A CLINICAL LECTURE ON THE "RIDING FRAGMENT" IN FRACTURED LEG.

Delivered at Guy's Hospital.

[With Special Plate.]

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GENTLEMEN,—I should by rights commence this—a clinical lecture—with an account of one or more cases taken from our wards; but as the remarks that I have to offer will be founded on the experience of very many, it is somewhat difficult to select individual instances in illustration of the subject before me. I shall therefore only use the skiagraphs of two recent cases of fracture to prove some of the assertions I shall make, and have to ask you to accept.

GENERAL CONSIDERATIONS.

Strictly speaking, my subject is the "riding fragment" in fracture of the leg; but, at the same time, we shall be led to discuss the general value of operative treatment in simple fracture—a subject that has been much in evidence for the last five years, some surgeons even going so far, as you are aware, as to say that splints are superfluous. That an exaggerated estimate of the value of operation in simple fracture is largely held, I, as an examiner in surgery, can vouch for. At examinations frequently, in reply to the question, "What will you do in such and such a fracture?" I am told "I should try splints; but if I do not succeed I should at once cut down and wire." This phrase, "cut down and wire," seems to have become almost a password amongst students nowadays. It doubtless has its value; but there is distinct limit to its applicability. You know that there is nothing new in screwing and pegging of bones for compound fracture, or for ununited fracture. That was done very long ago; but operating for simple fracture is a thing of recent date, and its value, or at least the opinion I hold with regard to its value, will come out in the course of my lecture.

I first draw your attention to one or two general points, and, I would ask, What is the test of the value of any treatment in fracture? The answer is a double one. The less the time the patient takes before he gets about the better the treatment, and if that can be brought about by operating in a case of simple fracture, we are usually justified in adopting that course. For example, in fracture of the patella or of the olecranon, you will none of you doubt that the patient's return to work may be calculated by weeks where wiring has been performed, whereas, if an operation is not undertaken, months at least will supervene. Then the perfectness of restoration of the bone to the normal shape and solidity would be another test of the value of a treatment in fracture, and it is in obtaining this last that I think operation for simple fracture has been carried to extremes.

Evidently some fractures must be restored to the normal condition as nearly as possible for æsthetic reasons—for example, in fracture of the cheek bone or of the nasal bones. In others, the end that the surgeon has in view is purely utilitarian—as, for example, in a broken leg, where, in my opinion, he would not be justified in operating merely to avoid slight deviation of the axial line or irregularity in the union which the skiagraph would show, but which would not be detrimental to the patient.

I would here warn you all of a danger in skiagraphy. I know that it has happened for a patient to have his limb skiagraphed, after he had been properly treated, and because the picture showed an exceedingly slight irregularity along the edge of the bone indicating the position of fracture, he went from one surgeon to another to obtain an expression of opinion that the union of the fracture was not perfect, in order that he might sue for damages the gentleman who had treated him. You will find that few fractures would bear the test of photography in that sense, and I should warn you against appealing to it in your own work as proof of the goodness of your treatment, lest you should be called to account for not having produced a union of the bone absolutely as

perfect in appearance as it was prior to the accident, although its utility now may be in no way impaired. To merely satisfy, therefore, the demands of photography, I do not consider operations in simple fracture to be justifiable.

Yet I do not wish to underrate the value of this operation, and there are two great gains that result from it—one, the more certain adaptation and fixation of the ends of the bones in fractures of peculiar shape, to which I am about to refer; and, the other, an effect similar to that produced by massage.

Massage, as you know, is the removal of extravasated blood and lymph by a process of upward kneading. This end is more expeditiously attained by free incision, and so great is the gain in many instances that it might have been employed, in my mind, as one of the strongest arguments by those who have advocated operation in simple fractures as preferable to treatment by splints. I may remind you of a fact not mentioned in the textbooks, but which you find in Pott's original monograph on the fracture which bears his name, where he speaks not only of the fracture and deformity, but lays great stress on the injury inflicted on the joint by extravasated blood. Indeed, as you know, the argument that has been employed for operating in Pott's fracture is that those who treat this fracture by splints have great difficulty on account of the subsequent stiffness; and that argument is good. The reason of the stiffness not being present where an operation has been performed is that the extravasated blood has been allowed to escape, and not, I think, so much because the fibula has been operated upon.

There is one serious drawback, at least in the leg, to operation in simple fracture, although it is in fracture of the tibia that operation is perhaps most called for. Owing to the thinness of the tissues over the shin bone, the skin rapidly gets its vitality impaired, and death of the skin over—it may be quite a limited area—frequently occurs, whilst the tender condition in which the fracture has placed it materially interferes with its being rendered aseptic. Hence, wiring of the shaft of a tibia is by no means always certain to run a purely aseptic course.

THE "RIDING FRAGMENT."

After these general remarks I now come to the special subject of my lecture—namely, the "riding fragment." The illustrations that I shall give will be taken entirely from the leg; the remarks that I shall offer you can apply yourselves to other parts of the body. You will, in the first place, agree with me that a dresser finds much more difficulty in setting a broken tibia than he does in setting a broken femur; and I do not think that the explanation is that the thighbone, being hidden in a mass of muscle, is not so evident to the examining eye and finger as is the tibia, and that hence malunion is common but unobserved. For, were that the case, we should obtain results which certainly in my wards we do not often see—namely, considerable shortening as well as axial deformity.

A consideration of the anatomical connections of the femur and tibia will make clear, I think, to you why the one should be more easy to treat than the other. The femur is a single bone surrounded by two layers of muscle; the deeper layer lapping closely round the bone, the more superficial consisting of powerful muscles attached only by their extremities, which, from that very circumstance, exert a greater influence upon the bone when its shaft has been broken; of course I refer to the hamstrings and the extensors in front of the thigh. Now, in the leg we have to deal with two bones intimately united above, with no movement between them, and united through the greater part of their length by a stout interosseous membrane. In fact, instead of having to deal with a rod-like bone as in the thigh, we have to regard the leg bone as forming a flat plane or parallelogram, bounded by bones and filled in by the membrane stretched between them. The muscles, too, which deform the leg in fracture, are not free of these bones, as in the case of the thigh; for even the muscles of the calf are but partly attached at their extremities beyond the limits of the leg bones, the soleus, which forms part of the calf, having its attachment actually to the bones in question, and hence, when extension is applied to the foot in practice, the gastrocnemius is stretched, but the soleus is made to pull upon the broken upper fragment, and would have a distinct tendency, amongst other things, to approxi-

mate the fibula to the tibia, especially when the fibula is fractured high, as it usually is when the leg is broken indirectly.

It would seem, therefore, that I am making out a very bad case for the employment of extension in fracture of the leg. I admit I am doing so; but Hamilton years ago pointed out the same thing. Indeed, extension of the leg might almost be considered harmful, for the deep muscles are so attached all round the fragments that, if extension is made on the foot, the various extensors and flexors which are thus pulled upon exert their influence directly upon the fracture both above and below it; and hence, on purely anatomical grounds, it would seem to the surgeon that muscle relaxation in treatment of leg fractures would prove to be better than muscle extension, and I think that your own experience will bear me out that this is the case. The shaft of the femur, when broken, shows, as you know, great distortion; but, for the reasons that I have explained, it is equally free for restoration by extension to its natural position. But the shaft of the tibia, when it is broken, is not free to be restored with great ease, and that, partly because the shape of the fracture, when there is a "riding fragment," is, as I will show you, very peculiar, and because the very circumstances which held the bones firm during their entirety will equally hold them out of position when once they have been broken.

You know when the tibia alone is broken the fibula frequently acts as a splint, and there is practically no deformity; but let both bones be broken and displaced, and you will find—at least I shall hope to convince you—that the fibula is the great opponent to the restoration of the tibia to its normal line. This fact has already been pointed out, as you are aware, by my colleague, Mr. Lane, in connection with Pott's fracture; and although I do not happen to have met with the difficulties in that fracture that he seems to have met with, yet I am clearly of opinion that where, in the so-called "oblique fracture of the tibia" one fragment appears to ride over the other and is difficult of replacement, it is the fibula, rather than muscular spasm, which is one of the causes of this. That muscle spasm has little to do with the "riding fragment" is shown by the fact that, even under chloroform, the fragment can frequently not be replaced; and this, further, cannot be attributed to the bone perforating the fascia or muscle; for, when operating and freeing the bones entirely from all their connections the same difficulty of replacement remains.

Whatever share the ordinarily accepted causes of displacement may have in an ordinary fracture, I am confident that they do not exert any influence in producing or maintaining "riding fragments." The causes usually quoted are extravasated blood and inflammatory effusion, but both of these are got rid of when a fracture is cut down upon, and yet the difficulty of dealing with the "riding fragment" remains.

MODES OF FRACTURE.

In order that you may appreciate the dilemma in which I have placed you with regard to this "riding fragment," and in order that I may safely conduct you out of it, I must ask your attention briefly to the way in which bones are broken. Those of you who are acquainted with Helferich's work on fractures will be familiar with most of what I am about to tell you, but to many of you it is probably not a familiar subject. When a bone is broken indirectly like a stick across the knee, the strain first causes the tearing of the bone on its outer aspect. Presently the stress on the bent side of the bone or stick becomes such that the rent no longer can continue across the bone, but takes a line of least resistance to one side or the other, or both, and thus, when the stick is broken in two, you will observe that it began at first to snap across, leaving afterwards a long splinter standing out at the end of one piece, and a corresponding depression on the other; whilst if the fracture had run symmetrically this projecting piece would have become completely separated, and the stick would have been broken into three portions. This is what Helferich classes as a "greenstick, or indirect fracture;" or what Dr. Joseph Griffiths, of Cambridge, who has been working much at this subject, calls "the Y-shaped fracture." For, if you were to draw across the shaft of a bone or stick an inverted Y, the vertical stem of the Y would represent where the first strain caused the bone or

stick to part; the limbs of the Y representing the lines the strain takes when the stress becomes too great for it to continue in the original direction. Let these two limbs of the Y be completed, and the fragment of a bone breaks off as a splinter somewhat rhomboidal in shape. The fibula in Skiagraph A (Special Plate) shows this perfectly. Let only one leg of the Y be complete, and you have a fracture with a long fixed

Fig. 1.

splinter (Fig. 1, *b*), and the less in extent the vertical stem of the Y is (Fig. 1, *a*), the nearer will this fracture approach the true oblique fracture. Indeed, it is impossible to explain in a bone a true oblique indirect fracture in any other way than this. Transverse fracture is either the result of direct violence or may be produced indirectly if a bone or stick be held firmly just at the point of fracture; but when the indirect force breaking it is applied some distance from where the bone will yield, as is usually the case, the "grain" of the bone renders a transverse fracture an impossibility, there being always a greater tendency in bone for vertical than horizontal cleavage. It is evident that an oblique fracture of the form I have just indicated to you will have a greater tendency to overlap or to "ride" it being impossible to butt two inclined surfaces against each other without their slipping; hence, the "riding fragment" may be anticipated where such a fracture exists.

But you will see at once that there should be no difficulty in reducing or setting such an oblique fracture by mere extension; nor do I think there is. And yet I maintain that for the most part the "riding fragment" in a broken leg is not reduced by mere extension. Either, therefore, our extension, as applied, is inefficient, or we are not dealing with an oblique fracture when we think we are. This latter you will find to be the truth.

THE "SPIRAL FRACTURE."

There is another class of fracture altogether, long recognised and known by various names as the spiral fracture, or the fracture *en bec de flute*, but considered to be of infrequent occurrence, not to say rare. This I believe to be a mistake; and it is because we have not recognised the fact that this spiral fracture is of very frequent occurrence that surgeons have often failed to place the broken tibia in good linear position after fracture by the means of extension and muscular relaxation usually employed. Not infrequently pads are applied over the "riding fragment" to try and press it into position, and prevent it ulcerating through the skin.

My attention has been especially drawn to this fracture by Dr. Griffiths, the Reader in Surgery at Cambridge, to whom I have already referred. He has been working experimentally on this subject for some time, and, though his results are not yet published, he has permitted me to refer to them, and any Cambridge men present to-day will be familiar with the specimens of fracture that he has artificially produced and placed in the Museum at Cambridge. When first he told me that he thought that the spiral fracture was the most common form of fracture, I was very sceptical; but I am convinced that he is right, at least as far as the tibia is concerned. Two circumstances have forced this belief upon me. One, that in every case of "riding fragment" of the tibia in which I have felt bound to operate, I have found a spiral fracture, and the other that Mr. Shenton, who, as you know, has been skiagraphing every form of fracture for a long time past, tells me that out of the immense numbers of skiagraphs that he has made of fractures in this hospital, by far the greater are spiral in character. This fracture, and the way it produces the "riding fragment," I illustrate to you by these models, which you can make for yourselves out of strawboard postal tubes (see Figs. 2, 3, and Skiagraph A). Mark a short spiral occupying about 4 inches of the length of the tube and going not quite

completely round it. Unite the ends of the spiral by a straight line. Follow the pencil marks with a knife, and the tube is now divided into two. If you replace the portions in position, you will find that you can axially rotate one fragment on the other round the straight line uniting the two ends of the spiral, and thus open or close the fracture, as on a hinge. This line Dr. Griffiths speaks of as the hinge of the fracture. It results from a snapping of the bone at its weakest part after the rotary strain has first produced a spiral fissure. This "weakest part" is a line uniting the ends of the fissure (Fig. 2, *a-c*). Spiral fissures in bones exist, but unless united by a vertical split the bone remains unseparated into two fragments.

Fig. 2.

Imagine the case of a man being thrown to one side, the foot being fixed at the moment on the ground, whereby the tibia becomes torsed or twisted, and the spiral strain thrown on the bone results in a spiral fissure, which is converted into a complete fracture by the snapping of the bone along a line joining the two ends of the spiral represented in the model by the straight line to which I have referred. When the spiral fissure completely encircles the bone or tube—that is, when the ends of the spiral are in the same vertical line as the axis, or even overlap it—then the bone may snap in two more or less parallel lines between the ends of the spiral, as shown in Fig. 2, *a-c*, *b-d*, and thus the fracture opens with what may be termed a double hinge. As a matter of fact, however, the rhomboidal or triangular piece of bone between these two lines becomes separated, and we have thus a spiral fracture with a third fragment. This is well-shown in Skiagraph B (Special Plate). These spiral fractures are good examples of pure strain, stress not entering into their composition, the result of a twisting force. In a sense you might almost regard them as twisted oblique fractures, but they differ from the oblique fracture in two very important particulars: one, their mode of formation, which I have already described; and the other, that when fitted together any amount of pressure may be exerted on the ends of the bones in the direction of the long axis without the fracture being displaced. In a word, the fractured ends lock completely. This I show you upon this model. I can press with impunity on each end when the spiral is locked as though the tube had not been cut at all. If, however, I hold one end firmly on my hand and rotate the other inwards or outwards, according to the direction of the spiral, at the same time giving the slightest axial displacement, so as to cause the pointed extremities of the spiral to leave the receding angles (Fig. 3, *a*) in which they both lie, you will perceive that I have at once produced an angular projection which, were this a bone, would form a "riding fragment."

Fig. 3.

You will naturally say, if you have followed my description, there is nothing easier than to give a twist in the opposite direction and replace the point, and thus set the fracture. This would be true if a leg were a single bone and nothing else; but I shall show you when I apply my present remarks to practice that there are other factors that prevent our so easily disposing of this "riding fragment." You will also observe that the "riding fragment" thus produced necessitates no shortening of the bone or tube, because no force has been applied to either end of it in the direction of its axis, but merely a rotary force at right angles to it; and thus the

paradox of a "riding fragment" and yet no shortening is explained. But a "riding fragment" in an oblique fracture which is really an overlapping must be attended by a certain degree of shortening; and hence, whatever value extension may have in getting rid of the "riding fragment" in the latter it is, for mechanical reasons, of no use in the former.

DIAGNOSIS OF THE SPIRAL FRACTURE.

If these views I have laid before you of the "riding fragment" in fracture of the tibia be correct, it is clear that the methods of treatment would not be the same in both oblique and spiral fractures. When called upon to treat one of these cases, our first endeavour should be to determine if we are dealing with the so-called oblique or spiral fracture. At first sight both look alike. There lies the patient with perhaps a very bruised and swollen leg; and, on passing the finger down the shin bone, the projecting point, perhaps threatening to cut through the skin, is to be felt. The common explanation of this is that the calf muscles are drawing the lower fragment underneath the upper. If this is the case, a careful measurement with the tape will reveal a perceptible shortening; but I must admit that the use of the tape in fractured leg is not very satisfactory for many reasons, not the least being that you have to measure over a swollen limb, and are thereby more likely to err on the side of lengthening than of shortening. We will suppose, however, that there is evident shortening. If, now, extension be made, the knee being bent, we should expect, and we find that it occurs, that the limb regains its original length, and the bones slide into their proper position, so that practically the "riding fragment" disappears, to reappear the moment extension is removed. Such cases give dressers great trouble, for they say "This was all right when we put it up, but two hours after was as bad as ever." Yet my experience is that my dressers say more frequently, "We have tried extension, even under chloroform, but could not get the bones into position"—a fact alone that would make me at once suspect that they were not dealing with an oblique but a spiral fracture. But we will now suppose that on accurate measurement you have found no shortening—at least not enough to account for the marked projection and apparent overlapping of the upper fragment. You try by extension to "set" the fracture, and you fail. You turn the foot to bring it into its proper line with the rest of the limb, and in this you succeed, yet the fragment still projects. If, now, whilst having done all that you can, you will accurately compare the two limbs by means of the tape applied to the anterior iliac spine, the middle of the patella, and the ball of the great toe, you will see on the sound side that these three points are in one straight line; but on the fractured side you will find, in all probability, that the tape applied to the iliac spine above and the middle of the patella below does not touch the ball of the great toe, but passes to its inner side, thus suggesting that the foot is rotated outwards, although it may be very slightly. This outward rotation is explained by the fact that the fracture is a spiral fracture, and that therefore your efforts to correct the distortion have been unavailing. I am bound to say that I do not myself feel always at all certain as to the form of fracture that I am dealing with, whether oblique or spiral, especially when there is much swelling about the leg; for, as you can show on these models or on a bone spirally broken, a very small amount of rotation suffices to render very prominent the "riding fragment." And, considering that limbs are not formed to gauge as are the parts of a delicate machine, it is not strange that we sometimes mistake for a twist inwards or outwards what is really a natural peculiarity in the limb. The difficulties, therefore, of being certain of the form of fracture are very considerable, so that after all, when the question arises, Is this a case in which operation is called for in order to replace the fragments satisfactorily? we have to answer the question not so much by our positive knowledge that it is such and such a fracture, as by our failure accurately to adjust it by the various non-operative and manipulative methods at our disposal.

THE REPLACEMENT OF THE "RIDING FRAGMENT."

I must now try to answer the question, Why is it that the "riding fragment" in the tibia is so difficult to replace?

and I assume in these remarks that the difficulty has arisen from the fact that the fracture is spiral, for, as I have already told you, it is the far more frequent form of fracture. Early in my lecture I referred to anatomical details, pointing out that the tibia, unlike the femur, was not a free agent. It has by its side a second bone to which it is united, especially above, very firmly, and all down its length, by a stout membrane. When a twisting force is applied and about to produce a fracture, what happens is that the twist tells first on the unyielding tibia, and that bone having given way the fibula snaps at its weakest point, that is, towards its upper end (see Skiagraph A). We know this to be the case, for we see constantly in skiagraphs the tibia broken spirally, the fibula snapped. It is what we should expect mechanically. The twisting force which would twist both bones at the same time would have to be so powerful that, in my opinion, the ligaments of the knee would sooner yield; for, as I have already told you, the tibia and fibula with their membrane form a flat surface like a board, which it would be most difficult to torse as a whole.

Having, therefore, to deal with a spiral fracture in the tibia and a snap of the fibula, when we attempt on grasping the foot to restore the tibia by mere axial rotation to its proper position, which in theory we should be able to do in every case, we are met by a very evident opposing force.

As long as the skin remains entire it is almost impossible to say what this opposing force is; but I have no doubt in my own mind to what to attribute it, from the experience that I have gained from skiagraphy and by treating these cases by open operation. With the tibia fully exposed, the fragments absolutely free from any intervention of muscle or fascia, without anything visible to oppose the restoration of the spiral by suitable rotation, yet over and over again have I found this to fail. Attempts at fitting the fragments together, as one can do in a model, being frustrated by the sense of a spring, as it were, forcing the fragments back into their false position; and when I have succeeded in at length "setting" the fracture, it has required firm wiring or screwing to keep the bone *in situ*. It is clear, if my observations are correct, that some hidden force is working against us, and what that hidden force is I think you will see by looking at this Skiagraph A. You observe the tibia shows a most beautiful spiral fracture; not only with a "riding fragment," but the bones have been so completely displaced that there is considerable shortening. It is more than a mere opening of a spiral. The fibula, you will see, is also broken into at least three pieces, the third detached rhomboidal fragment being very marked. Now, in this case I exposed the tibia. There was nothing apparently to prevent an easy adaptation of the ends, yet I was manipulating for a considerable time before I could achieve my end, and then only after somewhat roughly, apparently, bending the fracture in a way I should not have dared to do had I not been able to see what I was about. I succeeded in locking the spiral, yet it required firm pressure with the thumb on the part of my dresser to keep it locked, otherwise we could see it gradually opening with a kind of spring action, and yet nothing to account for it. We wired it, and the result seemed quite satisfactory. A few days afterwards I saw the man in bed, and my attention was drawn to two facts. First, that the skin had sloughed over the fracture, exposing part of it. The sloughing was due to the simple fact that the skin was in a very unhealthy condition at the time I operated, and we predicted that its death was likely to occur. But the second thing I saw was even more unsatisfactory. My spiral fracture had deliberately unrolled itself on its hinge, and there was—to a very slight extent I must admit—the sharp pointed end of the upper fragment projecting. The same force which opposed me at the operation was evidently still acting, and but for the wire holding firmly would, I have no doubt, have completely reproduced the original deformity.

There is but one explanation of this circumstance, as also of the general difficulty that everyone finds in keeping the "riding fragment" in its place, and that is the action of the fibula. We have but to suppose that the jagged end of the broken fibula, as seen in Skiagraph A, has been driven at the time of the accident into the surrounding fibrous connections and firmly held there in a false position, to understand how a rotary action applied to the tibia to lock the spiral would, for anatomical reasons, give an equally rotary

action to the fibula, the fracture of which bone, not being spiral, would not be similarly influenced. Hence the fractured ends of the fibula, forced, as you see them to be, out of their axial line into the surrounding soft parts and there fixed, were twisted by the surgeon's hand, only to exert their spring action the moment the force of his hand was taken away; or, as in this particular case, to continue their spring action until they had, as far as possible, unlocked the adapted spiral in the tibia. This idea I do not claim as altogether new. Mr. Lane, as I have told you, has already applied a similar remark to the difficulties in reduction in Pott's fracture; but I would expand his view and say that I believe the fibula the main cause of the great difficulty constantly found in setting fractures of almost any part of the shaft of the tibia. Further, the fact that the fibula is broken at a higher level than the tibia gives the lower fragment a greater power of leverage than if they were broken on the same level.

INDICATIONS FOR OPERATION.

Now as far as the subsequent utility of the fibula is concerned, I am quite unaware that a slightly angular union of that bone is any great detriment; but, as an obstacle to the perfect restoration of the axial line of the whole limb, the fracture of the fibula becomes a very important matter. My experience has now been such in these cases that where I shall in future decide in a fractured tibia that operation for adaptation is required I shall not hesitate, if I meet with what I call the "spring-action difficulty" in retaining the tibia in position, to cut down on the fibula as well, and place its ends in their proper relation. If you agree with the views that I have placed before you as to the causation of the "riding fragment" in fracture of the tibia, the treatment that I shall propose to you will be evident from what I have already indicated—namely, that where the suitable manipulations required by the oblique or the spiral fracture fail to give a good position, adaptation by operation is called for—not of necessity wiring, or even screwing, for sometimes the fragments when replaced do not tend to move. This, however, is not generally the case, and the addition of a wire which does not add to the gravity of the treatment makes assurance doubly sure. What degree of "riding fragment" calls for operation must be determined by the surgeon in each case. To operate in order to obtain an absolute linear adaptation of the shin bone that will stand the test of a skiagraph is not, as I have already said, in my opinion justifiable. A slight displacement—say one-eighth of an inch—looks large with photography, and can certainly be felt by the finger, but is not only of no importance, but will have disappeared by the natural modelling processes that take place in the course of a few months; where, however, the "riding fragment" threatens to become compound, or where there is shortening, or where the foot cannot be placed in its proper line and retained there, then it is (circumstances permitting, and if best results are to be obtained) that operation is in my opinion called for.

The two cases from which the skiagraphs are taken have been recently in our wards, and I have selected them as typical examples of the ordinary forms of fractured leg. Case A I have further chosen on account of the illustration it affords not only of the difficulty in reduction of the deformity at the time, but as emphasising the continued effect of the deforming force, where that has not been sufficiently overcome at the time of operating.

The strictly clinical details of the cases are not worth giving, as they show nothing out of the way. In both cases, every attempt had been made by extension, muscular relaxation, the administration of anæsthetics, and in one the division of the tendo Achillis to overcome the difficulty of replacing and fixing the "riding fragment," and not until these simpler means had proved ineffectual did I consider operation called for.

The operations in both were identical, namely, free exposure of the fracture, thorough removal of extravasated blood, forcible replacement of the fractured ends with (in Case B) the removal of the rhomboidal third fragment, as, owing to the position it occupied, it prevented the locking of the spiral fracture. Once in position, the fractures were wired with stout silver wire, partly by perforating and partly by encircling the ends of the bones.

I am indebted to the courtesy of Messrs. Shenton and Kirkman, of Gray's Hospital, for the admirable skiagraphs illustrating this lecture.

CALCULI IMPACTED IN THE URETERS.

PATHOLOGY, SYMPTOMS, AND SURGICAL TREATMENT.

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Numerous cases have been recorded where all the symptoms clearly pointed to the presence of a calculus in the renal pelvis, but when the kidney was explored no stone was found. Doubtless in many of these the stone had descended into the ureter, and so escaped observation. Now the rule is to explore the ureters, as calculi may be arrested at any part of their course.

Considering the anatomical arrangements of the ducts one would expect stones to become embedded where the pelves become narrowed to form the ureters, and where the ureters become constricted in their passage through the walls of the bladder, and from the statistics of cases of calculous anuria collected by Morris,¹ this is shown to be the case. He states that in 56 cases where the situations of the calculi were noted, obstruction took place as follows:

"1. In the renal pelvis and blocking of the upper orifice of the ureter, 7 cases. In 4 of these both ureters were blocked at the renal orifices.

"2. In the upper end of the ureters 30 cases. Both ureters were blocked in 5 of these cases. In 3 there was another stone impacted lower down (2 in the mid-part, and 1 near the bladder).

"3. In the middle portion of the ureter in 7 cases. In 1 case both ureters were blocked, and in 2 others there was a second blockage by calculus higher up.

"4. In the lower end of the ureter in 10 cases. In 1 of these there was an impacted stone also higher up, in 3 of them both ureters were obstructed.

"5. In 2 cases complete suppression was caused by obstruction of both kidneys by a large vesical calculus."

When the calculus is stopped at the upper end of the ureter it usually protrudes into the renal pelvis, and when it is embedded at the lower extremity of the canal it may, covered with vesical mucous membrane, project into the cavity of the bladder.

The impaction of calculus in the ureter is one of the most common causes of total obstruction to the escape of urine. When this occurs it is more certain to cause complete plugging than if the stone is lodged in the pelvis of the kidney. Should the ureter be suddenly and completely occluded, by the impaction of a stone in the lumen of the tube, the effect upon the corresponding kidney is very different from what is produced by incomplete and transitory blocking of the passage, as exemplified in cases of calculus in the renal pelvis, in the twisting of the ureters met with in movable kidney, or by the obstruction caused by the pressure of pelvic tumours.

The pathology may be examined under the following heads:

(1) Calculus impacted in one ureter, the other kidney being competent.

(a) The stone causing complete occlusion of one ureter.

(b) The stone causing incomplete plugging, with the escape of urine at intervals.

(2) Calculus in one ureter, the other kidney being incompetent.

(a) The stone causing complete occlusion of the ureter of the working kidney.

(b) The stone causing incomplete plugging, with the escape of urine at intervals.

The first class of cases to be studied are those where the patient possesses one active healthy kidney, the ureter of the other becoming blocked by a stone, which may cause either complete or partial obstruction to the escape of urine. When the lumen of one ureter is suddenly and completely closed, the backward fluid pressure of the urine very soon causes a marked diminution in the flow of blood through the kidney, atrophy of the organ rapidly takes place, and in most instances this is followed by a compensatory hypertrophy of the gland

at the opposite side. The destruction of the renal tissue is brought about in two ways: (1) By the insufficient blood supply consequent upon the pressure of the fluid in the capsules of the Malpighian bodies; and (2) by the pressure of the fluid within the pelvis causing dilatation. The pressure exerted by the urine which accumulates behind the obstruction leads to the expansion of the calices and flattening of the papillae. When the blocking is sudden and complete wasting of the kidney takes place without the pelvis becoming distended sufficiently to produce a swelling in the loin. The pelvis and calices of the kidney are not liable to sudden distension, they are only capable of slow and gradual dilatation. Should a stone become impacted, the secretion is arrested by inhibition of the corresponding kidney. If, on the other hand, the obstruction is incomplete or transitory, and the urine is permitted to flow into the bladder at intervals, advanced unilateral hydronephrosis develops. When relief occurs the previous high pressure within the uriniferous tubules and Malpighian capsules is suddenly diminished, and the vessels of the glomeruli being relieved from external pressure a considerable hyperæmia is induced, followed by rapid secretion of urine containing albumen. Supposing, however, instead of a sudden relief of the constriction, there is stricture rather than transitory obstruction, and only leakage from the narrow passage is possible. In these circumstances the activity of the gland is maintained, with sudden and occasional varying pressure within its cavity. If this be long continued, considerable hydronephrosis will result. There are, therefore, two conditions which cause marked distension, partial obstruction of the ureter with leakage, and complete transitory blocking associated with rapid and sudden collapses and dilatations of the upper urinary tract.

When the plugging of the ureter is incomplete, and the urine is allowed to escape at intervals, the pelvis of the kidney gradually becomes distended by the retained excretion and hydronephrosis results. It is in such cases when hydronephrosis reaches its highest degree of development, dilatation of the pelvis takes place behind the obstruction. The pressure exerted upon the structures leads to an expansion of the calices. Gradually the parenchyma of the kidney disappears and is replaced by fibrous tissue. As the pelvic cavity and the capsule approach one another, the renal form of the organ is rapidly lost, the outer surface may become rough, irregular, and lobulated, the depressions behind the lobules corresponding to the connective tissue within the sac, which indicates the remnants of the calyces of the kidney. The pouches communicate freely with one another, and in most instances with dilated pelvis, but in a few rare cases the sacs may be shut off from the pelvis by fibrous tissue. In the highest grades of hydronephrosis the kidney may be represented by an enormous membranous sac, which can only be recognised as renal in its origin on account of its relation to the ureter and colon. To the latter it is frequently adherent, but it may also be bound to other organs, such as the spleen, liver, pancreas, or it may be united to the peritoneum, omentum, or mesentery.

These changes are only possible when the kidney on the opposite side is able to perform its function in a way competent with life.

It is not often that both ureters become blocked at the same time, but the course of events may be as follows:

There is a history of repeated attacks of renal colic on one side, associated with the presence of hydronephrosis and other physical signs of obstruction. The symptoms become suddenly relieved, coincident with the escape of a large quantity of clear urine and some gravel, and followed by slight and transitory hæmaturia. These symptoms are repeated from time to time, then suddenly cease; the last attack is more prolonged than former ones, and the relief, in place of being sudden, is slow. There is no abrupt rush of urine, no escape of gravel, and no transitory hæmaturia. A stone has become firmly impacted in one ureter, and this accident will be followed by rapid and complete atrophy of the corresponding kidney and by hypertrophy of its neighbour. Years pass, these old attacks of nephritic colic are forgotten, but in the course of time the only working kidney becomes the seat of the old disease; a calculus forms in its pelvis, and, passing down into the ureter, becomes impacted there, and may cause either complete occlusion, followed by anuria, or the plugging

Skiagraph A.

TO ILLUSTRATE MR. C. H. GOLDING-BIRD'S PAPER.

Skiagraph B.