in a great many cases—probably the majority—ensures a successful result for the subsequent bone transplantation. Such a standard of safety is, however, founded on an empirical basis; each one of the three factors may prove untrustworthy.

In the first place a six months period is an arbitrary one, as in a given case the tissues may be sterile at the end of two months or may be still capable of infective reaction as late as nine, or even 12, months after healing. A knowledge of the anatomical situation of latent septic foci in these ununited fractures throws considerable doubt on the ability of physio-therapeutic treatment to produce with certainty a "flare up" when it is remembered that the encysted foci are found in the avascular fibrous tissue between and around the bone ends and in the bone ends themselves. For the same considerations no vaccine or serum test can be expected to afford evidence of any positive value. Finally, there can be no doubt as to the necessity of excising adherent skin scars in the region of the non-union, but in my experience this operation does not go far enough.

Provided the necessary preliminary mobilisation of joints, tendons, and muscles, and the stretching of contractures have been obtained, it is desirable to be able to carry out with safety a bone transplantation where indicated, at the earliest possible date. This is especially desirable in complicated injuries such as combined bone and nerve lesions where operative interference is necessary for the repair of the latter. Furthermore, from the standpoint of the patient the prolonged delaying of an operation is to be avoided, if possible, but this economic factor must not be allowed to exert undue influence in the plea for early operation.

We are confronted with the fact that there is no certain test or combination of tests by means of which one can determine when a limb has reached the stage of safety. It is therefore reasonable to regard every limb with an ununited fracture as capable of an infective reaction at any stage, however remote the time of healing may be. An attempt to effect a radical excision of the area containing the suspected foci in every case before performing the bone graft would seem to be a logical procedure.

A Two-Stage Procedure.

Working on this basis, during the past 18 months I have used a two-stage procedure in bone graft operations in the majority of my cases and have now adopted it as a routine in every case.

Stage 1.—When the wounds have been soundly healed for eight weeks, during which period regular physio-therapeutic treatment has been carried out, the following operation is performed. After an excision of the adherent skin scars the site of the non-union is exposed. The fibrous tissue filling up the gap is excised, together with a slice of the bone ends sufficient to expose vascular tissue. The block of tissue is removed as far as possible *en masse*, and all isolated bone fragments and attached bone "spikes" are included. The clean section of the bone ends and the removal of the fragments is an essential step. The excised tissues are placed in a sterile test-tube or jar and sent to the pathological laboratory. The bed for the subsequent graft is now swabbed out thoroughly with Harrington's solution. The bone ends and the region of the gap—now increased in size—are covered in by a restoration of the fascial and muscular coverings and the skin wound is sutured after undercutting the flaps to allow easy approximation.

This operation is at once an attempt at wound sterilisation, a provocative measure, and a reconstruction of the bed for the future graft. In two to three weeks' time the limb is usually ready for the resumption of physio-therapeutic treatment.

Stage 2.—The bone transplantation is performed in from six to eight weeks' time after the uncomplicated healing of the first stage operation. During this period the usual physical treatment is continued. Ionisation of the wound area is always prescribed in order to obtain the maximum softening of the superficial and deep scars. The details of the technique of the bone graft operation are outside the scope of this article, but my experience of more than 80 bone transplantations for various disabilities has emphasised the superiority of the inlay graft over all other methods. A graft must be long enough to reach several inches above and below the actual gap and should need no additional fixation when accurately wedged into the gutter.

The bacteriological examination of the tissues removed in the first stage is of the greatest importance, whether the findings be negative or positive. If the tissues prove to be sterile, and an uncomplicated healing of the operation wound occurs, the future bone graft can be awaited with confidence. The cultivation of organisms (other than skin germs, e.g.,

Staphylococcus albus, the appearance of which should cause a scrutiny of the operative technique) associated with primary healing of the operation wound affords strong indication that sterilisation of the area of non-union has been achieved.

Two cases in my series illustrate this point. In one, an ununited fracture of the femur of 12 months' duration, with wound scars which had been healed for six months, *B. proteus* was cultivated from the fibrous plug found in the medullary cavity of the lower fragment. Infection of the wound followed. In the second case, non-union of the radius, the same type of organism was isolated, but primary healing occurred and the patient resumed physio-therapeutic treatment in two weeks without any subsequent reaction. In this type of case the second stage should be postponed a little longer than usual, though the waiting period need not exceed three months.

In my opinion the two-stage procedure for bone-graft operations, carried out as described above, has conclusively proved its value, and I regard any procedure less radical than that advocated in the first stage as an inefficient index of the subsequent sterility of the limb and an inadequate preparation for the introduction of the transplant.

SOME ADVANCES IN POLYGRAPHIC TECHNIQUE.

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THE clinical polygraph has only gradually been making its way into everyday use since its introduction by Sir James Mackenzie many years ago. This instrument in the hands of a few pioneers has given us such valuable information of the mechanism of the heart beat, and has so far unravelled the tangled skein of cardiac irregularities, that it might appear surprising that the clinical polygraph is not now in daily use by all practitioners.

There are, I think, several reasons why this instrument is not as widely used by the profession as the importance of the information it yields would warrant. The chief obstacle may be a difficulty in procuring an instrument; but that is not the only cause, for one occasionally meets a medical man who possesses an ink polygraph but has given up using it. The great objection to the instrument in the past has been the length of time taken not only in assembling the instrument, taking the tracing, and then packing it up again, but in measuring out the tracing and arriving at a correct interpretation. The busy practitioner, much as he would like to use the polygraph, finds he cannot spare the time which is at present necessary if he would acquire the information it will yield.

It is obvious, therefore, that before the polygraph can come into general use the technique must be simplified. I

FIG. 1.—The polygraph in position of use, and the wrist splint.

claim that the following three procedures, which I have adopted, very materially reduce the time, not only in taking the tracing, but in measuring it and arriving at an interpretation: (1) the adoption of a box in which the instrument can be carried about fixed ready for use; (2) the use of a wrist splint; (3) the introduction of a modified slide rule for measuring out the tracing.

Description of Improved Methods.

With the aid of diagrams only a short description of each improvement is necessary.

1. *The new polygraph box.*—Fig. 1 shows the polygraph in the box. The top and front of the box open on hinges; when shut they are fastened by lock and key. All the parts of the instrument, including even the pens, are kept in

position for use. It is only necessary to lift the machine forward into the position shown in the figure and fill the pens before taking a tracing.

2. *The wrist splint.*—In the past a source of annoyance and loss of time in taking a tracing has been the movement of the patient's wrist, resulting in the radial pen being thrown off the paper and spoiling the tracing. This splint, which I have adopted and found very helpful, is also shown in Fig. 1. The wrist is fixed in a position of hyper-extension and the radial artery thrown into prominence. The ordinary wrist-piece is strapped into position round the splint, and the forearm then rests on the operator's knee. The radial pen will write perfectly straight on the paper, and it is possible to keep it quite close to the edge of the paper without any fear of the pen moving off; in fact, the patient can move the forearm without altering the position of the pen. The splint can be applied to either the right or left wrist. Some workers are now using the glycerine tambour elbow-piece for recording the brachial pulse instead of the radial. This, I believe, was first used in Germany and introduced into this country by Dr. T. Lewis. I do not, however, find that it gives such a good tracings as the old wrist-piece.

I do not propose to give an account of the ordinary methods now in use of measuring out a tracing with a pair of compasses. It is only those who use the polygraph who will at once appreciate the enormous saving of time and labour effected by the introduction of my slide rule.

3. *The modified slide rule for measuring tracings.*—This consists of a piece of polished wood with grooved sides to carry a slide. The slide has a window which is partially filled with a thin sheet of celluloid, and a space is left between the celluloid sheet and the ends of the frame of the slide, so that the waves can be marked on the tracing with a pencil. Fig. 2 shows a part of the slide rule, with a tracing

FIG. 2.—The polygraph slide rule.

fixed in position. The tracing is fixed at each end of the slide rule by drawing pins. The slide is then slipped on and moved until the sheet of celluloid lies over the ordinates. The ordinates of both the radial and venous curves are then traced on to the celluloid. These two ordinates are marked by a cross at their upper end. A line 1/10 second to the left of and parallel to the ordinate of the venous tracing is now marked in, c, and gives the position of the beginning of the carotid wave, when the radial ordinate is at the beginning of the rise of any one of the radial beats. Another ordinate, A, 1/5 second to the left of the carotid ordinate, marks the position of the beginning of the auricular wave. An ordinate, v, 2/5 second to the right of the carotid ordinate, gives approximately the summit of the v wave.

Any of these points can immediately be fixed in any particular part of the tracing by moving the slide along until the radial ordinate lies at the beginning of the rise of the corresponding radial pulse. Similarly, any two consecutive radial, carotid, or auricular waves can be marked on the celluloid sheet and the spacing rapidly compared throughout the whole tracing by moving the slide over it. Any other of the many measurements that may be necessary can be made in the same way.

The most convenient method of marking in these ordinates is to use a copying pencil, but if ink is preferred I think the best is Arnold's black waterproof drawing ink. When finished with, the ordinates can easily be erased from the celluloid sheet by a damp cloth. The ordinates can be marked in neatly and rapidly by running the pencil along a thick piece of celluloid cut to the segment of a circle described by the pen. The same arc of celluloid will serve for any tracing if the pens are pushed home into their receiver before taking a tracing.

I hope these improved methods will direct other workers to attempt to simplify still further polygraphic technique. These appliances can be obtained as follows: the polygraph box from Mr. D. Bulmer, 8, Rosebank-road, Woodsley-road, Leeds; the wrist splint from Mr. Arthur Vizard, 46, Great George-street, Leeds; the slide rule from Mr. Fred Raper, 24, Servia-place, Servia-road, Leeds.

ON REPAIR OF THE MALE URETHRA.

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THE plight of the man who by injury or disease has suffered the loss of a portion of his urethra is miserable alike from local discomfort and mental distress. Any operation which affords a possible chance of restoring the channel is worth a trial. It is for this reason that we wish to report a case in which we successfully repaired an extensive urethral defect by a method of grafting preputial skin into the gap. Whilst fully realising that no great stress can be laid upon an isolated and possibly fortuitous success, we desire to record the case, since there are, no doubt, instances of men suffering from gunshot injuries of the urethra in which the method may prove of some service. The operation was done over a year ago and the interval is sufficient to render the permanency of the result well-nigh certain. The details of the case are as follows:—

The patient, a strongly built man aged 37, was seized in April, 1917, with a sudden extravasation of urine due to a stricture of old standing. Very extensive incisions were made into the scrotum and lower abdominal wall with perineal drainage of the bladder. Much sloughing ensued, especially about the perineum, but he eventually made a good recovery, the whole of his urine passing by the perineal opening.

On Nov. 14th, 1917, he was admitted to the Manchester Royal Infirmary. Examination showed a small fistulous opening through which the whole of the urine was discharged. This opening was placed immediately in front of the anus and was embedded in much scar tissue.

On Nov. 26th the patient was anaesthetised and placed in the lithotomy position. A median incision 2½ inches long was made, so placed that it embraced the fistulous opening at the hinder end of the incision. Much scar tissue was encountered, but by the aid of a Wheelhouse staff the proximal end of the distal portion of the urethra was identified. This was dug out of scar tissue and freshened by a cross section. The distal end of the proximal segment was then sought. It was found easily, but was difficult to define owing to its being almost flush with the triangular ligament. With both ends thus freed, it was seen that there was no possibility of direct end-to-end union, the gap being 1½ inches in extent.

In order to obtain material to fill in the gap a circumcision was done on a year-old infant with a very long prepuce. This was done by the old forceps method. The portion of skin so obtained was divided vertically and by separating and reflecting the small strip of lining mucosa some increase of the size of the graft was obtained. The graft thus made was rectangular, and consisted for three-quarters of its area of skin and for one-quarter of mucous membrane.

The next stage of the operation was to convert this graft into a tube fixed to the divided ends of the urethra. The graft was first stitched by three sutures to the cut edge of both ends of the urethra on the dorsal surface of the canal. A large silver catheter was then passed and the graft was fixed by sutures at both ends to the cut edges of the urethra on its ventral aspect. A continuous suture, inserted parallel to the catheter, converted the graft into a tube, having skin and mucosa for its inner lining. The sutures were of a lightly chromicised catgut. The soft parts were then united over the graft with some difficulty owing to the scar tissue and the covering layer consisted of little more than skin, which was brought together without drain by sutures of silkworm gut. The metal catheter was left *in situ* and was retained unchanged for eight days, at the end of which time it was removed and no further attempt was made to pass an instrument. On the fourteenth day the patient developed a subacute left-sided epididymitis, due no doubt to the long retention of the catheter. This gave little trouble but was slow in subsiding. The wound healed without incident, no urine having leaked at any time since the operation. The patient passed urine freely after removal of the catheter and continued to do so without difficulty and with no undue frequency.

No further instrumentation was done until March 9th, 1918, 15 weeks after the operation, when sounds were employed to investigate the condition of the urethra. A 9/12 sound was passed without any difficulty. On his discharge from hospital at the end of March a sound passed without any evidence of narrowing of the grafted segment, and three months later a 9/12 sound passed readily.