SPLINTING FRACTURES OF THE HUMERUS

BY

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Although abduction ("aeroplane") splints for the upper limb are now in fairly general use the types are so various and their application often so indifferent that a description of a simple standard model and of its application may be useful, especially to those war surgeons who have not had experience of work in an organized fracture clinic.

A Simple Aeroplane Splint

The model illustrated (Fig. 1), made of Cramer wire, 10 cm. in width, follows fairly closely that of Böhler, except that the upright portion fitting the patient's trunk is not brought down over the iliac crest. It has been found that this is not necessary to keep the splint well hitched up into the axilla, and that it causes the patient needless inconvenience and even possibly helps to produce that tendency to rotate backwards round the trunk which

FIG. 1.—Upper limb abduction ("aeroplane") splint, made of Cramer wire, before padding. The splint has been bent unevenly where it is to fit into the axilla, to help prevent the tendency to slip backwards.

is the principal weakness of the Böhler splint. The portion of the Cramer wire that fits into the axilla is bent so that, as seen from the front, the part supporting the arm is at a right-angle with that part which fits against the trunk and lies in the sagittal plane, but, as seen from above, the arm support makes an angle forwards of about 30 degrees with the sagittal plane. When the splint is applied with the vertical part against the lateral border of the

trunk from the axilla downwards this forward angulation of the arm support ensures the attainment of the correct position of the arm on the splint, which is indicated below. Incidentally, in making the splint with this forward angulation of the arm support it will be found that the anterior edge of the arm support is at a higher level than the posterior edge. This causes the weight of the arm on the splint to exert a forward thrust which counteracts the tendency of the splint to rotate backwards. The splints are fixed together with wire in the model illustrated. They may, however, quite well be tied with tape so long as this is done tightly. Wire fixation is of course more lasting.

The next job is padding. The splint must be padded with wool or tow, very liberally applied and tightly bound on, so as to give the effect of a firm cushion, like a chair seat rather than a feather cushion. Traction is most simply obtained, for both closed and open fractures of the shaft of the humerus, by the application of an unpadded plaster splint from the deltoid to the wrist only. In supracondylar and condylar fractures the plaster must of course be extended to the metacarpo-phalangeal joints. It is also easier to fix the limb to the splint in plaster than without.

Only in cases of fracture of the neck of the humerus do the disadvantages of plaster outweigh the advantages, especially since full mobility at the elbow can be permitted and encouraged from the start. In these cases strapping is preferable as a means of traction. In all cases the traction to be applied is very slight, a piece of fine rubber tubing being a useful alternative to ordinary tape or twine.

How to Apply the Splint

The application of the splint (Fig. 2) has been very fully described by Böhler. The essential points are: (1) The splint must be *pushed up* into the axilla, thus causing full abduction of the upper fragment, which in cases of

FIG. 2.—Aeroplane splint, well padded, being held well up into the axilla, for fixation to the trunk. The limb is in plaster, to which traction has been applied. (Fracture of the humerus.)

fracture of the shaft is pulled down as well as forward by the pectoral. (2) The splint *must* be applied with the arm brought forward to form an angle of 45 degrees with the sagittal plane, and not, as many textbooks still illustrate, brought out straight from the side (Fig. 3). This is absolutely essential for correct alignment of the fragments, owing to the forward pull of the pectoral. The patient's hand should be almost opposite his nose (Fig. 4).

The fixation of the splint can be secured in a variety of ways. The basis is open-weave bandaging, overlaid with plaster-of-Paris, starch bandages, or, as in the case illustrated, with elastoplast bandaging (Fig. 4). It is usually advisable to bring some turns of the bandage from the bottom of the splint over the opposite shoulder, but the splint depends for its efficiency on firm bandaging to the *opposite* shoulder (Fig. 4), which should be well

FIG. 3.—In applying the splint the arm is brought forward to form an angle of 45 degrees with the sagittal plane.

FIG. 4.—Final position of the splint.

padded. A rolled bandage fixed to the splint gives comfortable support to the hand (Fig. 4).

This splint, once well applied, can remain untouched for two or three months. It is a great advantage to leave it on for a time after the fracture is well consolidated and full movements are allowed. There is never any difficulty in regaining adduction at the shoulder-joint, and the support afforded by the splint facilitates the development

of a full range of other movements. The splint should be finally removed only when these movements are fairly full and of course painless.

The Thoraco-brachial Plaster Spica

The alternative form of fixation for fractures of the humerus is the thoraco-brachial plaster spica (Fig. 5). In the case illustrated the arm has not been brought quite as fully forward as is desirable, and the degree of abduction is slightly greater than it should be. The plaster is unpadded, and extends to the wrist only (which should be protected with a little flannel bandaging). A metal stay is required, and a short piece of Cramer wire fills the bill. A cock-up splint is provided for the hand. The chief points to note are that the plaster is applied with the shoulder on the affected side dropped, and that the plaster is not brought over the opposite shoulder at all. The method is in fact fundamentally different from that of the (full) abduction splint, and the nature of this difference should be fully grasped. The upper fragment is left in

FIG. 5.—The thoraco-brachial plaster spica, an alternative form of fixation for fracture of the shaft of the humerus.

the position which it naturally occupies in fractures of the shaft, owing to the forward and downward pull of the pectoral.

In our opinion the plaster spica is the treatment of choice for compound fractures of the shaft of the humerus in the early stages. It gives better immobility, it facilitates closed treatment, and it is safer for evacuation, when the patient with a fresh or infected fracture may have to travel under trying conditions. Its only disadvantage is that it immobilizes the shoulder in a position which may, if it has to be retained for more than a few weeks, render the recovery of full abduction difficult. For this reason it is an advantage to change over, once consolidation is fairly well advanced, to an abduction splint for the later stages of treatment. No traction or fixation is then required, the limb being merely supported on the splint.

The plaster spica is essentially a splint for fractures of the humeral *shaft*. For fractures of the neck full abduction is required, and for supracondylar and condylar fractures the abduction splint is also preferable because it gives a better

elevation and because there is no advantage in completely immobilizing the shoulder-joint, which of course is never quite immobilized on an abduction splint.

Comment

The application of either splint is really not difficult and merely requires a little practice, which can be put in with great advantage on orderlies or assistants until the surgeon, or whichever member of his team is to do the actual job, is able to carry it out quickly, easily, and confidently. But it is quite essential to have the patient's conscious co-operation, and for this reason neither abduction splint nor plaster should ever be applied to a patient just recovering from an anaesthetic. If a general anaesthetic has been given the arm should merely be bandaged to the trunk as in the first-aid treatment of a fracture, and the splint or spica applied as soon as the patient has fully recovered from the anaesthetic. Skilled and gentle application, especially with an intelligent and skilled assistant to hold the limb *under slight traction*, is practically painless.

DIPHTHERIA PROPHYLAXIS

OPTIMUM DOSAGE AND TECHNIQUE IN USE OF ALUM-PRECIPIATED TOXOID

BY

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Of the reagents available for the specific prevention of diphtheria there can be little doubt that, volume for volume, the most highly antigenic is alum-precipitated toxoid (A.P.T.), the preparation of which was first described by Glenny and Barr (1931a). Thus, its value is widely appreciated and utilized in the immunization of horses; laboratory experiments on guinea-pigs have shown A.P.T. to be a better antigen than unmodified toxoid (Park, 1937; Jones, 1938), and Glenny and his colleagues (1931b) have provided the explanation of why this should be so. In human work, when used by one injection, its results, while admittedly erratic, are unapproached by those of any other compound employed as a single dose; while when used in two doses, as it always should be, it consistently produces a Schick-negative rate of over 98 per cent. (Chesney, 1938, 1939; Parish, 1936; Thomas, 1937; Lewis, 1939b, 1939c). Even, however, when two injections are employed the procedure may be open to improvement, as it is the purpose of this paper to demonstrate.

Many workers have carried out antitoxin estimations on the blood of persons injected with two doses of A.P.T. (Jones and Moss, 1937; Fraser and Halpern, 1937; Schall, 1938; Paschla, 1939; Volk and Bunney, 1939). For the most part these have been on small numbers of cases tested about three months after the second dose. Until, therefore, antitoxic estimations on a large scale are performed knowledge of the exact degree of antigenicity of A.P.T. in man must remain vague and conjectural. An attempt at such an investigation is now being made in Croydon, under the supervision of Dr. O. M. Holden.

Blood Antitoxin Values Sixteen Months after Two Injections of A.P.T.

It is not possible at this stage to give the full results of this inquiry, which is still proceeding. When A.P.T. was first used in Croydon, some two years ago, it was given

in a dosage of 0.1 c.cm. followed in a fortnight's time by 0.5 c.cm. in the same arm. Although it was realized that, immunologically, a month's interval was better, it was considered that a fortnight's interval, under the circumstances then prevailing, presented fewer administrative difficulties. Of the 100 cases so treated it has been possible after a mean period of sixteen and a half months to obtain blood samples from forty-nine. All cases were originally Schick-positive, and the mean age of the children at the time of inoculation was $9\frac{1}{2}$ years. All the cases were from two schools that had experienced a mild outbreak of diphtheria for some weeks before and during the time when the inoculations were being given. The antitoxin levels obtained were as follows.

Distribution of Blood Antitoxin in Forty-nine Children Sixteen Months after the Second of Two Fortnightly Injections of A.P.T. (0.1 and 0.5 c.cm.)

No. of children	Antitoxin Titre in Units per c.cm. of Blood										
	5	2	0.5	0.35	0.2	0.1	0.04	0.02	0.01	0.004	0.002
	1	1	1	1	2	5	9	7	11	7	2

Parish and Wright (1938) have pointed out that antitoxic immunity must be regarded quantitatively as there is no fixed level of immunity. An arbitrary level may be taken to be from 0.005 to 0.05 antitoxic unit per c.cm., a scatter of 0.045 A.U. around 0.01 A.U. In this way the above forty-nine children may be grouped into three classes: (1) Eleven, or 22.45 ± 6.1 per cent., had more than 0.05 A.U. per c.cm., which should be enough to neutralize the toxin produced by any but the most massive infection: these are immune. (2) Twenty-seven, or 55.1 ± 7.6 per cent., had between 0.005 and 0.05 A.U.: while these have less antitoxin than the previous group they may still be considered potentially immune. (3) Eleven, or 22.45 ± 6.1 per cent., had less than 0.005 A.U. per c.cm. It is conceivable that sudden invasion with large numbers of virulent organisms (as from an actual case) may cause clinical symptoms in cases of this group before they can react to the secondary stimulus: these are potentially susceptible. Allowing for chance variations, this proportion— 22.45 ± 6.1 per cent.—is unlikely to differ by more than twice its standard error in samples of the same size; that is, it may be 34.65 per cent. or 10.25 per cent. If this lower figure is taken it may be felt that 10 per cent. is an undesirably high proportion to have as little as or less than 0.005 A.U. only sixteen months after the injections, for this level may not give high protection against sudden invasion by virulent organisms. It is therefore necessary to consider means of increasing the antigenic effect.

Greater efficiency may be obtained in two ways without raising the total number of injections. First, the only reason for limiting the initial dose to 0.1 c.cm. is the fear of reactions. The results in the Croydon cases demonstrate quite clearly that little or no trouble will be experienced in children below 8 years, and, therefore, below this age the initial injection should be 0.5 c.cm., as Bousfield (1938) has suggested. Over 8 years it is wise to limit the dose to 0.25 c.cm. Chesney (1939) quotes work by Jensen (1937) as suggesting that there is "no immunological advantage in giving 0.5 c.cm. as an initial dose." While this may be so, it is quite common to find, even with careful work, a certain quantity of antigen escaping from the puncture when the needle is withdrawn, and in many cases it is likely that the effective dose is less than that actually injected. By giving 0.25 or 0.5 c.cm. allowance is made for this. The interval between the injections should never be less than one month.