recent months he had been carried off the Rugby football field owing to an attack of pain in the left loin when collared, and even when dancing he was sometimes obliged to retire with similar symptoms.

At examination the right kidney was palpable and enlarged, the left kidney tender on palpation. Micturition was not quite normal, the patient being obliged to pass urine once during the night. The urine was clear and contained no pus, but a streptococcus was grown on culture. Temperature 99°.

Cystoscopy showed the bladder wall to be healthy, with slight injection of the mucous membrane around the left ureteric orifice. Pyelography demonstrated hypertrophy of the right kidney and disorganization of the left kidney. (See Figs. 5 and 6.) In this case the injection fluid used was a 30 per cent. solution of sodium iodide.

A rise of temperature and increase of pain in the left loin followed this examination, which indicated immediate operation. The left kidney was therefore exposed by a lumbar incision; it was found to be so large and tense that an incision had to be made in the capsule to draw off the retained urine and solution of sodium iodide before it could be delivered out of the wound. Nephrectomy was then readily performed. Examination of the specimen after operation revealed an enormously distended pelvis and complete obliteration of the calyces.

Recovery was uneventful, the feeling of fitness so soon after a major operation being again noticeable.

Commentary.

It is a matter of considerable interest that the disease in each of these cases was on the left side. The obstruction in Cases I and II was congenital, an aberrant vessel kinking the ureter in the one and a stricture at the uretero-pelvic junction blocking the other. In the third no cause could be found for the destruction of renal tissue. There was no dilatation of the ureters in any of these cases.

A comparison of the condition of the urine shows how little such an examination, by itself, must be relied on to determine the presence or absence of a gross lesion of the kidney.

Bacilluria was present in all three cases but without pus formation. The urea concentration test was of some assistance in determining the efficiency of the kidneys, but more reliance was placed in the appearance of the pyelograms to assist in estimating their function.

The chronic ill health produced by hydronephrosis in which there is no pus formation, and where the opposite kidney is functioning satisfactorily, is noteworthy. Equally remarkable was the sense of well-being that each patient demonstrated within fourteen days of removal of the diseased organ. This characteristic was not due to an improvement in the metabolism of nitrogenous products, for previous to operation the sound kidney had been proved to be excreting the normal amount of urea consistent with good health, but rather to the removal of an organ which, by virtue of the process of degeneration, is circulating toxins of an unknown chemical nature in the blood.

The pyelograms reproduced on the accompanying plate faithfully represent the normal as well as the abnormal anatomy of the kidneys. Those of the healthy organs show the calyces with their cup-shaped extremities, while those of the hydronephrotic kidneys reveal stunting, or even entire absence.

A further study of pyelography in cases in which the renal cortex is being destroyed will aid in determining the extent of the damage. Thus, in the early stages there is distortion of the calyces, but later the pyelogram shows shadows of globular shape, three to six in number, situated immediately beneath the capsule, and which are adjacent to the large shadow representing the overdistended pelvis. It will be noted in all cases that the shadow of a normal kidney is always more dense than that of a hydronephrosis owing to the dilution of the opaque media by retained urine.

Finally, we give it as our considered opinion that, as a result of the introduction of cystoscopy, ureteral catheterization, and pyelography, no surgeon is justified in performing an exploratory operation upon the kidney. Science has placed in our hands the means of making an accurate diagnosis without recourse to cutting down upon the kidney and inspecting it with the naked eye.

Our thanks are due to Dr. Reynolds and Dr. Salmond for the pyelograms, and to Mr. Shiells for the drawings.

BARBED wire entanglements guarded by armed men have been set up to isolate the towns of Poleau, Heaveney, and Wister, Oklahoma, U.S.A., where an epidemic of small-pox is prevailing. According to the *New York Medical Record*, compulsory vaccination is also in force.

A BONE CLIP FOR THE OPERATIVE TREATMENT OF FRACTURES:

END RESULTS IN THE CASE OF GROWING FEMURS.

[With Special Plate.]

BY

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FASHION plays an important part in surgical technique, and surgical fashions come and go; but they go with greater reason than they come. The principle that nearly every simple fracture requires operation because perfect function depends on perfect anatomy, was preached by Sir Arbuthnot Lane. In course of time it came very near to being one of those accepted surgical generalizations which Sir Arbuthnot himself now says are always wrong. To establish a true generalization is harder, far harder, than to devise, and even to popularize, a new surgical procedure. That perfect function is compatible with imperfect anatomy is now accepted in the treatment of fractures. Our object as surgeons is to recover the function of a broken limb, not necessarily to restore its radiographic symmetry. Experience of war injuries, together with the influence of orthopaedic surgeons, has been largely responsible for the revulsion against converting simple into compound fractures by operating on them. But as long as there are house-surgeons not yet fit to be called surgeons, and surgeons whose waking thought is the knife, operations on simple fractures will continue to be done. All this by way of apology, since I may be accused of unnecessary operations.

Of all bones liable to fracture probably the femur gives the greatest trouble to the setter. One of the chief reasons is the strength and bulk of the muscles which surround and are attached to it. Uncontrolled action and spasm of these muscles, even in young children, may prevent reduction under anaesthesia, and the difficulty is directly proportional to the time which elapses between the receipt of the injury and the attempt to secure replacement of the fragments. House-surgeons do not fully recognize that all fractures, simple as well as compound, are acute cases, and that the best results can only be obtained by immediate treatment. Within four hours of the injury a direct pull under anaesthesia will effect reduction in nearly all fractures of the femur, even including those of the upper and lower thirds. The use of an extension table and the direct application of a plaster-of-Paris case to the limb will usually suffice to maintain good position, and in due course a perfect functional result may be looked for. Flexion of the hip or knee may be required in the difficult cases of fracture in the upper and lower ends respectively; but time is of the essence of the contract, and the earlier the house-surgeon gets to work the easier is his task. If his chief prefers it equally good results can be obtained by the present-day modifications of Thomas's splint. That he should fail in certain cases is no discredit unless it is due to unnecessary postponement. That the surgeon should succeed where his house-surgeon fails is not to be expected except in those cases where a correct interpretation of the skiagram shows the way to successful reduction, and experience alone can teach these points. Inevitably, therefore, the question of operative treatment of some fractures will arise, and the bone most frequently calling for open reduction will be the femur, since alignment of the fragments is of such importance. Spiral fractures of the lower third of the tibia also present especial difficulty. Personally I do not operate on any of the common fractures unless two attempts at reduction without open incision have failed.

If there will always be cases needing operation it is surely desirable that the technique should be as simple as possible, and my conception of an internal splint is the simplest appliance which will hold the bony fragments in accurate apposition whilst the limb is immobilized in an external splint. Even if open operation is necessary to effect reduction a splint for the bone may not be required, and this is well exemplified by the common type of supracondylar fracture of the humerus. Open reduction is often necessary, but satisfactory apposition can usually be secured by complete flexion at the elbow-joint.

In May, 1917, I first described a clip made of spring steel, which was made for me by Henry Lewis, of Westmoreland Street, W.1, for the treatment of fractures of long bones.

FIG. 1.—C. H. Fracture of femur, September 4th, 1917. X ray taken on September 10th.

FIG. 2.—C. H. Clip applied September 14th, 1917. X ray taken on September 18th.

FIG. 4.—L. N. Fractured right femur, September 22nd, 1917. X ray September 25th. Lateral view.

FIG. 5.—L. N. Clip applied October 1st, 1917. X ray taken October 4th.

FIG. 3.—C. H. X ray taken December, 1920.

FIG. 6.—L. N. Skiagram taken three years later.

My object now is to show the late results of this method of treatment, with especial reference to its influence on growth of the bone. The technique of my operation was described in this JOURNAL four years ago.³ It has been urged against circular constriction of a bone that it leads to atrophy, and that if such an appliance as the Parham and Martin band is used refracture is liable to occur. There is much truth in

FIG. I.—A shows a transverse and an oblique fracture of femur, produced by saw cuts, held in position by clips, drawn from an actual specimen. The upper oblique fracture was easily secured by one clip. The lower transverse fracture is held in good position by two clips, one of which is provided with a supporting flange. The second flange embraces both flange and proximal fragment. B shows the introducer, the prongs of which pass through small loops at the end of the clip. This instrument is made with a screw-joint so that the two halves can be taken apart.

this, but the danger can be avoided by the use of a clip which does not encircle more than two-thirds of the circumference of the bone. It may be seen in the accompanying skiagrams (see Special Plate) that subsequent growth of the bone lessens this proportion so that the danger of pressure atrophy is a decreasing one.

The femur cases which I illustrate were selected for operation only after two unsuccessful attempts at reduction had been made in each case, and all the operations were done over three years ago. If I apologize for finding it necessary to operate on them I see no reason to apologize for the operations themselves. The functional results are perfect and the skiagrams show the anatomical results.

Only a brief description of the necessary instruments is required since the accompanying block (Fig. 1) shows the method of application and two types of clip devised for oblique and transverse fractures. For the latter I have devised two clips, one of which has a long flange attached to it, so that it may support both fragments and be grasped by a second clip. In practice, however, I have found that one clip will nearly always suffice, even for a transverse fracture, and absolutely transverse fractures are not very common. The transverse type which most often resists manipulative reduction is that in which the upper fragment overrides the lower one, and here operation may be called for. A single clip will support the lower fragment whilst the external limb splint is applied.

As to the clips themselves, they are made in several sizes, ranging from half an inch to an inch and a half in diameter, the width of the metal band being proportionate to the diameter. Very careful tempering is required to secure the clip against fracture when it is opened for introduction, and this point has received particular attention from the maker. The tension of the spring is also important, since pressure atrophy must be avoided. This is further guaranteed by the

presence of sharp teeth turned in at intervals from the edges of the clip so that there is a small clear space between the bone and the metal. These teeth obviate the need for screws and secure a firm grip on the surface of the bone. The avoidance of screws is important, for thus the medulla of the bone remains untouched, and it is well known that screws do actually become loose by atrophy of the bone in which they are embedded. In the absence of sepsis this atrophy has been denied; but any surgeon who has had to remove screws on account of pain, and not for sinus formation, knows that the screw often rotates in its socket under the action of a screwdriver, and the simplest method of removal is to seize the head of the screw and pull it straight out, proving that its bite has ceased to be effective.

The instruments required for my operation are few in number, and the technique followed is the same as that of other methods of internal splintage of bones except that the clip replaces the bone clamp, and, when once the clip is applied, the operation, except for closure of the wound, is at an end. Thus the length of the operation is reduced by one-half. For clearing the periosteal space I know of no better instruments than Lane's curved elevators, and four of these, two at each end of the wound, will expose the bone, and hold the muscles temporarily out of the way. The size of the clip to be selected is important, and for this purpose the diameter of the bone as shown in the skiagram is an accurate guide. To ensure adequate tension the clips are made on the small side, and, in children, a three-quarter inch clip is most frequently used. The clips are stamped with their diameter. In adults the diameter of the bone is usually more than an inch, and an inch and a quarter clip may be required. In subtrochanteric fractures I have used a clip with a diameter of an inch and a half, but always the diameter of the clip should be rather less than that of the bone which is to be secured.

It is obvious that there is an optimum position for the clip so that it may exert pressure along the lines of force which tend to separate the fractured ends. The tension of the spring results in a closing pressure roughly at right angles to the direction of its opening. This must be borne in mind when applying the clip, and it is important to secure this position before the introducer is removed. It is easy to ascertain by trial how far round the bone the instrument should be passed, and then the introducer can be disengaged by a tap on its lateral aspect to free the prongs from the rings of the clip. The clips boiled for the operation should not be touched by the hand, and they can easily be picked up by the prongs of the introducer passed through the rings of the clip. The introducer is made of such a size as to comply with the requirements of aseptic surgery, and not even the gloved hand should go nearer to the wound than the handle of the instruments.

FIG. II.—Showing the operation completed so far as the bone is concerned. Lane's bone elevators are still in position.

The skiagrams, of which I publish a selection (see Special Plate), are all from cases operated upon over three years ago, and the fractures involved the upper third in the case of C. H. and the middle third in the case of L. N. L. N.'s fracture was a very long one and somewhat spiral. The pictures taken shortly after the operation show very good apposition of the fragments, and, what is more interesting still, the late skiagrams show considerable strengthening of the bone in the neighbourhood of the clips. This demonstrates the fact that these clips do not interfere with the growth of the bone, and doubtless as time passes they will lose much of their grip upon the enlarging shaft.

I have also used this method of fixation in fractures of the tibia, where the reduction of the fracture is oftentimes particularly troublesome. Perfect alignment here is essential to avoid permanent lameness, and such injuries are resistant to manipulation owing to the lack of control over the lower fragment. The lower end of the tibia is certainly not an ideal site for a bone clip, since the bone is largely subcutaneous and the clip cannot be buried as it can in other situations. Nevertheless, if the clip occupies a position above the level of the boot it is not likely to cause trouble, and only occasionally have I had to remove one on account of discomfort. If for any reason it is necessary to remove the clip after its duty has been performed the wound must be re-opened and the clip prised from the bone. No surgical instrument that I know of will cut through this spring steel, and to find the loops of the clip and insert the introducer is extremely difficult. This instrument, however, has been made so that it can be taken apart and introduced, one blade at a time, like midwifery forceps.

With regard to compound fractures, it is generally recognized that the use of internal splints should be avoided until sepsis is banished. There are, however, cases where the position obtained by external splintage is so unsatisfactory that some fixation of the bone becomes justifiable, and an apparatus which secures the position of the fragments without penetrating their substance is surely better than wire or plates.

As a matter of fact, I have used this clip in several compound fractures, mildly infected, as is common in civil practice, with the happiest results. In these cases the clip should be removed as soon as there is evidence that a reasonable amount of consolidation has taken place and there is no risk of recurrent deformity.

Description of Skiagrams on Special Plate.

FIG. 1.—C. H., male, aged 5 years. Fracture of femur on September 4th, 1917. Skiagram taken on September 10th, antero-posterior view. Traction failed to reduce the deformity; 3/4 in. shortening.

FIG. 2.—C. H. Clip applied September 14th, 1917. Skiagram taken on September 18th, antero-posterior view. October 8th: Firm union, no shortening; massage started. October 29th: Patient could raise leg in bed and flex knee through 30 degrees; began to walk on crutches and swing leg. November 5th: Walking on leg and bending knee freely.

FIG. 3.—C. H. Skiagram taken December, 1920, antero-posterior view. Both legs 24½ inches in length. Perfect movement of all joints. Small area of thickening to be felt in upper third of thigh.

FIG. 4.—L. N., female, aged 4 years. Oblique fracture of right femur on September 22nd, 1917. Skiagram taken on September 25th, lateral view. Traction failed to reduce the deformity; 1 in. shortening.

FIG. 5.—L. N. Clip applied October 1st, 1917. Skiagram taken on October 4th, lateral view.

FIG. 6.—L. N. Skiagram taken three years later, lateral view. Perfect functional result.

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- ¹ *Lancet*, xciii, p. 726. ² *BRITISH MEDICAL JOURNAL*, January 5th, 1918.

THE RELATION OF THE CURVATURE OF VESSELS AND OF HOLLOW VISCERA TO THEIR INTERNAL PRESSURE.

BY

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In considering the pressure within hollow viscera and vessels it is constantly overlooked that the curvature of the containing wall influences the pressure within it.

Historic.

The general problem of the equilibrium of a stretched flexible membrane with the pressures on each side of it was solved by Lagrange¹ in his *Mécanique Analytique*, 1788. The subject was developed chiefly by Poisson² in memoirs dated 1812 and 1829. For surfaces of simple curvature the equations connecting pressure, curvature, and tension can be reduced to very simple forms, such as those given below, and their truth can be demonstrated without the use of higher mathematics. Such demonstrations are easily available in mathematical textbooks—for instance, Besant and Ramsey³ and Lamb.⁵ The formulae are also discussed in many textbooks of physics, such as Poynting and J. J. Thomson,⁶ or the more elementary books of Edser⁷ and of Wagstaff.⁸

They are usually quoted in connexion with the surface tension of liquids, since the surface films constitute, almost without complications, material illustrations of mathematical statements. Some further applications have been made in the domain of physical chemistry.

The physical principles are well known to engineers; in estimating the bursting pressures of boilers and steam-pipes the curvature of their surfaces has to be taken into account,⁹ and the formulae are embodied in the British Board of Trade regulations. The principles are still recognizable, though horribly disguised by the British units of measurements, in formulae used by artisans and to be found in "Mechanics" Pocket-books."¹⁰ When sheets, strings, or wires in tension are wound upon cores, or when a turn of rope is tightened round a bollard, the same principles are involved. Allied formulae are used by architects in estimating the stability of arches and domes.

Although they are thus familiar in many branches of science, the formulae and the physical facts which they express appear to be unknown to the majority of medical writers. An exception was the Rev. Samuel Haughton, M.D.,¹¹ who, in his *Animal Mechanics*, 1847, referred to Lagrange's work and applied it to the parturient uterus.

Formulae expressing the Relation between the Curvature of a Stretched Membrane and the Pressure which it Exerts.

For the derivation of these formulae works on mathematics may be consulted: here they are accepted as data.

In a stretched membrane let t (tension) represent the pull on either side of a line of unit length drawn on the surface, in a homogeneous membrane t will be everywhere the same; let p represent the excess of pressure on the concave side of the membrane over that on the convex; and let r and r' represent radii of curvature such that they lie in two planes at right angles to each other whose intersection is normal to the surface. If the C.G.S. system of units is used t will be dynes per centimetre, p will be dynes per square centimetre; and r and r' will be centimetres. Then—

$$p = t \left(\frac{1}{r} + \frac{1}{r'} \right). \quad 1.$$

If the content of the membrane is fluid, p will be everywhere the same.

As the sum $\frac{1}{r} + \frac{1}{r'}$ is independent of the aspect of the planes in which the radii lie (Euler), it is convenient to choose r and r' as radii of the principal curvatures—that is, the curvatures which are maximal or minimal. For the sphere $r = r'$, therefore, the pressure inside a spherical stretched membrane is given by the equation—

$$p = 2 \frac{t}{r}. \quad 2.$$

For the cylinder with straight axis, r' of the curvature parallel to the axis is infinite, and $\frac{1}{r'}$ is zero; therefore the pressure inside a cylindrical stretched membrane is given by the equation—

$$p = \frac{t}{r}. \quad 3.$$

The length of the cylinder does not affect the pressure.

The reciprocal of the radius is a direct measure of the amount of curvature, and the two terms are used synonymously in mathematical works; the equations can therefore be expressed in words simply—the pressure inside a stretched membrane is proportional to its tension and to its curvature, and the influence of curvature as such is emphasized.

Here a protest must be made against the practice, still common among medical people, of using the word tension to designate what is properly termed pressure. For exact definitions of these words reference must be made to the philosophical literature of mechanics; broadly a tension is an internal force which increases with expansion of the material bearing it, and a pressure is one which decreases. To speak of the "tension" of gases, of dissolved bodies, or of pulses is confusion of language and leads to confusion of thought. In the case of the pulse the arterial wall is in tension, the contained blood is under pressure; the pressure is a force directed outwards, the tension is a force directed along the surface of the wall; since the wall is curved there is a resultant force directed inwards; this force balances the pressure of the blood outwards. The wall may be said to "exert" pressure as a result of its tension and curvature. Another common source of confusion must be indicated. The word pressure as used by mathematicians and physicists designates the ratio of a force to an area, real or imaginary. The total force acting on a surface is not a measure of pressure, but the magnitude of the force divided by the