It will be obvious that the apparatus is capable of considerable modification to suit the ideas of the individual surgeon. Thus the tubes may be made of unequal size and either smaller or larger than the standard size. The size and shape of the anastomotic apertures and the mechanism for forcing the tubes together can be changed without affecting the principles of action of the appliance. Indeed, that used successfully for the first three cases of the series was a home-made apparatus in the construction of which I had the valued assistance of Mr. Elson, the theatre mechanic at Charing Cross Hospital. The instrument here illustrated was made in stainless steel by Messrs. Allen and Hanburys; it was employed in the other seven cases.

That the anastomosis is an adequate one is shown by the barium enema film (Fig. 4) taken six months after

FIG. 4.—Barium enema of a case six months after operation.

operation. It will be noted that the two culs-de-sac, representing the original out-drawn loops, have retracted into the abdomen and are rapidly diminishing in size.

Results

The results in the ten cases are as follows. One patient died shortly after operation of a fulminating chest complication. In this case a preliminary blind caecostomy had been performed for complete obstruction three weeks previously. The remaining nine cases all did well. In eight of them one operation only was necessary, the fistula closing spontaneously at periods varying from six weeks to six months. In the ninth case the growth had already invaded the abdominal wall and formed an abscess therein when first seen. At a preliminary operation the abscess was drained and the diagnosis was confirmed by microscopy. A few weeks later the bowel was resected with a portion of the abdominal wall; the tubes were then inserted. Despite the patient's emaciated condition the anastomosis was established in the normal time. The resection of the abdominal wall in an emaciated patient, however, prevented both the falling in of the skin edges and the retraction of the bowel ends into the deeper layers, with the result that a permanent mucus-lined fistula was established. This produced a small amount of faecal leakage. A year later the patient submitted to a slight operation for closing this; the operation was performed without opening the peritoneum, there now being plenty of fat present to interpose between the closed bowel and the skin.

Some infection of the open part of the wound around the tubes almost invariably occurs, but in no case has it proved serious. I have lately been using the sulphonamide preparations prophylactically in these cases with, I think, some benefit. I have not seen any bleeding accompany the necrosis of the portion of the bowel wall,

nor has this necrosis extended beyond the limits of the pressure rims on the appliance.

Summary

A new instrument is described for use in extra-abdominal (Paul's) resection of the colon in which the drainage tubes themselves are made to perform the anastomosis after sufficient time has elapsed for the peritoneal surfaces of the two apposed loops of bowel to become adherent. In this way the dangers associated with the application of the ordinary clamp are avoided. In the majority of cases one operation only is necessary for the complete procedure.

VOLKMANN'S ISCHAEMIA

OBSERVATIONS AT OPEN OPERATION

BY

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The following case has afforded a study of the living pathology, and seems to be of importance in providing data for discussion of the cause and treatment, of this serious complication of fractures about the elbow.

Case Report

A child aged 10 had a severe injury of the elbow at 2 p.m. and was admitted to hospital at 6 p.m. A radiograph showed a supracondylar fracture of the humerus with marked backward displacement. There was intense swelling about the elbow, with deformity. The fingers were swollen, powerless, painful, numb, and livid. No contractures were present, but straightening the fingers caused severe pain. The radial pulse was absent. A diagnosis of an early stage of Volkmann's ischaemia was made.

Reduction was carried out at once, in accordance with the accepted view that full correction of the bony deformity prevents the onset or aborts the condition. A radiograph showed full reduction. At 10 p.m. there was no improvement in the fingers, and operation was decided upon. The alternative was to elevate the limb and reduce flexion of the elbow. Though this is a common method of dealing with the complication it seemed illogical as likely to displace the fragments and a contradiction of the generally accepted primary necessity for full reduction. The region was disclosed by an antero-external incision lateral to the biceps tendon.

Operative Findings and Procedure.—(1) There was no blood clot in the antecubital space. (2) The venous junction of the superficial and deep veins in this region was not compressed but shared in the general venous engorgement. (3) The muscle bellies of the flexor groups arising from the internal and external epicondyle were blue-black in colour. Division of the overlying fascia was carried out, and resulted in considerable improvement in the colour of the muscle. (4) The median nerve was similarly congested. (5) The brachial artery presented the most interesting features. At a point two inches above the elbow-joint there was a sudden change in its normal calibre to that of a thread: this change continued into the radial and ulnar branches. The tunica adventitia was injected with novocain, and this coat, with its sympathetic nerve fibres, was stripped for three inches above the constriction and just below it. No expansion of the artery or its distal branches occurred after the lapse of ten minutes. The wound was then closed.

Progress and Result.—In twelve hours the condition of the fingers had improved, and in eighteen hours pulsation had returned in the radial artery. In thirty-six hours full restoration of the circulation had taken place, as seen by a normal appearance of the fingers. Perfect function of the fingers, hand, and wrist had been restored, as well as full movements

of the elbow, except extension, which was limited by the operation scar. Six months after the original injury this scar was excised and skin-grafted. At this procedure the brachial artery and its branches were seen to be of normal calibre in the previously affected region.

Observation in the above case supports the opinion that an intense arterial vasoconstriction is present in Volkmann's ischaemia, the change starting at a definite point on the brachial artery. Intense venous engorgement is also present. Operative intervention upon the artery did not here result in a speedy alteration in the state of affairs. It cannot be claimed that an operative measure which brings relief after eighteen hours in an acute vascular crisis is a factor in the cure. Similarly, as regards operative measures on the venous side, there was no haematoma to release. While decompression of the muscle bellies caused an improvement in the appearance of these, there was no immediate relief in the peripheral circulation, as seen by the state of the fingers.

It would appear that surgical intervention directed to the arteries does not contribute to a favourable termination of the circulatory changes in Volkmann's ischaemia. Reduction of the fracture and expectancy, with judicious freedom of the elbow flexure, while preserving the position of the fracture, form the first measure, assisted by elevation. It is possible, however, that decompression of the muscle bellies by division of the fascia may prevent the occurrence of permanent muscle changes during the slow process of vascular readjustment.

Discussion

Just as pathologically there are two changes in Volkmann's ischaemia—arterial and venous—so do two theories based on these changes exist. Volkmann's opinion was that the condition was due to venous congestion and deprivation of arterial blood—an opinion which supports the pathological findings of these days but does not elaborate the mechanism of such changes. Brooks's experiments show conclusively that arterial deprivation alone does not cause these changes, and numerous clinical observations on cases of damaged arterial supply of the upper limb amply confirm this opinion. Brooks's experiments, repeated by Middleton, emphasize the venous element, and there seems little doubt that the resulting cellular infiltration and subsequent fibrosis in the muscles are the result of venous congestion.

The arterial change is very striking, but, as has been shown, treatment directed to the artery does not rapidly alleviate the condition. The sudden change of calibre roughly corresponding to the fracture site might suggest that this has been caused by direct contusion of the artery by the fractured upper fragment. Garber (1939), quoting a case of Clarke's, found this constriction in an identical position two inches above the elbow-joint in a case of ischaemia associated with fracture of the upper third of the radius and ulna. This important case seems to disprove any theory of direct injury. He also points out that pinching the artery causes a local constriction at the site of pressure, but that there is no distal vasoconstriction spreading to the radial and ulnar arteries. It is therefore not possible to assume that there has been an arterial disturbance by the direct effect of the fractured bone ends. The pronounced venous changes led Middleton to suggest that the essential cause of the ischaemia was compression of the junction of the superficial and the deep venous plexus, but, as already pointed out in my case, no haematoma was found in the antecubital fossa, and it was also observed that the venous

junction shared in the engorgement. It is apparent that the vascular changes in Volkmann's ischaemia are striking on both the arterial and the venous side.

It is probable that the venous engorgement accounts for the pathological changes in the muscles and that relief of this engorgement mitigates the permanent damage. A parallel is found in the good effect of cranial decompression in cases of cerebral oedema.

The cause of the arterial and venous changes has yet to be explained. A general venous engorgement can be accounted for by the distortion and general obstruction of the normal circulation by reason of severe deformity and the accumulation of metabolites which cause capillary dilatation. It seems that the physiological response to this is a vasoconstriction of the arteries in an attempt to diminish the blood flow to a limb already soaked with fluid. The practical inference is that attention must be directed to the venous engorgement by reduction of the deformity, elevation of the limb, and, if need be, the emergency measure of decompression of the muscle bellies to limit the local damage while vascular readjustment is taking place.

REFERENCE

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OCCLUSION OF THE BRACHIAL ARTERY AND VOLKMANN'S ISCHAEMIC CONTRACTURE

BY

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Until recent years the most widely accepted theory of the cause of Volkmann's ischaemic contracture was that it was due to acute venous obstruction. This view was supported by clinical observations and by the experimental work of Brooks (1922) and Jepson (1926). Middleton (1928) described the anatomical details contributing to the condition.

In 1928 Leriche published a case of Volkmann's syndrome following a supracondylar fracture of the humerus on which he had operated and found complete obliteration of the brachial artery. He resected the obliterated portion of the artery, and the patient rapidly recovered. Since then many cases have been presented supporting this observation (Fontain and Kunlin, 1936; Brentano, 1935; Fèvre and Bertrand, 1935; Leveuf, 1938; Leveuf and Funck-Brentano, 1938; Garber, 1939; and Griffiths, 1938a, 1938b, 1940). Furthermore, Wilson (1932) and Brooks (1922) showed that lesions similar to those of Volkmann's syndrome could be produced by occlusion of the main artery of a limb. Finally, both Jefferson (1934) and Griffiths (1940) have reported cases in which this syndrome has followed embolism.

Although not yet widely recognized in this country the above evidence shows that some at least of Volkmann's contractures originate from an arterial lesion. The following report may be of some value in support of this theory, but is open to the criticism that, since contracture did not develop, the case may not have belonged to this group at all. The arteriectomy recorded below is, I believe, the earliest following arterial contusion with signs suggestive of Volkmann's syndrome: the arteriectomy was done early enough, in fact, to prevent the development of this dreaded malady.