Then, on considering the anatomy of the ligament, and G. and E. Weber's remarks and drawing, we might be persuaded that these anatomists had finally proved the correctness of the view of various previous writers, that this ligament checks adduction. The more so, as the Webers' plausible theory is, that by checking adduction, the ligament serves, when we stand on one leg, to balance or keep up the trunk, preventing it from falling over to the unsupported side. But, when we consider that the trunk can be bent over laterally to a considerable extent, by a movement of adduction, and reflect that this is naturally prevented by the abductor muscles, we shall finally be inclined to agree with Dr Knox's more recent opinion, expressed in his Manual of Anatomy, that "the functions of the round ligament have not been satisfactorily determined."

It occurred to me to expose the ligament from behind, by removing the floor of the acetabulum, while the capsular ligament was left entire. The round ligament could now be seen in its natural position; and, by putting the joint through its various motions, the condition of the ligament in each became a matter of simple demonstration. I found that it is not tight either in adduction, or in rotation, inwards or outwards, all of which are checked by parts of the capsular ligament; and, that it is rendered tight in one position only, viz., when rotation outwards is combined with flexion.

I now proceed to show, more particularly, that the use of the round ligament is to check this combined movement.

How to expose the ligament.—With a gouge and mallet remove the bone from the greater part of the space between the obturator foramen and the great sciatic notch, as seen in fig. 8. The cut should reach upwards, so as to encroach upon the horizontal ramus of the pubes, and beyond the ilio-pectineal line; approaching as near as to about a quarter of an inch from the obturator foramen, where care should be taken to avoid injuring the origins of the round ligament, which lie opposite rather more than the upper or anterior half of the obturator foramen. The opening should become smaller and rounder as it approaches the acetabulum. The bone is very thin opposite the ligament, but so thick behind and above, that a sloping cut is required. The fatty tissue and synovial membrane, forming the Haversian cushion, being picked away, the round ligament will be exposed down to near its origin. Any loose synovial or fatty tissue on its surface may be removed, so as to expose the fibres of the ligament proper.

It is now evident that the ordinary direction of the ligament is vertical; I mean, when the limb is straight, as in standing erect, or as the body lies on the table. Also, that the ligament, in the greater part of its length, is of a rounded form, soft or pulpy, and more or less twisted, except in that position which tightens it, when it assumes the form of a straight-fibred thick belt.

The *depression on the head of the femur* is not simply a pit for the insertion of the ligament. Draw two lines across the middle of the head, as in fig. 2, and it will be seen that the pit is situated in the lower and posterior quarter, but only a little behind and below the centre. The form and direction of the pit may be now observed; that it is elongated, or ovoid, and that the long axis is directed horizontally backwards, or backwards and a little downwards. Amid some varieties as to size and depth, the above will be recognised as the typical form, if a series of thigh bones be examined, especially before the cartilage is removed or dried, the pit being usually larger in the natural state than in the macerated bone. Also, that its posterior termination becomes shallower and rounded off at the edges. The ligament is not attached across the breadth of the pit, but only to its anterior end, the posterior part being a groove, now seemingly directed away backwards from the ligament, but intended to lodge it during its action. The anterior part we may distinguish as the *pit*, the posterior as the *groove*.

The cushioned *recess in the floor of the acetabulum*, varies a good deal in form, size, and direction. Although it sometimes has a rounded figure, the examination of a series of specimens will show that it is generally somewhat square shaped; and, when the pelvis is placed with its natural obliquity, is usually directed upwards, and, taking it as a whole, a little backwards. This might seem to indicate, that the round ligament naturally lies upwards and backwards; but, if carefully examined, it will be seen, that the anterior superior angle of the recess is the highest part, sometimes considerably prolonged, and that this part is vertically above the notch, or even a little forward from its middle. This high part evidently corresponds to the high position of the ligament, as in figs. 6 and 8. The posterior superior corner of the fovea would seem to correspond to the position of the ligament in rotation inwards, as in fig. 3; and the anterior inferior angle, or near it, to its position in rotation outwards, as in fig. 4. Not unfrequently the recess presents a decided notch, or angle, just at the latter part. The recess averages an inch to an inch and a quarter, and the height generally exceeds the breadth. From a preparation before me, it is evident that the recess goes a little higher up than the ligament can be carried, as in fig. 7. It is probably more extensive in other directions as well, and the want of these extreme parts may account for the occasional varieties of form. Whatever the variety may be, the typical form is, that it broadens above the notch, and tends to throw out three angles, forwards, backwards, and upwards, of which the latter is the most prolonged and most distant from the notch, or origin of the ligament.

The demonstration may be most conveniently made, and preserved, on a ligamentous preparation of the half pelvis and upper third of the thigh bone,—the capsular ligament being dissected, but entire. To prevent mistake, the pelvis should be held as in the subject lying on the table, and the exact position and motion of the thigh bone carefully noticed, especially that it is not rotated or flexed unintentionally. I have confirmed the results thus obtained, by exposing the ligament in a subject, and putting the entire undissected limb through its motions. The removal of the obturator internus might have proved some little source of fallacy, by allowing rotation inwards to go too far, were it not that the round ligament is not rendered tense in that motion. The conclusions to be stated are the result of experiment with the undissected limb, as well as with the ligamentous preparation; while those regarding the checking structures are from observations on the ligamentous preparation. It is just possible that these checking structures may be assisted passively by some of the removed muscles. The joint is, of course, naturally steadied by the opposing groups of muscles, the force being thrown on the ligaments only when the motion has reached its extreme.

It is necessary to premise, that there are three special bands, or thickened parts, with peculiar direction of fibres, incorporated in the capsular ligament. 1. The *Ilio-femoral band*, proceeding from below the base of the anterior inferior iliac spine, broadening out into a triangular shape as it descends to be attached to nearly the whole length of the anterior inter-trochanteric line. Well described by the Webers as of greater thickness than the tendo Achillis, or the ligamentum patellæ, as indeed, next to the concealed sacro-iliac, the strongest ligament in the body, and, of course, of corresponding importance. 2. The *Pubo-femoral band*, from the horizontal ramus of the pubes, above or in front of the cotyloid notch, downwards and outwards to the lower roughened part of the inter-trochanteric line, about half an inch in front of the trochanter minor. 3. The *Ischio-femoral band*, a strong flattened band, proceeding from the acetabular margin, just behind the cotyloid notch, winding upwards and forwards across the back of the neck of the femur, and inserted into the great trochanter at the upper end of the anterior inter-trochanteric line, just where the upper or outer part of the ilio-femoral band is attached. The higher fibres of the ischio-femoral band join, or descend from, the ilio-femoral band, but are not specially concerned, as the rest of the band is, in checking rotation inwards.

It will be granted that a ligament is not in use until it is tight; that, if a motion be checked, no matter by what, before the round ligament is tight, that this ligament has nothing to do with checking it; that, if a motion goes so far as to tighten the round ligament, it is a function of the ligament to check, or assist in checking, that motion; and, finally, if the ligament can be made tense in one movement, and in that only, that this is conclusive demonstration of its use. I may add, that the condition of the ligament in several movements, might lead the careless observer to conclude that it is tight, when it is merely extended, or nearly so, but not tight. Let the experimenter begin at once, by rotating outwards in the flexed position, and he will understand what tight really is. In order to judge of the degree of looseness in different positions, pass a loop of string round the ligament, and try whether it can be pulled into an angle off the head of the bone, and feel with the finger whether it is pulpy and round, or flat and firm.

Condition in the various movements.—Care must be taken that the movements be not confused, especially that the limb be not rotated unintentionally in either direction. Each movement is understood to be carried to the extreme, and to commence from the state of extension.

1. *Extension*, or the ordinary position in standing, and as the subject lies on the table; the limb straight, and the toes a very little everted. Ligament directed vertically upwards, and loose. Groove directed downwards and backwards from it.

2. *Flexion.*—Carries groove forwards; and ligament backwards and downwards, and renders it more loose.

3. *Abduction.*—Brings down upper attachment of ligament towards lower, and makes it entirely loose. Is checked especially by pubo-femoral band.

4. *Adduction.*—See fig. 5.—Ligament is carried a little up, but is not made tense; is round, twisted, and pulpy, and may be pulled by the string away from the ball into an angle. Groove is directed downwards and backwards from the ligament. Extreme attempt at adduction is checked by some strongly resisting structure, but no strain upon the round ligament. In the ligamentous preparation this checking structure is seen to be the ilio-femoral band, especially

its lower and thickest part. In moderate flexion, adduction is checked rather by the upper or outer part of the ilio-femoral band. In extreme flexion, adduction is checked by the cervix coming against the pubic part of the acetabular edge.

That adduction is more extensive in the flexed than in the extended position, is well known; but that the limits of the latter have been greatly misunderstood by the Webers, is evident from their argument, that although we can make the knees touch, we cannot press them together without some degree of flexion of the hip. This we cannot do for the same reason that bandy-legged persons cannot even bring the knees together. The resistance in either case is at the malleoli. But if one limb be removed out of the way, the body being supported and prevented from moving, the other limb can then be adducted considerably. This is better tried on the dead than on the living subject; but, that extended adduction is not so early checked, or early enough to support the body on one leg, as the Webers suppose, is readily enough shown in the living body by standing on one leg, and then bending the body over to the opposite side. If the round ligament, or any other ligament of the hip, were of use in naturally balancing the body on one leg, it ought to prevent the above mentioned extent of adduction. It is, of course, the abductor muscles which keep up the body when the opposite leg is lifted. These reasons were enough to upset the Webers' view, however plausible it may at first seem in theory, as seen in fig. 7; but the demonstration settles the matter, by showing that the ligament is not tight in extreme adduction.

5. *Rotation Inwards.*—See fig. 3.—Ligament carried backwards; is nearer tight than in adduction, but is pulpy, twisted, and round; bears no strain, and is not the checking structure. Groove quite away back from ligament. Is checked, in the extended position, by the ilio-femoral band; in the flexed position, by the ischio-femoral band.

6. *Rotation Outwards.*—See fig. 4.—Ligament carried forwards towards pubic part of brim of acetabulum. Is much in same condition as to tightness, feel, and form, as in rotation inwards; but now lies in groove, or a little forwards from its lower end, which is directed obliquely backwards and downwards.

Rotation outwards is checked by the whole front of the capsular ligament, the ilio-femoral band especially resisting. The ball is pressing forwards against the upper part of the front of the capsule.

7. *Adduction with Rotation Inwards.*—Ligament is somewhat tight, but upper part of it is soft and round; not bearing much, if any, strain.

8. *Adduction with Rotation Outwards.*—Ligament much as in the last—that is, in either of the two rotations, combined with adduction, the ligament is somewhat tighter than in either rotation simply, but yet without strain, soft and round.

9. *Flexion with Adduction.*—Ligament not quite tight. Groove away downwards and backwards from ligament. In extreme flexion and adduction the ligament is loose.

10. *Rotation Inwards with Flexion.*—Ligament looser than in simple rotation inwards.

11. *Rotation Outwards with Flexion.*—See figs. 6 and 8.—Ligament directed upwards, and more or less forwards, according to the less or greater extent of flexion. Ligament flat, straight-fibred, and occupies groove; completely tense, and evidently a checking structure. The effect of flexion is to make rotation outwards, carry the ligament upwards, instead of forwards, as in simple rotation outwards.

In this position the limb may now be abducted and adducted; the round ligament still remaining on the stretch, as the effect of these motions, in this position of the head of the femur, is merely to carry the pit forwards and backwards, the upward strain, given by rotation outwards with flexion, still remaining on the ligament.

The reason why the flexed position enables rotation outwards to put the round ligament on the stretch is evident on the ligamentous preparation. Flexion so relaxes the front of the capsular ligament that the latter now allows rotation outwards to go much farther; the round ligament then comes into play, and is assisted by the upper or outer part of the ilio-femoral band, which, though at first relaxed by flexion, is made tense again by the rotation now going farther.

That the round ligament is not by any means the only check at this stage of the movement might be inferred from its size, compared with the force it would have to resist, and is shown by the fact that, if the limb is held so as to make the round ligament tense, and the ligament be then divided, there is no jerk or yielding. The other checking structure is, as above remarked, the ilio-femoral band. Of course, if two ligaments are to be of use naturally in checking a motion, they must become tense at the same time; and the division of one will not allow of yielding unless under a force sufficient to rupture the other.

Next to the position in which it is truly tight, the round ligament approaches the tight, or extended, condition in the following:— 1. Adduction with flexion. 2. Adduction with rotation inwards. 3. Adduction with rotation outwards; but in none of these positions does it bear the strain.

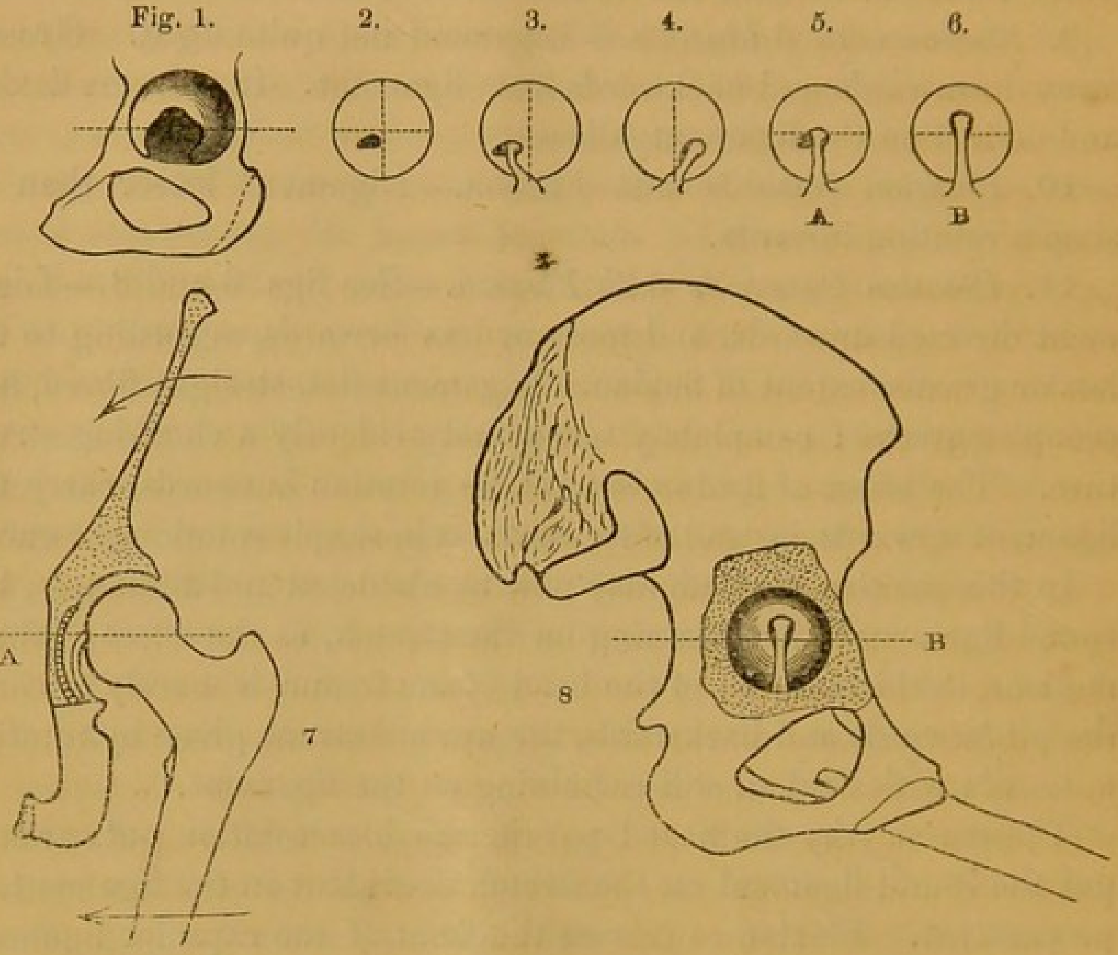

Fig. 1. Typical form, size, and direction of cushioned recess in acetabulum.

Fig. 2. Situation, form, and direction of the pit and groove on the head of the femur.

Figs. 3 to 6 show the direction and condition of the round ligament, and its relation to the groove in different movements. The pit is larger than the average, but not larger than in the specimen from which the diagrams were made.

Fig. 3. As in rotation inwards.

4. Rotation outwards.

5. Adduction.

6. Rotation outwards with flexion. The ligament tense, as in fig. 8.

Fig. 7. Diagram showing the vertical position of the ligament, and how, theoretically, it might be expected to check adduction. But fig. 5 shows its condition in extreme adduction.

Fig. 8. The round ligament is seen, exposed from behind, by removing the floor of the acetabulum. The femur is flexed and rotated outwards, carrying the ligament upwards, until it becomes tense, and checks the movement.

That the use of the round ligament is to prevent or assist in preventing dislocation in the forward and outward direction, as determined by rotation outwards in the flexed position, is therefore a matter of fact whether or not we understand why this movement in particular should require such a provision to check it. But it does not seem difficult to explain the why.

A glance at the skeleton will show that the acetabulum and femur are so directed, that the head of the latter has a natural tendency to be dislocated forwards by the outward rolling of the limb, as in standing or walking with the toes, as they usually are, more or less everted. Indeed, unless in the rotated inward position, part of the ball lies naturally out of the socket, pressing forwards against the capsular ligament. The natural tendency, then, of the hip joint, from its necessary mechanism, is to dislocate forwards, although the fact is that the forward dislocations are comparatively rare. Very various notions are probably entertained as to the way in which the direction which the dislocation of the hip shall take is determined. The backward dislocations are not the most frequent because the back of the capsular ligament is comparatively thin; but, rather, the back of the capsule is thin because the ball does not tend by the natural motions of the limb to throw itself out backwards, and because the front of the capsule checks rotation inwards as well as rotation outwards. My idea of the matter is, that the ordinary backward and upward direction of dislocation is determined simply by the obliquity of the shaft of the femur, the force driving the bone out in that direction; and we would expect the accident as all the more likely to occur if the limb was caught in the rotated inward position. Dislocations forward, on the other hand, whether pubic or obturator, we would expect, theoretically, to happen from the limb being wrenched in the rotated outward position, carrying the natural motion so unnaturally far as to rupture the thick anterior capsule.

But, whatever may be the explanation of the direction of the different dislocations, it is evident that the natural tendency is for the bone to throw itself out of the socket forwards. Now, to prevent this, there are two strong ligaments. In the extended position, as in standing with the toes turned more or less out, it is checked by the whole front of the capsular ligament, including the entire ilio-femoral band. But by flexion, the front of the capsule is relaxed, allowing the outward rotation to go farther, until it is checked by the round ligament, and by the outer part of the ilio-femoral band. The limb is in this position when it is lifted and advanced in walking, or in stepping up, with the toes everted; in sitting with the knees apart, or with one leg laid across the other knee; or in the tailor position, or on horseback. In all these, and other allied positions, the hip joint is flexed and rotated outwards, and the round ligament is called into play to prevent the ball starting forward from the socket.

The question occurs, Whether the ligament serves a similar purpose in the lower animals? It is known to be present in nearly all mammals, with a few well-known exceptions, among which are the very variously limbed orang, elephant, and seal; and is largely developed in the bird. It may be simply that a ligament is placed in the interior of the joint to check over-motion in that direction in which the bone is most liable to leave the socket. But, my examination of it in several quadrupeds, leads me to suppose that it is employed on the same principle as in man It has much the same anatomy within the joint, only shorter, which accords with the seemingly more limited rotatory motion of the quadrupedal hind limb. In the horse, a large part of the ligament leaves through the notch, plays round the transverse ligament, and passes to meet its fellow above and in front of the symphysis pubis; but this does not affect its position within the joint. In the quadruped and bird, the joint is naturally in a state of acute flexion, moving backwards to semi-flexion or partial extension; so that, as in the flexed position in man, an outward rotatory motion carries the ligament upwards, and this seems to accord with the direction of the ligament, the groove on the femur, and the recess in the acetabulum. This, however, I state only as probability, recollecting that in each case, as in man, it can be actually determined only by demonstration by the method proposed in this paper.

In conclusion, it is right to add, that it must be now ten years since I first employed this method of demonstrating the use of the round ligament, during which I have shown it to many anatomists, and taught it yearly in my class.