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SURGICAL ADVANCES DURING THE WAR.

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IF we look in retrospect over the six years of war, we cannot help being impressed by the progress that has been made in war surgery. So great is the change between then and now, that we are apt to assume that it is all surgical and all advance. In order to assess fairly where we stand, we must recognize that there are three aspects to the matter: advances in accessory methods that help surgery, real and permanent advances in surgical technique, and improvements due to altered conditions of warfare. Of these the first is the most important.

The excellent results of surgery in this war compared to those in any previous war are undoubtedly due in part to the fact that the modern soldier is first-class human material, and that his fitness is maintained up to and during battle and preserved from the time of injury to the time he reaches the surgeon by the services that train, clothe, feed, house and transport him. It would be impossible to overstate the value to the surgical services of modern transport, from the ubiquitous Jeep, that mechanized mule that can go anywhere that man or animal can go to pick up and bring back wounded, to the Dakota that has worked from strips laid down a few hours after the battle has passed on and has abolished time and distance. Modern transport has served to get surgical units right forward, to move them as the line moved, to keep them supplied at all times; it has brought the wounded rapidly and smoothly to the advanced operating centres and away again to centres of definitive surgery and the more specialized units; in short, it has allowed surgery to be done as the needs of the wounded demanded rather than as the exigencies of war allowed.

The aims of war surgery, stated in the broadest possible terms, are to save life, to prevent suffering and to preserve function, and the chief causes of death, pain and disablement are hæmorrhage, shock and infection.

Of the medical advances that have contributed to surgical progress, the most outstanding is undoubtedly resuscitation as practised by the Army Blood Transfusion Service. This service, which, as a separate organization, is peculiar to the British Army, has enabled surgeons to operate, to operate without nervous haste, and to operate successfully, on men with

injuries that would certainly have placed them in the hopeless category in the last war, and has, in the opinion of the writer at any rate, been a potent factor in reducing the incidence and lessening the mortality of gas gangrene.

When the service was started at Bristol shortly before the war under Sir Lionel Whitby, resuscitation stood very much where it had done at the end of the first world war. Stored blood, though it had been used in Russia and Spain, was not in common employment. Liquid plasma was known but rarely used, and dried plasma and serum were unknown. Within a few months a large panel of donors had been raised in the West of England and an organization for collecting blood had been devised, a set of apparatus that in many parts of the world and under the most trying circumstances has shown itself to be better than that of any other army had been designed and put into large scale production, and considerable research had been carried out on the keeping properties of blood under every condition likely to be encountered, and on the means of sending it by every kind of operational transport. Blood substitutes were investigated, a technique for the filtration of plasma was developed, and a drying plant was installed. In addition to blood and blood substitutes, the service has supplied crystalloid fluids to the whole Army.

Under this central organization a base transfusion unit was established in every theatre of war to organize supplies of whole blood and liquid plasma from local resources and to distribute apparatus and dried plasma from home. The units in Middle East, and later that in B.L.A., were commanded by Lieut.-Col. G. H. Buttle. An essential part of the overseas transfusion service was the Field Transfusion Unit, consisting of an officer, specially selected and trained in the technique of resuscitation, and having with him technical assistants and a refrigerator van to carry his store of whole blood. The influence that the Army Transfusion Service with its band of experts has had on war surgery cannot be exaggerated. It became recognized that the Field Transfusion Officer was the key man of a forward surgical group, that without him a surgical team was robbed of half its value, and that where he worked the pre-operative ward over which he presided was rightly the functional hub of the surgical centre from which reception room, X-rays, operating theatres and wards should radiate.

Traumatic shock may have many causes and may be reproduced in the laboratory in a number of ways; but the experience of the battlefield has shown that in the healthy soldier recently wounded, shock is essentially oligæmic. The treatment of shock is early, rapid, and adequate replacement of the lost volume, and adequacy must be assessed in quality as well as quantity. In the first two years of the fighting research workers, especially in America, were plasma-minded to a dangerous degree. It was soon learned, however, that though plasma can restore blood volume in shock and apparently restore blood-pressure, it cannot bring a man who has lost blood into a condition to withstand operation, to ward off gas gangrene or to overcome infection, while its value in restoring blood-pressure is not great in cases where there is a blood loss of 40 per cent or more of the circulating volume or where the loss is likely to continue. The amount of resuscitating fluids used varied from campaign to campaign and from battle to battle with the type of fighting and the availability of blood, but in general 30 pints of blood and 20 of plasma are needed at a forward operating centre for every hundred casualties. The only criterion is the need of the man. The quantity to be given is the quantity he has lost; the rate at which it is to be given is as rapidly as possible till his systolic pressure has reached 90 to 100 mm. In cases of necessity blood has been given at the rate of half a pint a minute by using two veins simultaneously, and as much as 18 pints has been given in the course of a two-hour operation. Reactions have been recorded from the giving of incompatible infected or hæmolysed blood, but reactions with blood correctly grouped only occur in the oft transfused, and should not be encountered in forward surgery, where it was said that "Blood can do no harm if it is sent by Buttle and given by Buttle's boys." Anuria has been reported following transfusion, but the available evidence suggests that this is due not to the blood, but to the lack of it; that the kidneys are irretrievably damaged during the period of low blood-pressure that precedes transfusion, which thus allows men who would otherwise have died to survive long enough to develop anuria.

Chemotherapy has developed from tentative beginnings under the stimulus of war. At the outbreak only sulphanilamide and sulphapyridine were available, and nothing was known about their use in wound treatment. At the time of Dunkirk the position had not changed greatly: sulphathiazole, more potent than sulphanilamide and less toxic than sulphapyridine, had been added, but no firm conclusions on the practical applications of chemotherapy in war had been reached. The prophylactic use of sulphanilamide at the time of wounding was advocated, but, partly owing to supply difficulties, the suggestion was never implemented in the British Army, and it was not till America came into the war eighteen months later that the local application of sulphonamides with the first dressing was tried on a large scale.

By 1942 the experience of desert fighting had established the value of the sulphonamides in prophylaxis. They failed, as might have been expected, to sterilize contaminated wounds or to prevent infection in those which had received no surgical treatment, but they were able to keep a local infection local and to prolong from a few hours to many days the period during which the excision of dead and contaminated tissues was safe and profitable. This phase of the fighting was characterized by the length and difficulty of the lines of communication, by the light equipment and constant movement of the forward surgical units. During heavy battles, of which there were many, the first priority cases, abdominal and sucking chest wounds, hæmorrhages and mangled limbs, absorbed the forward operating potential, and all others had to be sent further back, many travelling several hundred miles before receiving their first surgical treatment. It was found that where selection had been good, the immobilization well carried out, and sulphonamides administered regularly from the time of wounding, these cases arrived in excellent condition, their wounds possibly foul and smelly, but the limbs around them soft and free from the signs of inflammation. The wounds were bacteriologically but not clinically infected and the patients were comfortable and well. At this time all transportable head injuries were sent back to the neurosurgical centre at Cairo, where excision and suture was nearly always found to be possible up to four days after injury. In all these casualties, regular chemotherapy was assured by the simple method of twice daily administrations instituted by Colonel Buttle, to whom British war surgeons and British wounded owe more than to any single man. Previously, when four-hourly dosage was attempted, the amount actually given on the line of evacuation was a matter of guesswork; afterwards every man put on sulphonamides and carrying the conspicuous sulphonamide label, received without fail five tablets at 08.00 hours and 18.00 hours, wherever he might be at the time.

In 1943 the first trials of penicillin were made in North Africa during the Sicilian landings. As supplies became plentiful and the Army moved up through Italy, penicillin was used increasingly in the forward treatment of wounds, and the operation of two-stage closure that was developed as a main plank in surgical policy in Italy was made possible by the help or at any rate by the feeling of confidence that it gave. When 21 Army Group invaded Normandy in 1944, they went with a fully organized penicillin programme and a penicillin officer to observe, advise and supervise its administration. Even in the grim weeks of the beachhead the majority of casualties had their first injection of penicillin within a few hours of wounding and maintenance doses during treatment and on the way to England. Later, when the Army broke out from that strip, penicillin administration was carried out during the whole phase of advance across Europe, regardless of movement and distance, with the same regularity as in a civil hospital.

The part that chemotherapy has played in war surgery can be assessed fairly only when the tumult and the shouting have died. At present, as with any new discovery of value, those who have fostered the method, those who feel that a nation at war should cry its wares, and those merely on the lookout for items of news value, tend to pull out the loud stop, while the honest and the cautious react by stepping on the soft pedal. Whether chemotherapy has influenced the course of flesh wounds reaching the surgeon early and treated by efficient excision is open to question. The general opinion of forward surgeons is that such wounds remain clinically clean and can be closed by delayed primary suture from three to five days later, whether treated with penicillin, sulphonamides or with no bacteriostatic. In gas

gangrene, too, there is no useful evidence that chemotherapy has played any part in delaying infection or saving life.

In more complicated wounds—those first receiving treatment many hours after injury, those in which complete excision has been impossible or in which dead space remains afterwards, those in which oozing or soiling from discharge continues after operation or in which bone is involved—chemotherapy has increased the scope and safety of surgery and allowed earlier closure. The secondary suture of compound gunshot fractures within ten days of wounding, converting them from open to closed fractures, is one of the outstanding advances of this war: that direct fixation of the bone fragments and the burying of unabsorbable materials in any quantity has led to failure, does not detract from the success of closure when such liberties are not taken. In wounds of the head and spine chemotherapy has given greater safety and improved results. In thoracic injuries, direct installation of penicillin into the pleural cavity has altered the outlook in hæmothoraces, reducing greatly the incidence of chronic empyemata and permanently damaged lungs. Operations for the removal of dead bone and inaccessible foreign bodies, and reconstruction operations, particularly those involving bone grafts, can, with the help of penicillin, be undertaken earlier and with correspondingly improved functional results, without the fear of a systemic flare-up following interference.

Penicillin is undoubtedly more efficacious and more widely applicable than any of the sulphonamide group. It is unaffected by the presence of pus or body fluids or by the density of the infection, and it is innocuous to the host in any quantity and over any period. The limitations to penicillin therapy lie in its bacterial field, which, however, contains most of the dangerous pathogens, and in the difficulties of its distribution and administration, which demand pathological control and hospital facilities that are not necessarily available everywhere and at all times in war. It would be a mistake to look on the final campaign in Europe as in any way typical of warfare. The luxury conditions under which the medical services worked, of personnel, of auxiliary help, of housing, of immunity from attack, of supplies of every kind, and of intake and evacuation of casualties, have never been seen before and are unlikely ever to be seen again. The sulphonamides can be used in any conceivable conditions of warfare and, combined with surgery, can give a protection that, while perhaps inferior to that conferred by penicillin, is a great advance on anything known before.

While resuscitation and chemotherapy are the two outstanding advances in parasurgical sciences that have led to surgical progress during the war, it must not be forgotten that many of the methods which during the campaign came to be looked on as a matter of course were new or on trial at its beginning. In the surgery of abdominal wounds, the routine post-operative use of gastric suction and intravenous fluids in all cases with lesions involving the alimentary canal was one of the chief factors contributing to the greatly improved results which have been recorded everywhere. These methods were only finding their way into civil surgery in 1939 under the influence of Wangenstein, and their introduction into the Army was largely due to the example of Major T. Giblin of the Australian Force in the Desert.

Against this background of improved surroundings in which surgeons, having at their disposal accessory methods unknown in the last war, worked upon the fittest fighting men in history brought to them by every device of modern transport, must be considered actual progress in surgical methods. Most important and most striking has been the gradual change in wound treatment: first excision, vaseline packs and closed plaster treatment; then excision, with drainage, immobilization in padded and split plaster casts and simultaneous sulphonamide therapy during evacuation; later the two-stage operation in which the primary debridement and the closure of the wound three to five days later were looked on as parts of one procedure, separated in time by the need to avoid the dangers of fulminating infection, and in space by the exigencies of war; finally the organization of forward surgery, penicillin therapy, evacuation, and base surgery with the object and result of closing 90 per cent of wounds within a week of their infliction.

To those who read the report of the Inter-Allied Surgical Conference in Paris in 1917, it

may seem that the final result of wound treatment in this war was to arrive at the same conclusions as did the surgeons in the last, with the added safety and improved results made possible by penicillin, and that the closed plaster treatment was an unfortunate interlude that set the clock back, confused and obscured the lessons that had been learned by 1918, and delayed the development of wound closure by some two years. Neither of these views is accurate. The closure of wounds in the last war made its appearance only in 1917, and at the Armistice it was by no means universally accepted or firmly established; the indications for suture were not clearly realized nor the dangers of primary suture appreciated. In this war the matter has become one of surgical policy rather than individual enterprise. It has been realized that delayed primary suture, if certain precautions are observed, can be practised without serious risk in the great majority of soft tissue wounds, and it is equally realized that primary closure, at any rate in wounds of the limbs, is wrong. The closed plaster method again is not an anachronism, but the best possible method under austere conditions of warfare that may be seen again, though it should never replace the two-stage closure when conditions make this possible.

In the treatment of late sepsis, the Bunyan-standard envelope has provided a device better than anything previously available. Modern methods and favourable conditions have made the kind of wound needing continuous or intermittent irrigation much rarer than in the last war; but for the granulating stumps of guillotine amputations, infected compound fractures of the bones of the leg, and late septic burns, the Bunyan bag has proved ideal, abolishing pain instantaneously and doing away with the need for dressings, yet allowing constant inspection and, if necessary, palpation of the wound surface through the transparent and flexible material, and bringing a foul sloughing wound to a state of clean healthy granulations in a few days.

There has been little progress in the operative treatment of vascular injuries. As in the last war, most surgeons carried arterial sutures in their kit, but few had the luck to find a lesion to suture and fewer still succeeded in restoring a patent vascular channel. A trial was made, especially by Canadian surgeons, of joining temporarily the severed ends of a main artery by tubes of glass or acrylic resin, in the hope of maintaining the nutrition of the parts distal to the injury till a collateral circulation had been established and shock had been overcome. Maintenance of a useful circulation was seldom obtained, and the method had so many obvious risks, the washing of toxic products or thrombi from the distal part of the limb into the general circulation, and the bleeding from other wounds which followed the necessary heparinization, that the method came to be regarded as no more than an interesting experiment, suitable only to conditions of luxury warfare and unlikely to pass into accepted practice. Ligature of a divided vessel has remained the standard treatment for arterial injury.

Much, however, has been learned about the care of the patient and the limb in cases of arterial injury, and the incidence of gangrene and of amputations has been appreciably lowered. The essentials are, first, restoration of the circulation to full efficiency and of the circulating blood to full oxygen-carrying power by transfusion of an amount of blood equal to that lost. Secondly, the fullest utilization of all channels leading to the threatened limb. In Africa dilatation of collaterals was obtained by injecting the sympathetic ganglia, but later it appeared that a more effective dilatation is obtained by warming the whole of the body except the limb. Trial has been made of fascial decompression, particularly in the calf after popliteal ligation, in order to assist the flow in the arterioles and capillaries, but without much success, and this step is probably unwise unless the calf is obviously tense. Thirdly, reduction of the metabolism of the starved tissues and, therefore, of their demand for oxygen. This is achieved by keeping the limb cool. The maximum benefit is probably obtained by exposure to room temperature in a cool climate, and further cooling by ice may cause damage.

The surgery of abdominal wounds has remained practically unchanged since the last war, an indication, not of any lack of assertiveness in the forward surgeons of this war, but of the high standard set by those of the last. That the results are better is due, above all, to acces-

sory methods, to rapid and smooth transport, to the abundant supplies and nursing facilities that were put forward, to rapid and adequate resuscitation before operation, to suction and intravenous fluids afterwards. The one technical advance to be recorded is the adoption of a policy of exteriorizing colon wounds and performing proximal colostomy for those of the rectum and even for large buttock wounds near but not involving the anus. Experienced surgeons have safely sutured small wounds of the large bowel, particularly on the right side, but exteriorization remains unchallenged as a general policy.

In wounds of the head, the chief advance has been the organization of special units to attend to these injuries. In Africa till the end of 1942 head injuries were all sent to a neuro-surgical centre at the base in Cairo, and the clean healing and excellent results that were obtained under these difficult conditions were proof of the advantages of segregation as well as of the great value of the sulphonamides. When the line lengthened beyond Benghazi, a second neurosurgical unit was sent to work in Cyrenaica, and as the pursuit continued this unit was split into an advanced section with the Eighth Army and a base section at Tripoli which received the less urgent cases direct from the front and undertook the after-care of those operated upon by the forward unit. Later an ophthalmic unit was grouped with the neurosurgical one, and eventually in Italy an otolaryngologist and a maxillo-facial surgeon were added to the team.

In general, it may be said of special surgery that the policy of having few units, and those large and good, has proved its value against the alternative one of peppering a number of lesser experts round the forward surgical groups, where segregation is impossible, and the one-track man is little help to his hard-pressed colleagues yet gets too little of his own work to learn much. These specialist units have been placed so far forward that they can receive the majority of the severely wounded after resuscitation but without previous handling yet far enough back to be at the meeting point of several lanes of forward evacuation and to be well housed, staffed and supplied.

The results of this policy can be seen in improved results, whether judged by mortality, by clean healing, or by the control of late infection. The death-rate from penetrating head injuries, which was 45 per cent in the only fully recorded series of the first world war, that of Cushing, fell to 20 to 25 per cent in the fighting in Africa, Italy and Normandy, and to 10 per cent in the later stages of the fighting in Europe. Deaths from late infection, which amounted to 25 per cent in Cushing's cases, were 11 per cent in the earlier African fighting, 4 per cent in the Tunisian campaign and 6 per cent during that in Europe. The percentage of operation wounds healing by first intention has risen during the war from 70 per cent to 90 per cent. The same general principles as were enunciated in the last war remain, but the advent of bacteriostasis has enabled primary closure to be carried out in the majority of cases.

A new concept is the closure of basal wounds, not merely from the skin, but from the cavities of damaged air sinuses by radical treatment of the sinus and by patching the dural defect with fascia lata. It is in such wounds that the co-operation of the otolaryngological and maxillo-facial teams has proved particularly useful.

In chest surgery special teams have rendered the greatest possible service, particularly in the evolution of principles, in studying the application of chemotherapy to thoracic injuries, and in dealing with late complications. The chief advance that has become apparent during the war is the acceptance of the principle that an injured chest should be emptied as soon as possible, not merely of blood, but of air, a principle expressed in the slogan of the Consulting Physician to 21 Army Group, quoted by his surgical colleagues, "Having saved the life, save the lung."

Plastic surgery in the last war was concerned with the late repair of severe deformities, particularly those of the face, at special centres in the United Kingdom. In this war maxillo-facial units, more properly designated plastic units, for much of their work was concerned with injuries other than those of the face and jaws, were attached to each Force in the Field. While no striking departure from the principles laid down at that time have appeared, the

presence of forward plastic units has enabled facial injuries to receive their first treatment upon lines designed to help the subsequent reconstruction, and the final stages have been carried out many months earlier with the help of penicillin. Plastic surgeons have co-operated with neurosurgeons in the primary treatment of head injuries and with orthopaedic surgeons in late repair work, they have assumed the care of major burns and of flesh wounds with large skin loss, and by their advice on straightforward methods of skin grafting and simple flap transference, they have been largely instrumental in extending the practice of two-stage closure to about 90 per cent of soft tissue wounds and to a proportion of compound fractures that is only slightly less.

The third aspect of advance, the change in the circumstances of war as they affect surgery, must be taken into account in any fair assessment. In 1941 Britain was alone, fighting for her life against a world of enemies; in 1945 her armed forces, with those of her allies, were sweeping all opposition before them. In Abyssinia wounds of the limbs were treated by the closed plaster method and healed by granulation, and wounds of the head and abdomen were, for the most part, fatal. In Africa flesh wounds were excised and drained forward and closed by secondary suture at the base, many hundreds of miles away, about the third week; the mortality of head wounds was about 20 per cent and of abdominal wounds about 40 per cent. In the Italian and European campaigns wounds were closed within the week by the two-stage operation, and the death-rate for head wounds fell to 10 per cent and for abdominal wounds to 30 per cent during the final stages.

This general improvement does not in any sense represent an advance in surgical skill. The progress to two-stage closure has been a gradual development, aided by steady advances in chemotherapy, for which the surgeons in Italy deserve full credit, but a development only possible in the surgery of an Army that was always advancing and confident of victory, protected day and night by an aggressive air force, rich in transport and supplies. To have carried out two-stage closure under the conditions of the desert advance would have been impossible; to have attempted it in Abyssinia would have been criminal folly. The results with abdominal wounds depend still more on time, place and circumstance, for in these injuries chemotherapy offers little help; the figures of any surgeon or of any group reflect, not success or failure, skill or incompetence, but the interplay of factors over which surgeons themselves have no control and medical administrators but little. It cannot be foreseen that the Ritz-Carlton conditions which the medical services on the Allied side enjoyed during the closing phases of this war will ever be repeated, and under more austere conditions a return to the simpler methods that have shown their worth in the past may be the truest form of advance.