fixed in any position desired by means of the T nut controlling the hand-piece. The rubber band (E) is passed above the elbow and attached to the T-shaped metal loop (F), now fixed in position behind the elbow. The T screws (CC) are loosened and the forward end of the splint is drawn out till sufficient tension on the broken segments is obtained. The screws are then fixed in this position. Fig. 4.)

FIG. 4.

Universal splint applied to a case of fractured forearm. The forearm is completely pronated.

Fracture in elbow region.—In Fig. 5 the T screws (CCC) and the winged nuts (DD) (Fig. 1) have been loosened and the forearm portion of the splint has been straightened and fixed in position. The T-shaped attachable loop (F) has been removed and the rubber band (E) has been used as an accessory sling.

Advantages of the Splint.

The advantages of this splint are the following:—

1. Only one splint is required for any typical fracture of the upper limb.
2. A gradual, painless, and sufficient extension is effected.
3. It is the ideal splint for field dressing stations. Once affixed, it need never be removed, as the rubber bands can be detached and sterilised daily.
4. The weight of the splint, with attachments, is only 1½ lb.
5. It can be packed flat or in sections. By the latter method it can be sent by post in a cardboard box 12 × 9 × 1 in.
6. The entire splint can be sterilised and can at any time be placed in an arm-bath.
7. The comfort of the patient is enormously increased and pain is practically eliminated.
8. The nurse's work is reduced to a minimum.

This splint is a combination of three splints designed and used by the writer at the Barnet War Hospital, and the results there obtained emboldened him to seek a wider field. They have been tried and approved by the following surgeons, whose encouragement the writer would here wish to acknowledge: Colonel A. Carless, Eastern Command; Major E. Hey Groves, Beaufort War Hospital; Surgeon-General N. R. Howse, C.B., V.C., Australian Forces; Captain E. C. Hughes and Sir W. Arbuthnot Lane, Bart., Millbank; Mr. D. Ligat, Middlesex Hospital; Mr. V. Warren Low, St. Mary's Hospital; Colonel T. H. Openshaw, C.M.G., London Hospital. Special indebtedness is due to Major Hey Groves for the inspiration of the work and assistance in preparing this article; to Lieutenant H. T. Booker, R.E., for the drawings; and to Lieutenant W. Daunt, R.A.M.C., High Barnet War Hospital, for experimenting with the earlier models.

FIG. 5.

Universal splint applied to a case of fracture of the neighbourhood in the elbow-joint.

ON THE TREATMENT OF RECENT GUNSHOT WOUNDS WITH BISMUTH-IODOFORM-PARAFFIN PASTE.

WITH SPECIAL REFERENCE TO COMPOUND FRACTURES.

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A LARGE number of cases have now been reported in which the bismuth-iodoform-paraffin paste (B.I.P.P.), introduced by Professor Rutherford Morison, has been employed with satisfactory results. These cases, however, have all been sent to England suppurating freely before this treatment was applied, and its use in recent wounds has not been reported. The writers wish to record their experience of the use of B.I.P.P. in recent wounds as encountered in a casualty clearing station and to advocate this method as a treatment for recently infected wounds in which suppuration is not yet fully established. They have been further encouraged by the report of Dr. Louisa Garrett Anderson and Dr. Helen Chambers on a large series of cases treated in England, for they say "the best results are obtained when B.I.P.P. treatment is applied soon after the man has been wounded." The danger of gas gangrene has deterred surgeons from employing the method at this early stage in wounds which are constantly infected with the various strains of organisms which produce gas gangrene. Fleming found in the bacteriological examination of 127 cases of wounds from one to seven days old *B. aerogenes capsulatus* (*B. perfringens*) in 103 cases, streptococci in 102 cases, staphylococci in 40 cases, *B. tetani* in 22 cases. He found also a variety of other organisms in 67 cases. In a series of 25 specimens, including missiles, fragments of clothing, pieces of excised skin and portions of resected muscle from wounds seen in this casualty clearing station within 24 hours of the receipt of the injury, the following organisms were found by Captain J. W. McNee and Captain J. S. Dunn in films and cultures: in 23 cases large bacilli of perfringens type; in 9 cases streptococci; in 1 case *Staphylococcus aureus*; in 1 case Gram-negative bacilli. In only one instance in which some fragments of cloth from a wound were examined by films and cultures was the result negative.

Advantages of Method and Technique.

The method rightly used has the following advantages:—

1. The wound can be closed by sutures, rendering prolonged drainage unnecessary, and in the great majority of cases there is no suppuration.
2. No change of dressings is required and much disturbance of the patient is avoided—a most important matter to freshly wounded men to whom rest is essential.
3. It greatly increases the facility and reduces the discomfort of transport. Apart from wounds of the viscera and central nervous system, the management of compound fractures presents the most difficult problem for the surgeon in a casualty clearing station, and it is in this class of cases that the writers have found the method particularly valuable.
4. There is no increased liability to the development of gas gangrene. On the contrary, it is diminished.

Technique.—The patients usually arrive in a filthy condition, encrusted with mud. The skin around the wounds, for now they are usually multiple shell, bomb, or grenade wounds, is cleaned with ether soap and rendered as surgically clean as possible. The part is surrounded with dry sterilised towels. Surrounding the entry and exit wounds there is always a margin of necrotic skin heavily infected with micro-organisms. This is removed by excising a ring of skin one-eighth of an inch wide. The wound is then freely opened up and all foreign bodies and loose pieces of bone are as far as possible removed. Further, all devitalised muscle is resected and bleeding points are secured with Spencer-Wells artery forceps. This resection extends not only to muscle which is obviously necrotic, but also to areas which are devascularised and non-contractile. It is in muscle in this condition that gas gangrene begins to spread. Although this procedure is most important, the writers have had long enough experience to know that in itself it is insufficient to prevent the subsequent development of obvious signs of infection in compound fractures. The raw surface

is then well swabbed with methylated spirit, and the B.I.P.P., consisting of 2 parts of iodoform to 1 of bismuth subnitrate with sufficient liquid paraffin to produce the consistency of Devonshire cream, is smeared all over the wound and the ends of bone with a piece of dry gauze. It should be well rubbed in to form a thin film on the surface, and care should be taken not to leave any excess. It is convenient to leave the ligaturing of bleeding points until this stage, as otherwise the ligatures are apt to be rubbed off. Gaps in muscle can be brought together with catgut stitches when necessary. The wound is then sewn up with interrupted fishing-gut sutures and a dressing of dry sterilised gauze is applied; this is covered with wool, and, if required, a splint is applied. In a favourable case the dressing need not be disturbed until the patient is evacuated to the base, as it is an invariable rule to examine the wound before the patient leaves. If the outer dressing becomes stained with discharge it should be changed without disturbing the gauze in contact with the wound. If the patient has to be evacuated immediately to the base it is advisable to insert the fishing-gut stitches, but to leave them untied or only loosely tied. They can then be tightened later on without fear of tension being caused in the wound by retained discharge. This applies particularly to very extensive wounds.

It will be observed that the writers have differed from the technique described by Professor Rutherford Morison in the free excision of damaged tissues, the reason being the liability to the development of gas gangrene in recent wounds containing devitalised muscle. Such muscle is highly dangerous and permanently functionless; consequently, no further damage is done by resecting it. Moreover, the belly of the individual muscle is frequently torn across, so that the muscle as an organ is rendered useless, unless it be sutured with catgut, which this technique renders possible.

Results of Treatment.

As a rule there is a general reaction following this procedure lasting from 24 to 48 hours. This is shown by an elevation of the temperature and pulse-rate. This soon subsides and there are no other alarming symptoms, so that the surgeon must not be deterred and tempted to examine the wound. Should, however, the wound be examined, it will be found in a favourable case that the edges present the signs of a mild inflammatory reaction, the evidences of which have disappeared by the third or fourth day. There is a discharge consisting of serum mixed with the products of decomposing B.I.P.P. It is not foul, but smells strongly of iodoform. The amount is roughly proportional to the area of the raw surface involved. Should the case not be progressing well, the general appearance of the patient is most suggestive, and there is pain and tenderness in the part affected, and when examined it is red and swollen. The temperature and pulse-rate remain high. This has only happened in two cases, one a shell wound of the thigh, the other a grenade wound of the wrist, neither of them being compound fractures. The symptoms and signs were unmistakable the day following the operation in each case; both cases recovered after opening up and draining the wounds freely. The failure was probably to be attributed to insufficient resection of damaged tissues. So far there have been no cases presenting signs of iodoform or bismuth poisoning, but care has been taken not to use an excessive quantity of B.I.P.P. nor to leave any lumps in the wounds.

The writers have used this method since September, 1916, but not continuously. A large number of compound fractures have come under their observation since that date which have been treated by various methods; but as they have found this method gives the most satisfactory results, they now use it exclusively in all compound fractures. They have found it valuable also where amputation has to be performed on account of severe laceration of the tissues; in such cases the stump almost invariably suppurates otherwise.

Illustrative cases.—The following short notes of five typical cases illustrate its use in compound fractures:—

CASE 1. Compound fracture of left femur.—Lance-Corporal W., wounded by a shell fragment at 10 P.M. on Feb. 17th, 1917. The entry wound was over the anterior aspect of the thigh at the level of the junction of the middle with the lower third, size of a two-shilling piece. The exit wound at the same level was 4 inches in length, situated at the back of the limb. Operation 12 hours later. The wound was freely opened up in front and non-contraction muscle and many fragments of loose bone were removed. The same was carried out through the posterior exit wound. The biceps muscle which had been completely divided across showed much laceration. The wound was well dried out with methylated spirit and B.I.P.P. applied. The muscles were brought into apposition with catgut sutures and the skin with silk worm

gut. The patient made a straightforward recovery and went to the base on the seventeenth day after operation. The temperature on one occasion (fourth day) reached 102° F., after which time it came down to normal. The anterior wound was healed, and posteriorly, except for a sinus leading down to a bare area of bone, the wound was healing well. Bacteriological examination showed exudate from this wound containing streptococci and staphylococci.

Radiogram of Case 5, showing the appearance of the fracture after being treated with B.I.P.P.

CASE 2. Machine gun bullet wound of right radius.—Corporal B. was admitted to hospital at 2 A.M. on Feb. 28th with a wound of the right arm. The missile had entered just below the head of the radius and passed out at a point on the same level over the inner aspect of the limb. The forearm was very swollen and tender, and there was no pulse at the wrist. Operation 11 hours after injury. On laying open the wound the radial artery was found divided close to its origin; both ends of the vessel were ligatured and several fragments of bone which were completely detached were removed. The radius showed much comminution just below the head of the bone. Wound dried out with methylated spirit, gauze and the B.I.P.P. applied. The wounds were entirely closed without a drain. The patient left on the seventh day after the operation when he was dressed for the first time. Both wounds were healed by first intention. He was transferred to England on the fifteenth day after the operation quite healed and with the sutures removed.

CASE 3. Rifle grenade wound of right radius.—Private M., admitted to hospital on March 8th at 6 P.M. He had been wounded six hours previously. There was an entry wound in the outer aspect of the right forearm the size of a sixpence. The exit wound, which was larger and showed more destruction of the skin, was on the same level and on the inner aspect of the limb. Operation eight hours after injury. Both wounds were freely laid open and several fragments of bone were removed; the shaft of the radius, however, was not completely broken across. After following the usual technique the wound was completely closed in layers. The usual general reaction followed and patient left with a normal temperature and pulse on the fifth day. The entry wound was healed by first intention and the exit wound showed a small amount of blood-stained serum from one point, otherwise it was healed.

CASE 4. Compound fracture of femur.—Private, admitted on March 3rd suffering from a scalp wound and a compound fracture in the lower third of the right femur, due to shell wounds. Operation 12 hours after injury. The scalp wound was excised and sutured; this healed by first intention and the stitches were removed on the sixth day. The thigh wound was freely opened up and all foreign bodies were removed. Skin and torn muscle were excised. The raw surface was treated with B.I.P.P. and the wound sewn up. A Wallace splint with plaster extension was applied. The patient was evacuated to the base on March 12th, the wound being quite healthy, and Colonel Cuthbert Wallace, A.M.S., informed us on April 1st that he had recently seen the patient in a satisfactory condition in a base hospital.

CASE 5. Compound fracture of humerus.—Private, admitted March 22nd suffering from shrapnel wound causing compound fracture of surgical neck of left humerus. Operation 12 hours after the receipt of injury. A shrapnel ball was removed from the axilla by new incision. This was treated with B.I.P.P. and sutured. The wound of entry was excised and all dead tissue was cut away. The raw surface and bone ends were treated with spirit and B.I.P.P. in the usual way and the wound sewn up. Patient was sent to the base on March 26th. There was then no sign of any suppuration in the wound when it was redressed with gauze and spirit.

Conclusions.

1. The method is applicable to recent as well as to wounds several days old.

2. There is no increased liability to gas gangrene if care be taken to eliminate that danger by free incision of damaged tissue.

3. It is the simplest and most reliable method the writers have had the opportunity of employing of avoiding suppuration in infected gunshot wounds.

4. It contributes greatly to the comfort and well-being of the patient for the following reasons: (a) wet dressings and irrigations are avoided; (b) as the dressings need seldom be changed there is a minimum disturbance of the injured part.

References.—Rutherford Morison: *THE LANCET*, August 12th, 1916, p. 268. Louisa Garrett Anderson and Helen Chambers: *THE LANCET*, March 3rd, 1917, p. 331. Alexander Fleming: *THE LANCET*, Sept. 18th, 1915, p. 638.

THE HÆMOGLOBIN VALUE OF THE BLOOD IN SURGICAL SHOCK.

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In a Memorandum recently issued by the Medical Research Committee (published in *THE LANCET* of March 31st) evidence is brought forward that shock, experimentally produced in animals, is usually accompanied by a considerable loss of plasma from the blood into the tissues. The loss of plasma not only diminishes the volume of the circulating blood but also renders it more concentrated, and the increased concentration is manifested by a rise in the *percentage* hæmoglobin value of the blood. The Memorandum also contains a reference to observations made in France by Captain Marshall, R.A.M.C., which support the view that loss of plasma from the tissues is an important factor in surgical shock in man.

Surgical shock in man, however, is frequently associated with considerable hæmorrhage; and, as is well known, the normal reaction of the body to hæmorrhage is the rapid absorption of fluid from the tissues into the blood. By this means the volume of the blood is more or less completely restored to its former level, although the blood becomes more dilute and its percentage hæmoglobin value is lowered. It seems probable that in a patient suffering from both shock and hæmorrhage the percentage hæmoglobin value of the blood represents the outcome of two opposing processes—namely, shock which tends to concentrate the blood and hæmorrhage which leads to dilution of the blood. Determination of the percentage hæmoglobin value in such a case ought to show which of these processes is predominant; a low hæmoglobin value may be regarded as indicating that the patient is spontaneously increasing the volume of his blood at the expense of his tissue fluids, whereas if the hæmoglobin value is approximately normal the physiological reaction to loss of blood is being counteracted by the tendency of shock to concentrate the blood.

We have recently had the opportunity of determining the hæmoglobin value of the blood in several cases of shock. The patients were injured almost simultaneously, and were admitted a few minutes later to St. Bartholomew's Hospital. Three hours later, when the hæmoglobin value of their blood was determined, four of the patients had lost a considerable amount of blood, and in three cases the hæmorrhage was not completely checked; all the patients showed well-marked clinical signs of shock. The nature of the injuries and the observations made on the blood are summarised in the table.

The hæmoglobin determinations in Cases 1–4 make it clear that the patients who recovered reacted to hæmorrhage by absorbing fluid from their tissues into the blood, and thereby restored the volume of the circulating blood. On the contrary, this compensatory process failed to take place in the patients who died from shock. Further, in Case 5, who had no hæmorrhage, the hæmoglobin value rose considerably above the normal figure. These cases are too few in number to justify any dogmatic statement as to the prognostic significance of the hæmoglobin value of the blood in surgical

shock. It seems legitimate, however, to point out, first, that they entirely support the view that loss of plasma from the blood into the tissues is an important factor in shock; and, secondly, that they have a direct practical bearing.

The obvious inference from these observations is that, in shock accompanied by hæmorrhage, a normal or approximately normal hæmoglobin value indicates that the patient is unable to make up for the loss of blood by absorbing fluid from his tissues. In these circumstances the volume of his blood becomes inadequate for the carrying on of the circulation, and the intravenous injection of saline solution (preferably a hypertonic solution) is desirable at the earliest possible moment.

No. of case.	Man or boy.	Age.	Nature of injury, &c.	Hæmoglobin examination on same day.*		Result.
				3 P.M.	6 P.M.	
1	M	30	Compound fracture of tibia and fibula of both legs. Wound of right knee, involving the joint. Considerable loss of blood. Right leg amputated at seat of election 2.30 P.M. Hb sample taken immediately after the operation.	67	—	Recovered.
2	M	—	Both feet shattered; severe hæmorrhage. Both feet amputated approx. 4 P.M.	87	95	Died from shock 40 hours after injury.
3	M	—	Compound fracture of right ankle and considerable hæmorrhage. Superficial burns of arm and trunk. Amputation at seat of election at approx. 5 P.M.	92	—	Died from shock within 12 hours after injury.
4	B	17	Compound fracture of left tibia and fibula. Fracture of base of skull. Moderate hæmorrhage. No major operation performed.	62	—	Recovered.
5	M	—	Very severe deep burn of right leg and side; tissues charred to a depth of 1 in. Popliteal nerve exposed and partly burnt. No hæmorrhage.	108	94	Recovered.

* In each case the injuries were received at 11.40–11.50 A.M.

At the time of the first hæmoglobin estimation none of these patients, except Case 1, had received saline injections; Case 1 had 1 pint saline per rectum between 2.30 P.M. and 3 P.M. Between 3 P.M. and 6 P.M. Case 5 drank several pints of fluid.

A DEVICE FOR INSURING SPONTANEOUS SEPARATION OF BLOOD CLOT FROM THE WALLS OF THE CONTAINING VESSEL.

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ONE of the chief difficulties that I, doubtless in common with many other workers, have experienced in the obtaining of serum from blood is the frequent refusal of clot to separate from the walls of the containing tube or cylinder. Many pathologists, it seems, have never been troubled by this difficulty; others, however, have. For instance, Lord Lister, as quoted by Sir W. Watson Cheyne,¹ observed that if blood be drawn aseptically into a glass vessel sterilised by heat the clot which forms does not contract and squeeze out serum. But, on the other hand, in reply to this quotation, Wright states that² “the whole of the serum industry depends on the fact that blood when drawn into a vessel which has been sterilised by heat *does* contract and squeeze out serum.”

Thus we have apparently a disagreement between two very eminent observers upon one of the commonest laboratory phenomena. Lister's unqualified statement would meet with little support from workers who have had any consider-

¹ *British Journal of Surgery*, 1916.

² *THE LANCET*, Sept. 16th, 1916, p. 507.