CHAPTER XII

THE GENERAL SURGERY OF WOUNDS IN THE GREAT WAR

THE *movement* of the casualty has been followed to a place of comparative safety at railhead; the other component in evacuation now calls for notice namely, concurrent *treatment* in the several posts or stations along the route.

The position of these posts, and the facilities for treatment there, were determined in part by military exigency, in part by physiological importunity. Developments in the scheme of evacuation were efforts to co-ordinate the physical time-constants of transport with the physiological time-constants of treatment. Geographically, the main problem centred on the location of the Hospitals of Evacuation.

The evacuating hospitals

At the end of the static warfare of 1916-17, some 10 to 20 miles on each side of No-Man's Land, the zones of the "Hospitals of the Front,"[1] Allied and German, stretched almost unbroken from the sea to Switzerland—the main line of defence in the treatment of wounds and of wounded men against wound infection and wound shock, and—what was only less important—against wastage through needless evacuation to the Base. In the warfare of the Western Front, these units may be visualised as a receiving, digesting, and discharging system for the whole of the vast outflow of sick and wounded from the front line. This stream flowed in continuously, with intermittent spates and occasional floods; less those "returned to duty," flowed out again by ambulance train, car, or barge to the expeditionary base (or the "hospitals of the interior")—a total for the B.E.F. for 1914-18 of 3,528,486 sick and 1,988,969 wounded admitted to medical units.

[1] British "Casualty Clearing Station" (C.C.S.); French "Hôpital d'Evacuation" (H.O.E.); American "Evacuation Hospital" (E.H.), German "Feldlazarett" (F.L.). The Feldlazarett seems to have combined in some respects the functions of our field ambulance "tent" division and casualty clearing station. *See also Appendix No 0*

It may be roughly estimated[2] that the battle-casualty reached this stage in his journey some 4 to 48 hours after wounding, the average being probably 8-12; and here, in the latter years of the war, he entered the atmosphere of a "hospital," laid out, organised, and equipped for *effective treatment* as well as for *movement*; beds with sheets, arranged as "wards" in huts or "brigaded" tents,[3] operating theatre, highly organised quartermaster's department, a nursing staff of fully trained women "attached" to the army as a "Nursing Service,"[4] surgical, medical, and radiological specialists. Here "first aid" and emergency treatment gave place to "resuscitation," operating under anaesthetic, and rest in a bed and skilled nursing.

Their function: the operative centre of gravity

On the Western Front, in respect of wounding—which we have accepted as the prime interest in the problems of evacuation—the casualty clearing station was essentially a centre for classifying (*"triage"*) and treatment, in particular for *operating*. From "the end of 1915" onwards, says the *British Official History*, the prime urge in the evolution of the C.C.S. from the "clearing hospital," the dominating feature of its activities, and the place of the unit in the military system, derived chiefly from the *progress made in the science and art of military surgery*, in particular in the *general surgery of wounds*. The natural line of approach, therefore, to an account of the functions, structure, and methods of work of the C.C.S., which will be given in the next chapter, is through a study of the evolution in the Great War of the *general treatment of wounds and of wounded men*. The evolution of the special surgery of regions and organs, though closely related to this, is an independent subject, and will be dealt with, so far as the scope of this work permits, in the next volume.

The objective

The clinical and experimental history of war surgery can without distortion be epitomised as a striving for *asepsis in the wound*, and for *counter measures to traumatic shock, in the wounded man*. A full study of these two problems would occupy—as it does in the great British, American and German medical histories of the Great War—

[2] For obvious reasons exact records of this are non-existent.

[3] *See plate at p. 413, and Appendix No 11*

[4] For status and duties of the Female Nursing Service *see Vol III* Female nurses were not used at the front in the French and German Armies

many hundred pages. On the other hand a mere statement of the theory and practice of wound surgery as at the end of the war would tend to set up an artificial end-point to what must be a progressive evolution.[5] Greater advantage it is thought will accrue from an endeavour to follow (in outline) the evolution of war surgery, from the mistakes and crudities of 1914 to the triumphs of 1918. For it cannot be thought that the Great War will be the last in which the road to success will be rough and toilsome, or that the study of the lines of research found most fruitful will not be of value. To this end, first of all we epitomise briefly the chief *pathogenic and clinical factors* in the problem that faced the surgical profession at the beginning of the war, as seen in the light of our post-war knowledge.

The factors in wound surgery

Wound surgery, it must be repeated, presents two distinct and well-defined groups of practical problems—(a) those which relate to the wound as such, and (b) those which derive from the function and structure of the part or organ wounded.

The British Historian says:—

"If it had been possible at the beginning of the war, as it was at the end, to prevent or control the spread of the septic process in wounds in the early stage, then the remedial operations on nerves, tendons and other structures which were so numerous when the wounds were healed or healing, would also have been greatly reduced in numbers and would have been more successful in their result."[6]

And it does not overstate the case. On the Western Front till the end of the war, the problem of the *wound, per se,* dominated the whole domain of surgery almost as imperiously as in the days of Hippocrates, of Paré, of Hunter, of Lister. Crowned though it was by ultimate success so dramatic as to wipe out the memory of early disasters, the history of the surgery of wounds on the Western Front in the Great War[7] is

[5] For example, through the achievement of Ehrlich's ideal of a "therapia sterilisans magna," for the coccal group, by the agency of drugs of the sulphanilamide type.

[6] *History of the Great War. Medical Services. Surgery of the War Vol. I p. 343.* "Wound Treatment in Hospitals in the United Kingdom" by Colonel C J. Bond, A.M S.

[7] The history of the surgery of the War as seen from an international and scientific standpoint has not yet been written. The nearest approach seems to be the American, an immense work of over 3,000 pages. From the standpoint of British experience the *British Official History* is admirable. No "Official" French history has been published—the works mainly consulted have been *Le Service de Santé* (Mignon), *Le Service de Santé de la III Armée* (Bassères), and the *Military Medical Manuals*—English translation edited by Sir Alfred Keogh The German

yet a painful and tragic one, by reason of the huge case mortality and morbidity associated with wounding, and of the fact that this was due chiefly to wound disease for which the medical service was nearly three years in finding and applying an effective remedy. And though the results ultimately achieved in the prevention of wound infection must be accepted as very remarkable, and certainly as calling for record for the benefit of warring posterity, and even, in some small degree, of civil practice, yet, like many other "lessons of the war" from which civilisation has been exhorted to find the basis for a new and higher plane of existence, the surgery of the war was in many respects a *réchauffé* of sordid experiences which it was thought had been swept into the scientific dustbins as relics of an unpleasant past.[8]

Return to Lister and Hunter[9]

From the first impact, in August-September of 1914, of virulent anaerobic infections with primary or secondary streptococcal involvements, in a degree increasing with the trench bombing warfare and high explosive bombardments of 1915-16, the medical profession found itself thrown back on the beggarly rudiments of its art, and called on to face anew the elemental problems of

Medical History of the war consists of (1) *Handbuch der Arzthchen Erfahrungen im Weltkriege 1914-18, Vols. I to 9*, edited by Prof Dr Otto v Schjerning, Chief of the German Medical Services during the War. (2) *Sanitatsbericht uber das Deutsche Heer (Deutsches Feld-und Besatzungsheer) im Weltkriege 1914-1918, Vols. I and III (Official History). Vol. II* was published in 1938 but was not available for this work.

[8] There are two sides in the interesting controversy that has been waged around these issues. "Perhaps nothing more forcibly demonstrates the change in conditions of surgical practice between those days" [*i.e.* "two hundred years ago" when "the craft of surgery had not been separated from the craft of barbery"] "and the present time than the fact that there is no worse training for the modern surgeon than that given by the necessarily slapdash treatment of war casualties." (Sir Alan Newton, Halford Oration, *M.J.A. 9th Jan., 1937, p. 41*). And again, "The work of a military surgeon develops quickness and resourcefulness, but in one respect military surgery is not good as an example—the personal responsibility is much greater in civil life. Younger men will have to bear that in mind when they go home and operate" (Lieut.-General Makins at the 11th Session of the Research Society of the American Red Cross in France, 22-23 Nov., 1918).

The first few editions of "Rose and Carless'" *Surgery* published after the war included a chapter on war surgery. In the editions subsequent to 1927 this was omitted as of no particular value to the civil surgeon.

On this, however, two comments should be made. First, that the enormous increase of road accident has some—though not it would seem a great—bearing on the matter. Second, and of great military importance, that (as pointed out by Sir Anthony Bowlby in the *British Official Medical History*) the surgery of war wounds demanded technical expertness of a very high order. It is indubitable that other important qualities were required as rapid decision, courage, restraint and great powers of endurance. Indeed a race of expert wound surgeons was evolved in the war, chiefly from the young men who learned their surgery on war wounds, and, in Australia at least, they have "made good" in civil life.

[9] It would hardly overstate the lapse to say, instead, "to de Mondeville and Paré."

wound healing; this experience it had to suffer before it could even begin to tackle with effect the gargantuan feast of clinical experiences, experiments, and problems in regional and reparative surgery, provided by the War Lords of Attrition in the shape of hordes of desperately wounded men, emerging not only from the major offensives of the Somme, Arras, and the Salient, but from the normal quietude of the Western Front. It was found necessary indeed (and the fact is one which gives food for thought) to begin *de novo* where Lister did, *i.e.*, with the knowledge given to humanity by Louis Pasteur that, whatever might be the cause of organic "disease" and nature of its "inborn factors," the pathogenesis of "diseases" due to "germs" was definitely, even crudely, mechanistic; to be tackled with mechanical weapons—selective chemical poisons, ablutions, drainings, excisions, as well as anti-toxins, vaccines, lymphogogues and vitamins. At the same time never in the history of scientific medicine was it more intimately understood that surgery is successful only in proportion as rational interference co-operates with the organic and instinctive processes that we identify in the *vis medicatrix naturae*.[10]

Apart from some disorder of the *"milieu intérieur"*—as by avitaminosis, diabetes, or chronic nephritis; or by some non-specific or temporary physiological disturbance, such as fatigue, or lack of food and water[11]—two factors militate against prompt

[10] The treatment of wounds is concerned with two processes, namely, *organic reaction* and *intelligent intervention*. The rational conduct and control by man of his physical health involves deliberate incursion into the domain of those primitive vital (biochemical and physical) processes, the central nervous control of which is vested in the lower cerebral centres and vegetative nervous system, whose activities in promoting healing we term the *"vis medicatrix naturae."* Of the origin of this term little seems to be known although the process was recognised by the ancients. *Hippocrates B.C. 460-357 c.* taught that "treatment is expectant though intervention may be profitable." *Ambroise Paré A.D. 1510-1590*: "I dressed the wound, God healed the patient." *John Hunter A.D. 1728-1793*: "The injury done has in all cases a tendency to produce the disposition and the means of cure" *Lister A.D. 1827-1912*: "I believe I happened to be the first to direct attention to the antiseptic agency of living structures, and there is, perhaps, no one who attaches greater importance to it than I do." *Colonel H. M. W. Gray*, Consulting Surgeon, B.E.F., *1918*· "The greatest principle of all is that of wisely assisting nature in her attempts to cure." The phrase *"vis medicatrix naturae"* appears to have been coined by the Glasgow physician William Cullen, 1710-1790.

[11] A matter of considerable importance, but one into which it is not possible to enter, concerns what has been termed the "Physiology of the Soldier." While there would seem inadequate grounds for postulating (as has been done) a peculiar physiological and psychic constitution referable to the war environment in effect universal among those who served in the front lines, it is indubitable that specific departures from normality on occasion can be discerned. In particular may be instanced the physiological degradation on Gallipoli from deficiency in accessory food factors, of water, and perhaps of carbohydrates; the "barcoo rot" of the Sinai-Palestine campaign, and on the Western Front the psychic shock of the "First Somme," and in general the great incidence of infection and of secondary

recovery from a wound *viz.*, the effect of the *physical trauma, per se,* and that of *microbial infection.* Since our forebears saw in "laudable" pus an essential element in the natural healing of wounds, the processes of healing and the local reaction against infection have been envisaged as running hand in hand. The problems of war surgery revolved round these elements in the situation.[12]

The Pathology of Wounding

Physical trauma in itself is, obviously, a cause of dis-ease, and it evokes "reactions," local and general, which do not differ fundamentally from those elicited by "pathogenic" organisms. Each has its internal components both of trauma —physical and toxic respectively—and of reaction general and local. We are concerned then with (1) the physical and psychic concomitants of wounding in general, such as pain, haemorrhage, and "traumatic shock," together with the specific physiological effects of regional and systemic traumata: and (2) with the infective concomitants—general intoxication, and local trauma from absorption of bacterial toxins or invasion by parasitic micro-organisms.

Having in mind these divisions and cross divisions of the subject, we may set it out simply for examination as follows:—

1. Pathology of the Wound. (*A*). Types of *missiles;* (*B*). Types of *wounds*; (*C*). Types of *infection.* 2. Pathology in the Wounded Man. (*A*). Effects of wounding *per se;* (*B*). Effects of "septic" infection.

1. The wound

The Traumatic Agent. (*A*). *Missiles.* Some 85 per cent. of all wounds (*i.e.,* of those admitted to field ambulance), including gassing, sustained by the A.I.F. on the Western Front were caused by

wound shock. One factor in the production of the latter, it is suggested, was a glycogen deficiency brought about by the frequent coincidence, while in the line, of defective nutrition, in particular of carbohydrates, with excessive physical and mental strain. The effects of haemorrhage were augmented by the concurrence of inadequate fluid intake with "sweat and fighting."

[12] It is entirely pertinent to an account of the evolution of antisepsis and asepsis in the war of 1914-18 to recall that de Mondeville in the 14th century taught aseptic principles, and that Larrey in the 18th-19th knew the value and the limitations of immediate suture and of antiseptic substances.

missiles.[13] The history of missile wounds in war as well as the mechanical factors concerned in their production has a direct bearing on the surgery of the Great War.

Rifle Bullets. The introduction at the end of the 13th century of "fire-arms" was associated (it would seem) with a much more lethal type of "wound" than heretofore. The "poisoning" of the wound attributed to the first "fire-arms," which made them for a time anathema, was doubtless the sepsis which developed in the large contaminated wounds caused by the low velocity soft leaden bullets which often themselves lodged in the wound. The velocity of the "rifle" bullet increased, but no fundamental change in small arm ballistics or wounding took place till the eighteen-eighties when the introduction of small calibre high velocity rifles burning "smokeless" powder, of which the French "Lebel" rifle was the first, throwing a hard small conical bullet with enormous velocity, opened up a new era in military surgery, as it did in warfare. Two new types of wound appear namely, the clean drilled wound with small aperture of entrance and larger of exit, and that brought about by the "explosive" effect of the high velocity bullet at close range. The ensuing debates concerned first the cause of these effects and their military significance, second their relation to the new international drive to eliminate "unnecessary suffering" in warfare, which, inspired by the success of the Geneva Convention, culminated in the agreement of The Hague. Factual contributions to this debate came from big-game shooters and from British warfare with "fanatical" warriors of the non-stop type, and concerned the comparative lethal or "stopping" effect of the small hard and the large leaden bullet and opened up the "dum dum" controversy. This carries through to the Boer War where the "humane" nature of the h.v. wound—which in that war was seldom sustained at less than half a mile—seemed soundly established. But when in 1905 Germany introduced the sharp-nosed-stream-lined-bullet, with a greatly increased muzzle velocity, the whole situation, military, medical and humane, was transformed. The experiments of Mann (America) into the ballistics of the new bullet, of Fessler (Germany) into its effect on the animal body, and of Sir Victor Horsley using wet modelling clay, pointed to an extension of the "explosive" effects on viscera, on bones, and on the aperture of exit at ranges from 200 yards up to 500. The tendency of the pointed bullet to assume an oblique position in space (the "Querschlager") and its easy deflection made for disruptive effects.

British surgeons, however, apparently continued to think—when they thought at all on these things—in terms of South African experience.

The Great War provided an unlimited supply of human rabbits and a wide range of experimental conditions. The German experimental findings were confirmed. In particular the close range of attrition warfare made common some degree of the "explosive" effect or severe disrup-

[13] For relative incidence of missile wounds, *see p 495*, for regional incidence, *see Vol III*. Death rates—K.I A. and D. of W—of various weapons of war show the comparative efficiency as *lethal* agents, but not their value in the furtherance of victory Thus in the Great War "chemical warfare" introduced a weapon in which the mortality was insignificant in proportion to the numbers disabled. The ratio of "killed" to "wounded" recorded of ancient battles was often immensely greater than in those of modern times

tion, ricochet increased the "Querschlager" effect. The clean drilled wound of soft tissue and cancellous bone, and stellate fracture of long bones, were often replaced by severe or gross disruption of the former and comminution of the latter.[14]

Shrapnel and Pistol Bullets. These produced a large but not "explosive" wound but were much more liable to introduce foreign substances and to lodge.

H.E. Shell and "Bombs." The severity of the average wound was also accentuated by the stupendous expenditure of high-explosive shell and grenade. The great variation in the shape and size of the fragments from these, and their comparatively low velocity, resulted in a very wide range of wound. Fragments often lodged and lacerated severely; and a distinct and important element in their action was that they almost invariably carried portions of clothing and other matter. They did not, however, as a rule cause local necrosis. The wounds inflicted were often multiple, and of a truly "shocking" nature.

(*B*). *Types of Wound.* For clinical purposes, the wounds caused by these various missiles were classified (1) by their physical and anatomical features, and, in particular by whether they involved a long bone; (2) by the region and organ chiefly involved; (3) by their local effect on the tissues

Physical Features. The following *types of wounds* were of clinical significance apart from their regional involvements. (*i*) Through and through bullet wounds without explosive effects, or with moderate wound of exit. Such wounds were often sterile. With these may be classed minor open wounds. (*ii*) Cul-de-sac wounds, large and small, with lodgement of missile. (*iii*) "Explosive" bullet wounds, and extensive shell wounds, with wide destruction of tissues. (*iv*) Multiple wounds. (*v*) Fractures.[15] As in civil life but "more so" the involvement of a

[14] The true exploding bullet was not used as a man-killing missile in the Great War. The "critical" velocity to produce "explosive" effects in an ordinary bullet is placed at 2,100 feet per second (*British Official History, Surgery, Vol I, p. 22*), or "close range . . . up to a mile" (*American Official Medical History*) The subjoined table shows the relative velocity of the British and German bullets fired from the service rifle in feet per second

	Type of Bullet	Muzzle Vel.	At 500 yds	At 1,000 yds.
1	Mark VII (British)	2,420	1,510	1,020
2	Spitzegeschoss (German) ..	2,980	1,780	1,090

In general the effects of missiles on the interior of the body depend on their (1) velocity, (2) weight, and (3) size and shape The rifle and machine-gun bullets were identical. It may be recalled that the pointed bullet flies "true" in virtue of the rotation on its long axis—3-4,000 times per second—imposed by "rifling"

[15] Figures showing the proportion of these are not available from Australian records. An estimate, based on the analysis of 206,976 woundings, is made in the *British Official Medical History* (*Statistics, p. 284*). Applied to Australian wounded admitted to field ambulances on the Western Front, the incidence of fractures appears as follows

Wounds with major fractures	11,278	9 10 per cent
Wounds with minor fractures . .	5,788	4 67 per cent
Other wounds	106,866	86·23 per cent

One of the most striking features of the surgery of the Great War was the fact that the appalling surgical problem created by the wounds involving the femur, tibia and humerus, found its mechanical solution awaiting the moment in the "Thomas" type of splint.

long bone or large joint was a grave matter making necessary an elaborate and special technique, or amputation.

Apart from the wounding of vital organs and structures, and of blood vessels, nerves and muscle with resulting haemorrhage, pain and other morbific nervous stimuli, and perhaps the release of "toxic" (depressant) substances, the most important local effect of a war missile was to produce a zone of necrotic tissue sown with germs; together most often with gross foreign bodies, in particular particles of clothing and missiles. This was the central fact of war wounds around which revolved the actions and reactions of wounds, and the art and practice of wound surgery.[16]

(*C*). *The Diseases of Wounds: Sepsis.* Rupture of the skin, by wounding, opens the way to a further trauma by pathogenic micro-organisms. The woundings of the Western Front did more—they drove these deeply into the tissues and provided them with pabulum, so that on the often grave *trauma* of wounding was imposed that of "infection."[17] Further, as already said, microbic invasion itself constitutes a "cause" of disease not less extrinsic and mechanistic, if more subtle, than a "wound": eliciting in its turn an organic reaction not very dissimilar.

The Infective Agents on the Western Front. Two biologically differentiated groups were prominent. (1) Certain groups of *anaerobic sporing bacilli*,[18] chiefly of faecal habitat, strictly saprophytic but intensely toxicogenic. These did not evoke a typical "inflammatory" reaction, but, in symbiosis, produced by local action the condition known as "gas gangrene"; or by neurotropic intoxication that of "tetanus." They also (it was generally believed) promoted the action of the next group.

(2) *The Pyogenic Cocci*—in particular the haemolytic streptococci.[19] Present in all stages of wound infection and especially important as "re-infection," these groups of organisms were responsible for the microbic

[16] Borst (*Researches into the Morbid Anatomy of War Injuries* Leipzig 1917) describes three zones in gunshot injuries of soft parts. The first, or innermost zone is represented by the wound channel or wound cavity, which is filled with necrotic tissue, extravasated blood, foreign bodies, and shreds of torn muscles. Next comes the zone of direct traumatic destruction with cauterisation of tissue This is of variable width, according to the physical and morphological peculiarities of individual tissues and projectiles. Bacteria find the best possible culture-medium in the necrotic or semi-necrotic tissue In the third, or outer zone, the tissue is not necrotic, although greatly reduced in vitality. (From *History of the Medical Department* of the United States Army in the World War, *Vol. XI, Surgery, Part 1, p 294*)

[17] For definition of infection see footnote *58, p 329*

[18] Apart from the Bacillus tetani and Bacillus Welchii these were for long very vaguely identified In 1919 the Medical Research Committee found that the three types of pathogenic anaerobes most concerned in the production of gas gangrene were in order of importance *Bacillus Welchii, Vibrion septique* and *Bacillus oedematiens* ("Report on the Anaerobic Infections of Wounds and of the Bacteriological and Serological problems arising therefrom" *Medical Research Council Special Report Series, No. 39, 1919, p 17* Quoted by W J. Penfold and Jean C Tolhurst "Formol-Toxoids in the Prophylaxis of Gas Gangrene" *M.J.A 26 June, 1937 p. 982*)

[19] One of the achievements of the Great War was to unmask in this group an enemy of wide-spread activities and great menace to the public health See also under Measles, in which disease immense epidemics of streptococcal pneumonia occurred chiefly in America.

trauma which produces the "pyogenic" inflammatory and febrile reactions and most of the secondary surgical problems of war wounds.

Bacillus Coli, Bacillus Proteus and Bacillus Pyocyaneus and other organisms were occasionally met with, chiefly as secondary ("hospital") infections.

The local reaction against these groups or organisms is the physiological basis of wound surgery.

2. Pathology in the wounded man

The effects of the wound *per se* on the wounded man were, pain, loss of blood and anoxaemia, and vital depression. On the other hand the general damage—"disease"—brought about in the system by subsequent microbial infection, is reflected in a variety of more or less specific clinical morbid states which, here too, comprise two groups, those brought about by the anaerobes and those caused by pyogenic cocci.

(*A*). *Effects of Wounding per se—Physiological injury and reaction*. pain, anaemia ("haemorrhage"), vital depression ("shock" and "collapse"). It will be convenient to defer discussion of these until we deal, later in this chapter, with developments in their treatment.[20] It may be observed here, however, that these reactions interacted with each other and with *septic infections* to produce a pathological state and a corresponding clinical picture of great complexity,[21] and this fact will be found to dominate the practical problem of treating the seriously wounded man.

(*B*). *Effects of Septic Infection—General microbial injury and reaction—wound diseases*. The traumatic effects of the two chief groups or organisms differ fundamentally, both in their mode of action (pathogeny) and the course, results and clinical features of the "diseases" produced. Thus in tetanus we have to do with an almost purely traumatic and general effect with little obvious clinical reaction, or none; in pyogenic infection with a disease in which the reaction is the prominent component;

[20] *See p. 333.* A further appreciation of the actual war-time studies into the ultimate nature of the clinical syndromes is given in *Appendix No 14.*

[21] Thus we find:—

"Shock (Path.) state of prostration following overstimulation of nerves by sudden pain as of wound" (*Concise Oxford Dict.*)

"Haemorrhage is so constantly associated with shock, and plays such an important part in its production, that the great majority of cases are examples of shock-haemorrhage rather than of pure shock" (Gray *Early treatment of War Wounds p. 82*)

"The condition caused by acute sepsis may so closely simulate shock as to be indistinguishable from it" (*Manual of Injuries and Diseases of War, Jan. 1918, p. 18*)

in gas gangrene with a condition pathogenically intermediate between these.

Specific Morbid States. Briefly, three clinical entities were prominent: (1) ***tetanus,*** (2) ***gas gangrene*** (both manifestations of intoxication), and (3) *pyogenic inflammation and septicaemia* (parasitic invasion). These three morbid states induced by "infection" formed a trio, each with special clinical, pathological, and immunological features; but from the point of view of surgical prophylaxis all were part of the general problem of "sepsis." Much was hoped from the biological process of artificial immunisation both for prophylaxis and treatment, and the production of passive immunity (by anti-sera) was fully tried out. Only anti-tetanic serum was of practical value in the war,[22] though an anti-gas-gangrene serum (against Bacillus Welchii and Vibrion septique) was produced and tried during 1918.[23] At the end of the war both the French and Germans were using a polyvalent serum.

Clinical "Diseases" "Tetanus." Though fully specific this disease was closely associated, both in its pathogenesis and incidence, with "infection" by the other anaerobes. It is pertinent here to note that the success achieved in civil wounds in the U.S.A. by the prophylactic use of anti-serum was fully confirmed in the Great War. An order issued in October, 1914, that every wounded man should receive a prophylactic dose of A.T.S. as soon as possible after the injury, led to a drop from 9 cases per 1,000 wounded in September to 1·4 in December—an improvement which, with fluctuations due to the circumstances of the fighting, was maintained throughout the war. The influence on this disease of the reduction of sepsis in general by improved surgical technique is stated in *The British Official History,*[24] as follows:—"It remains one of the great surgical lessons of the war that the excision of damaged and infected tissues, when it can be carried out effectively, does in practice prevent tetanus as in theory it ought to do. . . . It is obvious that this radical measure cannot be carried out in all cases," and therefore "the alternative method of administering anti-serum to the wounded cannot be dispensed with."

The importance of the reduction achieved is shown by the fact that (as stated—*loc. cit. p. 158*—by Prof. Sir F W. Andrewes): "Had a ratio of 8 cases per 1,000 wounded and a case mortality of 78·2 per cent. been maintained during the war, there would have been 13,683 cases of tetanus [in the British force] on the Western front with 10,700 deaths, in place of 2,529 cases and 1,265 deaths." But it is necessary also to record that the incidence over the whole war was 1·7 per thousand wounded with case mortality of 50·0 per cent.; as compared with

[22] It is of interest that early in 1915 the D.M.S., A.I F., Surgeon-General Williams, purchased large supplies of sera, anti-tetanic and anti-dysenteric, for the A I F in anticipation of Gallipoli In view of the urgency of the situation in France, the bulk of this was handed over to the War Office The organisation for the British system of supply, and a note on arrangements for vaccines and sera will be found in *Vol III.*

[23] The production of an active immunity did not in the war get very far beyond the experimental stage, but will perhaps be the method of election in future wars. Reference may be made to recent experimental work in Australia by Penfold and Tolhurst at the Baker Institute, Melbourne, into the production of active immunity against B. Welchii by formal-toxoids

[24] *Surgery, Vol I, p. 157*

3·5 per thousand in the Franco-German war with case mortality of 90 per cent. Particulars of the incidence of the disease in the A.I.F. are not available owing to the destruction of clinical records.[25]

"Gas Gangrene." This disease was comparatively rare before the war. In no previous campaign had it figured to any great extent, but it quickly assumed a position of tragic importance on the Western Front, especially in the first months when everything was in its favour.[26]

Its most important features and the surgical treatment of it are described in the next volume; for our present purpose it is sufficient to note that the disease appeared most commonly in grossly traumatised, contaminated, and neglected wounds, especially if closed, or in those in which the circulation had been interfered with. Haemorrhage, shock, and prolonged fatigue were potent disposing factors as also was the "dose" received, in which fragments of clothing were the most potent agent

Infection might be well established within a few hours of the receipt of the wound. In its usual form ("group" type) it developed as a local gangrene with gas formation and intense toxaemia, spreading, through the action of chemical toxins, from the zone of traumatic necrosis in the wound—most commonly in muscle but often in haematoma or other devitalised tissue. The case mortality is stated as *22* per cent. in the B.E.F. Its incidence varied from 5 to 6 per cent of all wounds in 1915 to a little over 1 per cent. in June, 1918

Pyogenic Infection. (Staphylococci and Streptococci). Taken together—as to some extent they may be—as the cause of the "pyogenic" type of infection, these agents were incomparably the most important factor in the problem of war wounds. No stage in the whole surgical campaign was free from their menace. It may be that, on this side of No-Man's Land, this group was the soldiers' "Public enemy No. 1." Recent advances in the knowledge of chemotaxis seem to promise a different outlook in the next war

The Treatment of Wounding

Treatment of the wound itself

We have now to follow the evolution of wound treatment in the Great War, first as applied to the wound itself. And here there may at once be noted a most striking feature. that, whereas (as we shall see later) treatment of the direct effects, physical and physiological, of the trauma moved away from the wound to the wounded man and came to centre on a vaguely defined clinical syndrome identified as "secondary wound shock," on

[25] The *German Official Medical History, Vol. III, pp 77-81,* records a total of 3,600 cases in four years of whom 2,542 were on the Western Front—about 0·8 per thousand of all wounded. Among the Germans on that front 1,656 cases occurred between August and December, 1914—*i.e.* 3·8 per thousand Serum treatment was carried out from the beginning, and from April, 1915, intensively. The injection was repeated before any operation up to three months after wounding The figures given in that history are obviously in many cases tentative

[26] Sir Cuthbert Wallace in the *British Official Medical History, Surgery, Vol. I, p. 134*

the other hand till the end of the war, except in one disease, tetanus, the treatment of microbic wound disease was almost wholly confined to local action on the wound itself. The following account of "treatment of wounds" will relate almost wholly to the prevention of sepsis. In this account we have to neglect the ligature and the suture although they were the first word in the art of wound surgery. But so far as the history of the Great War is concerned they belong to the past just as the chemotactic treatment of infection belongs to the future.

The objective in this vast campaign of war surgery was asepsis. The search for this comprised four stages:—

THE SEARCH FOR ASEPSIS.

FIRST STAGE (1914-15). *Open warfare.*

Beginnings: Unintelligent reliance on the supposed asepticity of missile wounds which were closed by suture. Effective surgery entirely done at the Base.

Reaction. (*i*) Crude chemical antisepsis—strong solutions, pastes. (*ii*) Irrigation and lavage (*iii*) Surgical common sense, wounds cleaned, drained and left open.

Experiment—official and individual, laboratory and clinical.

SECOND STAGE. (1915-17) *Static warfare.* Experiment and experimental application; technical advances, technical training, technical organisation. The foundations laid for a continuous campaign from Front to Base.

THIRD STAGE. (1917-18). *Static warfare.* Scientific wound surgery in static warfare—antiseptic and aseptic.

FOURTH STAGE. (1918). *Open warfare.* Scientific surgery in open warfare—aseptic and antiseptic.

FIRST STAGE. Beginnings

"Nothing," says Sir George Turner, "impressed me more during my work in the Great War than the ignorance of the younger generation of surgeons, who had been brought up on antiseptic or aseptic surgery, of what it was necessary to do when a case went septic."[27]

1914. The medical profession entered into the war in 1914 with an interesting and very remarkable handicap Well up in the methods of ensuring asepsis in surgical wounds, for the most part it knew little of "*septic*" wounds. In the early stages of the war the more fulminant forms of wound infection,

[27] From *Unorthodox Reminiscences* by Lieut.-Col Sir George Turner. (From review *The Times Literary Supplement* 17/9/1931)

familiar to an earlier generation as "hospital gangrene" and pyaemia, fell like the scourge of an unexpected pestilence on a race of surgeons grown complacent in the atmosphere of prophylactic asepsis, with whose toilsome and tedious evolution they were acquainted chiefly by tradition and Listerian Orations. The experience of the South African War and (with surprisingly moderate variation) of the Russo-Japanese, led to the belief that, in a large proportion of wounds, superficial or very casual chemical antisepsis with immediate suture was not only permissible but desirable. For the best part of a year, indeed, at the beginning of the Great War, the treatment of wounds in the field was vitiated by neglect of the fact that the *infection was contained within the wound itself,* so that for the most part paints of iodine or of picric alcohol were as whiting to a sepulchre, and repeated "dressings" of little more use than were the antics and the offerings of the priests of Baal.[28]

In the field ambulances during the first five or six months of the war, and later in the first "clearing hospitals," wounds were superficially disinfected and sutured. The time between first aid at the front and effective operation at the Base was commonly several days. The results were appalling. During the first six months the mortality and morbidity from "septic" infection dealt to the surgical profession in every nation concerned a staggering blow, from which it recovered only through tedious and painful apprenticeship.

The Surgical Debacle. For the situation in respect to the surgery of wounds in the first few months of the war the term "chaotic" would seem not too strong an epithet. In serious wounds, treated as they were for the most part by immediate suture, with or without some superficial antisepsis, sepsis was practically universal; "gas gangrene" was very common, tetanus

[28] In Jan., 1915, as A.D.M.S. 1st Australian Division Colonel (later Major-General Sir) N. R. Howse who in civil life was a surgeon of distinction, duly shocked but impressed an R.M.O. before the Landing by suggesting that, in the treatment of "abdominals" if he should spit on the wound and then move heaven and earth to get the man quickly to operation he would do more good than by fussing about with "dressing."

"A great deal of waste continues in medical units. Many of the wounded are dressed far too frequently between the firing line and the C.C.S." (Report by Lieut.-Col., later Sir H. S. Newland to D.M.S., A.I.F. Jan., 1918.)

"I generally had a look at the first field dressing myself, and usually changed them and applied picric spirit because men in my own battalion seemed more satisfied if I had seen them, and the psychological factor was worth considering" (R.M.O.).

an ever-present Sword of Damocles. The difficulties of the surgical problem were greatly enhanced by the nature of the wounds, the conditions of the fighting, and the absence of medical motor transport.

Within a matter of almost weeks an intense reaction against all this took place and followed two broad lines:—(1) a reversion to pre-aseptic surgical principles and practice, and (2) the initiation of research and experiment, clinical and laboratory. From these two can be traced the avenues of thought and action along which evolved the great surgical developments of the war. Only an epitome of this illuminating episode in the history of surgery can be given here.

Reaction

1. Reversion to Pre-aseptic Methods. The immediate suturing of wounds was abandoned, and three chief alternatives were adopted. Each of these contained the seed of more important later developments. Of the beginnings in this "reaction" a brief note only is required.

(*i*) *Crude Antiseptics.* Almost every known antiseptic substance was tried and much ingenuity expended in combining them—as instanced in Sir Lenthal Cheatle's solution of perchloride of mercury and carbolic. Most were futile, some grossly harmful. Of the cresol paste and salicylic and boric dusting powder—"Borsal"—devised in February, 1915, by Sir Watson Cheyne, Lister's most ardent disciple, the *British Official History*[29] notes that in cases arriving at the Base "the wound aperture was often blocked . . . or a dark evil-smelling discharge was exuding The limbs were swollen and acute progressive infection of the tissues was present. When opened up a surface resembling . . . necrotic liver substance was exposed."[30]

(*ii*) *Lavage.* This aimed at the production, by means partly mechanical, partly chemical, of a virtual asepsis and a granulating wound, permitting sometimes the secondary suturing of the wound. "Irrigation" and the "continuous bath" had been almost a sheet anchor in the treatment of the less fulminant forms of sepsis in the "nineties"

[29] *Surgery, Vol I, p. 259.*

[30] An explanation of the failure of this futile and wasteful "antiseptic" campaign may be found in failure to recognise the fact that Lister endeavoured to prevent wound "infection" rather than to cure. The "evil" brought about by the implantation in the wound of a particle of "dry septic pus," he wrote, "cannot be corrected by any antiseptic wash that is now at our disposal or that the world is ever likely to see." (Quoted by *British Official Medical History, Surgery, Vol. I, p. 258.*) As stated by Burghard, Leishman, Moynihan, and Wright ("Office international d'hygiène publique," 1915, *vol. vii, p. 946*—quoted by Carrel, *loc. cit. p.4*) "the treatment of suppurating wounds by means of antiseptics is illusory, and . . . founded upon false reasoning," and by Sir Almroth Wright (*B M.J. 24 Apr. 1915, p. 721*) "if it were ever to come about that an antiseptic sterilised heavily infected wounds, that would be a matter to announce in all the evening and morning papers." Carrel's quotation of these opinions was made with the purpose of vigorous refutation. It was, he implied, a matter of using antiseptics—"with brains."

and the early years of the 20th century, and proved a useful grapnel in the storms of 1914. The experimental developments of this quest, such as the historic researches of Sir Almroth Wright and of Doctors Carrel and Dakin and their co-adjutors at Compiègne, both of which began in 1914, are examined later.

(*iii*) *Primitive Asepsis.* The most important immediate practical result of the "reaction" was the return to surgical tradition and experience in the commonsense procedure of *mechanical removal of obvious foreign matter,* such as missiles, fragments of muscles, fascia, and loose bone, combined with incision and drainage Later, when from this line of treatment there was developing the general practice of excising wounds, this earlier procedure was still for two years the recognised method of dealing with all major wounds; and, combined with improved "antiseptic" methods and thorough drainage, it continued to be applied until the end of the war in the treatment of very large and awkward wounds and—a matter of first rate importance—of fractures.

2. Initiation of Experiment and Research. Laboratory research—for a time regarded coldly by the older surgeons—was initiated in 1914 at Boulogne, and, with clinical research, centred for a time chiefly in the hospitals established there.[31]

Progress of "reaction" at the Base

An authentic picture of the progress of this "reaction" is presented in the following epitome of notes of a discussion, held in February, 1915, under the auspices of the Australian Voluntary Hospital, on the *treatment of wounds involving fracture of the femur* arriving at the Boulogne Base Hospitals.[32]

Lieut.-Colonel G. Horne,[33] introducing the discussion said: "This is all new ground, and new means must be employed. The experience of the Boer War does not entirely cover this; in particular we have a bacterial flora of greater virulence and variety. The drilled hole of a rifle bullet is seldom seen in this campaign; the commonest wound is the smash of shrapnel and shell fragments. The chief problems are those of *suppuration* and *secondary haemorrhage,* and of the indications for *suturing.*" The discussion proceeded as follows:—

No. 11 General Hospital: "The question of free drainage is the first essential." *No. 13 General:* "The great difficulty has been the treatment of secondary haemorrhage—very large numbers are fatal.

[31] This will be dealt with in *Vol. III.*

[32] These notes, obtained from Lieut.-Col. Piero Fiaschi, through the courtesy of Lieut.-Col. George Bell, were distributed by the Acting D M S, A I F., Col. T. M Martin, to the Australian Medical units in Egypt in May, 1915. Officers from all the Hospitals at this Base took part in the discussion and as well the Consulting Surgeon to the B E F. Bases Colonel (later Lieut.-General Sir G W) Makins and Colonel Sir Alexander MacCormick, A.A.M C. (of Sydney, N.S.W.) Consulting Surgeon to the D D M S. at the Boulogne Base The Officer Commanding this unit was Col. (later Major-General, A A M C) W. L'Estrange Eames

[33] Lieut.-Col. Horne was in civil life a highly esteemed and cultured gynaecological surgeon, of Melbourne

Survival is rare after second occurrence without prompt amputation." *No. 14 General and Nos. 2 and 7 Stationary* dealt at length with the many varieties of splints in use *No. 13 Stationary:* "Is it worth while going in for these elaborate splints? If the leg is properly opened up at the front, the patient should be sent straight home (to England) in the splint without waste of time. How many limbs are taken off when they get to England after lengthy treatment here? We would suggest —open up the wound, irrigate with 1 in 20 carbolic or even 1 in 10, insert large draining tubes, and apply a long interrupted Bryant splint." *Rawalpindi Hospital* (Indian Army) suggested that men in the field ambulance should use more free draining. *Westminster Hospital.* Recommends drainage and irrigation, oxygen preferred to H_2O_2 "as it gets in where the latter cannot." *Lahore Hospital* (Indian Army): "Our practice is drainage and continuous irrigation." *Major Gordon Watson*[34] favoured treatment of femurs in France. *Major G. A. Moore* (Director of ambulance trains): "The ambulance trains now include a theatre in a special bogey van, where secondary haemorrhage can be treated." *Sir Alexander MacCormick* (Consulting Surgeon Boulogne Base) emphasised the influence of the method of transport from the front on the outcome of the case. He suggested that the field ambulances at the front should be supplied with the Thomas splint, "as it can be applied immediately and would obviate a lot of subsequent movement" *Colonel G. W. Makins*[35]: "A most important thing is to seek for the most efficient means of disinfection—wounds are treated well mechanically by means of drainage. Of anaerobic and streptococcal infection the first is more easily dealt with and more easy to control. Gas gangrene effects are soon over; the streptococcus is the more important as causing septicaemia, with much suffering and subsequent trouble. We look to the bacteriologists for a prophylactic vaccine." *Sir Almroth Wright*[36] dealt with the bacteriological aspect. "Everyone is surprised at the amount of sepsis, not only strepto and staphylococci but B. perfringens, B Tetani, and other anaerobes. The whole fighting area is one of intense cultivation; this may even be called a war of faecal infection—streptococcus and anaerobes. The missile goes through clothes soiled with faeces. Bathing and clean clothes may help to prevent contamination, in conjunction with use of carbolic in the Field Ambulances. Drainage is only the first and crude stage [of treatment], for lymph is the only real purifying agent." Methods of treating infection recommended by him were: (1) *Drainage*—promoting the exit and current flow of clear lymph; lymph lavage; use of hypertonic salt solution which causes secretion of lymph. (2) Prophylactic inoculation (streptococcal vaccine). (3) Antisepsis. But "no antisepsis will sterilize a wound, a small sowing is as bad as a big, if in a good cultivation medium; antiseptics reduce the sowing only." (4) "Frequent dressing, which removes pus and so far is useful. Irrigation is ideal."

[34] Col. Sir Charles Gordon-Watson, Consulting Surgeon Second Army.

[35] Colonel Makins was the author of the textbook of war surgery chiefly in use *Surgical Experiences in South Africa.* In the *British Official Medical History of the Great War* he was responsible for the following articles —"Injuries to the Pericardium and Heart," "Wound treatment in General Hospitals in France," and "Injuries to the Blood vessels."

[36] Consultant, B.E.F. Sometime Demonstrator of Physiology, University of Sydney See also *pp. 319-22.* His chapter in the *British Official Medical History, Pathology,* on "The physiology of wounds" is of quite exceptional interest.

Reaction at the front—the genesis of asepsis

While this reaction was proceeding at the Base, surgical work at the front was passing from the field ambulance to the casualty clearing station and developing along lines that was to make the C.C.S. the focal centre for effective surgery. In *March, 1915,* the D.G.M.S., B.E.F. issued "Circular Memorandum No. 6" which dealt with "The principles of the treatment of wounded before evacuation from the front: based on the experiences of the last six months." The points emphasised therein were as follows —

1. "All wounds should be regarded as infective or septic. sutures should consequently not be used as a rule. . . . 'Aseptic' (*sic*) surgery is out of place in septic wounds." (2) "No one antiseptic can be said to be superior to all others." [Solutions of Tincture of Iodine, carbolic, lysol, hydrogen peroxide, were recommended.] 3. "Men left lying out for a day or two are often severely collapsed," and require "saline," food, and stimulants "before dressing." 4. Strict precaution must be taken against tight bandages: "it is of the utmost importance that the first field dressing should always be removed as soon as possible." 5. Operations except those of emergency were not to be done in field ambulances, because "asepsis" could not be secured. 6. "Arrangements are now usually made to enable a certain number of patients to be retained in the C.C.S., and nurses have therefore been added to the personnel." 7. "Bad compound fractures . . . should as a rule be cleaned up at the clearing station under anaesthetic when time permits." 8. "Wounds of the skull or brain . . . can safely be sent to the base." If operation were done on these wounds at the C.C.S. "the wound itself should be excised and, if too extensive for this, its edges should be cut away."[37] 9. Chest cases should be retained in the C.C.S. for a week at least. 10. For "abdominals" as regards operations no fixed rule could be laid down "as much depends on the experience in surgery of the operator."

End of the First Stage. In July, 1915, there was issued the "Memorandum on the Treatment of Injuries in War." This important statement drawn up by the "Committee of Consultants," B.E.F., as a general guide to surgical practice, marks in effect the end—in the British Army—of our first stage.[38]

In this manual a considerable range of operative intervention was allotted to the field units—field ambulances and C.C.S. The following method was laid down for "the dressing" of large wounds "at the front."

"If it be an open wound, portions of clothing, obvious fragments of

[37] This was Colonel Gray's procedure.

[38] It formed the basis for surgery in the B.E.F. until its re-issue in Jan., 1918. In the period between the two issues is contained the creative period of war surgery in the B.E.F.

shell, and torn or hopelessly damaged portions of tissue should be removed by forceps and scissors. If the wound be not sufficiently open to drain of itself, large drainage tubes should be inserted; and in cases where more must be done an anaesthetic should be given, and the wounds enlarged and held open by retractors so that all recesses may be washed out and drained. A good method of mechanically cleaning the track of a perforating wound consists in drawing backwards and forwards through it a piece of gauze twisted to form a rope. Very large drainage tubes (5/8-7/8 inch) should be used, with numerous large lateral openings For large deep wounds counter-openings are necessary."

Antiseptics had been found of no avail "to inhibit bacterial growth within fouled wounds." *Drainage*, "in conjunction with the mechanical methods of cleansing, forms the essential element in the primary treatment of gunshot wounds." At the Base "the use of a blunt spoon may now be added as it removes blood clot, muscle and soft tissues well. Free removal of dead tissue is very important." The application of "powerful antiseptic media" to the wound was "undesirable"; but there was a "large consensus of opinion" favourable to the principles advocated by Sir Almroth Wright, "that the course of healing is most effectively furthered by means tending to increase the activity of vital processes concerned in its production." *"Gas gangrene and gaseous cellulitis"*—"the most important complication of wounds in this war"—was fully described but without reference to any special muscular involvements, and perhaps the more accurately for this! Treatment was to consist in "the removal of as much blood clot and devitalised tissue as possible, provision for free access to the air, and efficient drainage"—or by amputation.[39]

SECOND STAGE: Organised experiment and observation, 1915-17

"In the first Aphorism of Hippocrates it is written that experience is fallacious. . . . Yet we must confess that when experience leads us astray or experiment makes us stumble the cause is our faulty interpretation of facts which would be clear if we had eyes to see. . . . In diagnosis and treatment experience is unavailing unless that common sense, which has been said to be the least common of all the senses, is also brought to bear upon the problem."[40]

There followed some two more years of experiences, experiments, and sufferings in this orgy of human vivisection, in which some millions of wounded men of both sides were subjected to the method of trial and error in the search for the best means of treating infected wounds of every kind and every organ, and the wounded man in every stage of his wounding. Like most evolution, that of wound surgery was

[39] No attempt was made in the memorandum to apportion the operative responsibilities of the Field Ambulance and C C S respectively, nor to correlate treatment with movement. The use of the Thomas splint was mildly advocated, but no attempt made to ensure its general use at the front

[40] "Medical Facts and Fallacies" by Maurice E Shaw, *B M J*, *14 March, 1936, p 515*

a slow and painful process in which improved methods strove against an immense inertia of structure and habit. For the Allies this phase may be held to have reached a climax with the *Interallied Surgical Conferences of March and May, 1917,* when the results of experiences and researches of the past two years were summarised and principles laid down for the technique of combined movement and treatment which the two subsequent years of the war did little to modify, though very much to implement.

Like that of all creative periods the history of these two years is full of interest—more so, perhaps, than that of the year in which the principles and methods so painfully won were successfully applied. In the present work, however, the most that can be attempted is to indicate the course of the evolution, and to present the lines of reasoning on which experimental and clinical research were based; and perhaps to suggest reasons for the success of some and failure of others.

"Surgery" moves towards the front

By far the most important outward sign of the progress of surgery during this period was the gradual transfer of very much of what may be termed "essential" or "effective" surgery from the Base to the front. This was made possible, (1) by the stability of the Western Front, which permitted the building up of a system of highly organised medical units, and (2) by the development of a method of treatment—excision—whose purpose was the prevention of wound diseases or so great a mitigation as would permit the immediate or an early closure of many wounds, or, failing this, to promote the efficacy of secondary types of treatment. To achieve this end, operation must be undertaken within some 6 to 24 hours of wounding, though in exceptional cases it could be effective as late as 48 hours after the man was hit. Meanwhile, however, from 1914 onwards important developments had been taking place at the Base—designed in part to deal with declared or developing sepsis, in part to bridge the time-gap occupied by the ambulance train between the C.C.S. at the front and the General Hospital at the Base.

In the B.E.F. during the first two years of the war, and

to some extent throughout, the time-distance factor in this journey placed the British general hospitals outside the scope of prophylactic surgery, with the result that the trend of research and clinical observation at those hospitals converged naturally along the line of *cure*. It is to the resulting adventures in laboratory research and clinical technique that we must now turn—and primarily to those of Sir Almroth Wright at the British Base, with which must be associated those of Carrel and Dakin behind the French front at Compiègne.

At the Base: the search for antisepsis

Physiological Antisepsis: Serum Lavage. The vision of an El Dorado was never followed with greater eagerness than the pursuit in the war of the ideal means of combating sepsis. In his "Memorandum on the treatment of infected wounds by physiological methods" Colonel Sir Almroth Wright sets out the principles of his method as follows:—[41]

"The ideal of physiological treatment is to give intelligent aid to the organism in combating the bacterial infection. Saline dressings supply a means for evoking, in the infected wound, certain requisite physiological reactions. By their aid we can, while at the same time inhibiting bacterial growth, drain the tissues, resolve infiltration, and promote the separation of the sloughs—besides giving other assistance."

The therapeutic procedures involved were stated thus:—

"(1). . . . We have to promote the destruction of the microbes which have been carried into the deeper tissues, to re-establish normal conditions in those tissues . . . and to prevent 'the corruption of the discharges' and to inhibit microbic growth in the cavity of the wound. During the whole period occupied by these operations we have to be constantly on our guard to prevent active and passive movements which would propel bacteria along the lymphatics, and carry poisonous bacterial products into the blood. (2). When the microbes in the deeper tissues have been exterminated and the physiological conditions have been restored and the wound rendered to naked eye inspection perfectly clean, the time has come for dealing with the surface infection. (3). As soon as this has been suppressed . . . all our thought ought to be given to promoting the processes of repair, bringing together the tissues, and covering over the denuded surfaces."

These purposes Wright sought to achieve by exploiting the antiseptic and "tryptic" powers of the lymph and its contained

[41] For systematic presentation of the genesis of the methods of Wright and those of Carrel and Dakin and of the researches on which they were based the reader may be referred, for that of Wright to his article—a classic—in the *British Official Medical History, Pathology*, and for that of Carrel to the *Treatment of Infected Wounds* by Carrel and Dehelly (English translation *Military Medical Manuals*

leucocytes, by the use of hypertonic (5 per cent.) solution of sodium chloride with or without the addition of 0·5 per cent. sodium citrate to prevent coagulation of the lymph; applied *secundum artem* to reach every part of the wound[42] with the purpose of

"drawing out from the infected tissues lymph which has spent all its antibacterial energy, and drawing into the tissues from the blood stream lymph inimical to microbic growth."[43]

This was complemented by measures—in particular the use of normal (0·85 per cent.) salt solution—for inhibiting lymph-flow, and promoting phagocytosis and (by trypsin released from the broken-down leucocytes) the removal of slough, inducing subsequent granulation.

Results. The method was perforce applied chiefly in wounds which had reached the stage of progressive infection, in many of which preliminary cleansing had been very crude. At times it seems events went "according to plan"; but on the whole the results were disappointing. In particular secondary haemorrhage was thought to be more frequent; granulations were often flabby and hydraemic, and the stage of healing slow. The method has probably no permanent place as a technique; it was based for the most part on deduction from hypotheses, themselves the result of laboratory experiment inspired by the cult of "the teat and capillary glass tube" which had imperfect contact with clinical observation. Wright's claim to a place in history rests rather on the creation of an attitude of mind, a reaction from "muddle through" methods

Scientific Antisepsis: "Carrel-Dakin" Lavage. The method of treating contaminated and infected wounds which has been associated particularly with the names of Dr. Alexis Carrel and Professor Henry Dakin, has retained a place in the technique of civil and military surgery

Begotten at the end of 1914 from deep resentment at the surgical disasters of the first few months, and from a robust belief in the efficacy of Listerian antisepsis if applied with due regard for scientific criteria, the experiment comprised perhaps the most complete single campaign of combined laboratory and clinical research and typical American "team work" that was occasioned by the war. The researches, laboratory and clinical, on which it was based were made in laboratories

[42] Wright employed irrigation, gauze dressings, and for deep wounds the not very effective device of gauze wicks, the wound being covered by gutta-percha tissue to keep the dressing constantly wet

[43] *Brit. Off. Med History, Pathology,* p 5

established at Compiègne under the auspices of the Rockefeller Foundation, and in the "Temporary Hospital" ("No. 21") staffed by surgeons of the French Colonial Forces and controlled by the French Medical Service under the Secretary of State for the Interior.

Important as are the details of the technique, they do not to-day call for description. But the principles on which the system was based, and on which it was built up in the very "dust and heat" of war, have a very definite historical and educational value.

The Method The hypothesis on which the system was based is stated thus:—

"The surgical infection, at the outset, is always local. In war-wounds, it is carried by projectiles, and especially by fragments of clothing, impregnated with micro-organisms. Before crossing the boundaries of the wound, these flourish on the surface of the tissues. Therefore, during a period more or less long [placed by Carrel at broadly 12-48 hours] the infection is under control, since the microbes are, so to speak, within reach of the hand. The question then is simply, how to destroy them without harming the tissues?"

Professor Dakin's search for a substance[44] unirritating to the tissues but of sufficient bactericidal power to "kill all microbes present in a wound" led to the chloramines and thence to a neutral solution of sodium hypochlorite, prepared by special process.

Technique of Application. The method was in the first place applied to "old wounds," subsequently, in preference, to recent ones. The two essential factors in the technique were, first, the evolution of a method whereby the solution could be brought continuously in contact with *every* part of the wound, by the now well known scheme of perforated tubes and glass applicators, the intermitted flow being maintained by syphonage or gravity.[45] A second prime object in the method was to control the progress of disinfection to the point of a "virtual sterilisation" of the wound by means of daily counts[46] of the bacterial content of the wound, the purpose being to arrive at a measurable criterion of safety for *secondary suture.*

It is right to note that the conditions under which this remarkable experiment was carried out were exceptional; though the facilities were those of a base hospital, the position of Compiègne allowed casualties to arrive within time-limits that corresponded to those characteristic of a casualty clearing station.

Wright v. Carrel: Nature v. Art. Dakin himself has stated that the methods of Wright and Carrel were not fundamentally different. It is nevertheless certain that the two were at first conceived as antithetic. It is difficult for the present generation of surgeons to appreciate the

[44] Dakin and others *Proceedings of Royal Society 1916, Vol 89, p 232* Quoted by Carrel *p 2*

[45] During ambulance-train transport, on the suggestion of Bowlby, irrigation was maintained by syringing

[46] These were quantitative only.

bitterness of the quarrel between the a- and the anti-septists—which recall indeed the civil wars of Brobdingnag. British surgeons, it is clear, were "rattled" by the tragic failure of what they conceived to be Listerian principles; Carrel and Dakin helped to restore courage and sanity.[47] The method of "chemio-therapy" was adopted for reasons which are fundamental in the problem of the surgery of war wounds. "It seemed probable," Carrel states, "that the infection of war-inflicted wounds would be unsuitable for treatment by vaccines or serums. As the inoculation of the tissues by projectiles or fragments of clothing is massive, and *as the germs protected by necrosed tissues or blood-clots multiply beyond the reach of lymph-flow, it is extremely unlikely that such therapeusis could be effective.*"

The words here italicised state the essential difference between Wright's problem and that of Carrel, and also supply the key to their respective methods. Further, they presage both the success of Carrel's method and its ultimate supersession by the more direct method of excision. Indeed, the details of the preliminary surgical treatment required by Carrel make clear that—at this time, at least—only one consideration lay between irrigation with secondary suture and the immediate closure of the wound, namely the feeling expressed by Carrel in the statement that "*a surgeon has not the right to cause a single wounded man to risk useless dangers.*"[48]

Results. There is no gainsaying that, when this method could be applied as directed, it was very effective in achieving its purpose. Yet, though fully effective from September of 1915, it was not taken into general use in the British Army till the beginning of 1917 and little earlier, if at all, in the French. This neglect on the part of the French surgical profession seems to have been due in some part to the failing which so nearly killed Louis Pasteur—professional jealousy—but also, *pace* Carrel, to the progress in the French Army of *débridement* and suture. British failure to take it up must in part be set down to the physical factor which in no small measure determined the evolution of the surgery of wounds in the B.E.F.—namely the hiatus between the hospitals of the front and those of the Base.

The most general employment of this method in the B.E.F. occurred about the time of the Third Battle of Ypres. The notebooks of Australian surgeons working at Remy Siding show many cases sent to the Base under "Carrel" treatment, for which, by order of the D.G.M.S., special arrangements were made on the ambulance trains. Even then however there was strong competition by simpler methods, in particular the physiological "salt pack" and antiseptic "B.I.P." Acriflavine was on trial, and—as is strongly evident in the records of the Australian casualty clearing stations—there can be discerned a growing appreciation of the fact that the British

[47] Dakin (*loc cit.*) refers to Sir Berkeley Moynihan as undertaking experiments allied to those of Carrel

[48] *loc cit.* The italics here are in the original

Army was far behind the French in the courage of its conviction that the time had come for the immediate closure of wounds without the intervention of either physiological or chemical intermediaries.

These procedures, though trespassing on prophylaxis, were primarily at least intended for the treatment at the General Hospitals, and chiefly for that of declared infection rather than of contamination. We pass now to other methods and means designed to provide a short cut between the front line and the Base.

Front and Base—the effort for continuity

Under *methods* we have (1) the "salt packing" of Lawson and Gray and the Bismuth, Iodoform and Paraffin paste of Rutherford Morison (B.I.P.). (2) Under *means* came the "scientific" antiseptics, of which eusol, Dakin's solution, "acriflavine," and chloramine T, are types.

1. Methods. Methods of both types, "physiological" and "antiseptic," were devised in the B.E.F. with the purpose of ensuring continuity for the treatment by irrigation during the interval necessarily interposed by the ambulance train. Special arrangements were made for "Carrel" treatment. Wright's was applied by the ingenious device of the "salt pack."

The Salt Pack. In the idea of promoting serum lavage without mess and bother and of getting it going at the C.C.S. early in 1915 Lieut.-Colonel C. B. Lawson packed wounds with tablets of sodium chloride covered in gauze. The idea was taken up with enthusiasm by the Consultant Colonel Gray, and achieved a wide if transient vogue especially in the Rouen group of hospitals. Employed on the conditions laid down by Gray—(*i*) that the wound must be religiously cleaned up (in effect, *débrided*), (*ii*) that, unless specifically contra-indicated, the pack should be left *in situ* for a week or more, the offensive odour being dealt with *secundum artem*—results were obtained which justified its temporary vogue.

B.I.P. Surgeons familiar with the post-war history of this mode of treatment as developed by Winnett Orr[49] may perhaps find ground

[49] Vaseline alone is employed with gauze packing, especially in chronic suppurating bone conditions, rest is enforced by plaster casing. *See M J A. 9 June 1934*—article by A. V. Meehan

Morison's own idea of his treatment is told thus —

"I have discovered an antidote to true sepsis, and we are now about to leave dirty wounds undressed for a whole month Think of what this means for compound fractures. *Programme*. Open up and clean the wound, mop it out with spirit, then fill it with paste and cover with dressing *Paste*: Iodoform, 2 parts, bismuth sub-nitrate, 1 part, paraffin, q s to make a paste" (*B M J 21 Jan., 1939, p 140*—Obituary by Mr R. J. Willan) Mr Willan's claim that "'bipp' . . . is probably the only important new surgical measure introduced during the Great War which has survived and is still in use" is perhaps open to question In passing, in the use "B I P" we follow the *British Official History*.

for philosophic doubt as to the antiseptic rôle assigned to it. However this may be, the records of Australian units confirm the consensus of opinion that, though this procedure devised by Rutherford Morison in the middle of 1916, in the hope that it would provide a short-cut to early suture, fell somewhat short of its ambitious aims—and, perhaps, claims—it yet proved a most effective implement for bridging the gap between the front and the Base. The technique does not call for description—roughly, after exact surgical attention the paste was rubbed in to the recesses of the wound and all excess carefully wiped away and the wound commonly closed by suture but without tension. In August, 1917, the General Hospitals were required to furnish a report on the condition of the "Bipped" cases received. The report from No. 1 A.G.H. was that it should be "confined to such cases as offer a reasonable chance of excising damaged soft parts fairly thoroughly and in the case of fractures where it could be applied to the bone surfaces" (Lieut.-Colonel Balcombe Quick). "I regard B.I.P. as very useful, providing the wound has been efficiently cleansed and dried. I regard its use as reprehensible unless the surgeon is sure that the wound is free from foreign material and haemorrhage completely stopped" (Lieut.-Colonel T. P. Dunhill). The method had great vogue in Britain and in particular was exploited at the Great Endell Street Hospital staffed by women. As with other methods, the most important "lesson," it would seem, is that there is no royal road through antisepsis to asepsis.

2. Means: Scientific Antiseptics. The genesis of the idea of these derives, in part at least, from a source that has a peculiar interest for Australians. Professor Dakin[50] extolled the researches of C. J. Martin and Miss Harriette Chick as having "done much to supply accurate information as to the laws of disinfection"—in particular that they stressed the analogy between ordinary chemical reactions and the process of disinfection.

Neutral Chlorine Compounds. "Dakin's solution" (neutral sodium hypochlorite) and "eusol" (Lorrain Smith, July, 1915) made available the powerful antiseptic properties of chlorine. By the use of polybasic acid—such as phosphoric, carbonic, or boric—the irritant alkaline reaction became amphoteric, thus making available to the surgeon "buffer solutions" of considerable antiseptic power but withal congenial to the human tissues. Both were widely employed for immediate disinfection as well as for irrigation and lavage.

Oxidisers. Hydrogen peroxide was widely used throughout the war; ozone had a vogue for a time.

The Synthetic Dyes. Flavine. ("Acri-flavine" or "trypaflavine.") Created some years before the war in Ehrlich's laboratory and used as a trypanicide, the antiseptic qualities of the drug were tried out by Carl Browning and co-workers in January, 1917. It was tested clinically at the Base and in June, 1917, more exactly in Third Army experimental C.C.S. by McNee and Drummond. Their report showed that used in

[50] "Biochemistry and War problems"—*British Medicine in the War, 1914-17, p. 13.*

strengths of 1 in 1,000 or for irrigation 1 in 5,000 while it "prevented inflammation," flavine did not sterilise rapidly any but slight wounds, and most ran the usual course—anaerobes predominating at first and later giving place to streptococci which persisted for from 2 to 3 weeks. Briefly the same conclusion was reached as with all other methods and means employed—*good results could be achieved by antiseptics provided the wound were first given effective surgical treatment.*

The triumph of asepsis: excision

Logically, the subject of excision (the French *débridement*) presents itself in two distinct forms—(*a*) as a rational procedure evolved from the crude process of "mechanical cleansing of the wound," and (*b*) as a fortuitous, but not infrequent experience, by myiasis in men who had remained for some days unrescued. Of this many instances are recorded, salutary and otherwise, both in France and at Gallipoli.

"Colonel David Cade, A.A.M.C., recalls a case at Pozières of a German who was wounded in No-Man's Land and brought in after four days to the R.A.P. with a leg smashed above the knee, and the wound such that gas gangrene would have been expected It had however been flyblown, was full of maggots and all necrotic tissue had been consumed. There was no gas gangrene, and a clear 'line of demarcation' had formed. At the M.D.S. a 'butcher's' amputation removed the limb and next day the man was asking for a sausage; and was evacuated very well." (Note made in 1918 by the Medical Collator, A.I F.)[51]

In remarkable and suggestive contrast with the antiseptic and physiological methods, the technique which initiated a new era in the surgery of war wounds, and far more than any other factor was the *raison d'être* of the new strategy for the casualty clearing stations, had behind it no elaborate campaign of research; rather, it was the direct result of clinical common sense applying established principles.

The practice known as excision or *débridement* of wounds was a logical extension of the crude methods of mechanical cleansing and draining of the "reaction" period, and probably suggested itself soon to many surgeons.[52] For developing this method of treatment, as also in its logical consequence—that

[51] This treatment was known to the Greeks It may be suggested that the analogy to it is found in the use of B I P. and the salt pack rather than of excision; and that the action is chiefly mechanical and physiological—by promoting drainage—and only secondarily "antiseptic"

[52] A medical history of the war from a scientific and international standpoint is yet to be written—perhaps under the auspices of the League of Nations. The bibliography given in the *American Official Medical History* is international in character, that of the British History is somewhat parochial Opportunity for assessing the surgical work of the Central Powers has not been available to the writer.

more searching and perilous adventure in wound surgery, the return to the immediate suture—the credit both of priority and precedence must be given to the French Service.

The idea of "*debridement*" as the essential factor in wound surgery would seem first to have been voiced by P. Riche[53] in October, 1914 M. Depage is commonly credited with its scientific development and most energetic advocacy. At the Interallied Surgical Conference in March, 1917, the French surgeons referred to the method as well established Its combination with primary suture was rapidly developed during 1917.

"Excision" in the B.E.F.

In the British Service, with increasing care in the general clean up of wounds, individual surgeons both at the Base and the front were experimenting with procedure more exact than hitherto. The first published accounts of deliberate "excision" are those by Gray and Milligan[54] The latter was an Australian, and his article, dated June, 1915, is here reproduced.

"After eight months of experience of the early treatment of projectile wounds . . I desire to place on record a method of treatment which has given most gratifying results, and which, if practised thoroughly, will materially lessen the time a wounded man is absent from the firing line. In a modern projectile wound we have to deal with a varying amount of devitalised tissue and a varying amount of ingrained infected material, both of which are always present. The devitalised tissue varies in different wounds from a microscopical amount, through all quantities, to the gross obvious slough. The ingrained infected material is inseparably fixed to this devitalised tissue, and nothing short of the complete removal of the tissue can possibly get rid of the infected matter. Cleansing measures are placed at a great disadvantage, for only those

[53] *Bulletins et memoires de la Societé de Chirurgie, Paris, 14 Oct., 1914*—Quoted by *American Medical History, Vol. XI Surgery, Part I, p. 297.* The credit has also been claimed for Drs. Leriche and Gaudier of the French Army (Proceedings of the International Red Cross Conference at Paris, 1937).

The comparative slowness of the British Service in this development was doubtless largely due to the fact that the Anglo-French agreement required that so far as possible British casualties should be treated in Britain. This involved their rapid transit to the sea bases, and the Channel crossing. Development of *treatment* at the front was therefore made subservient to the prime purpose of *movement* Moreover the structure of the British Medical Service, like that of the British Army, was primarily based on the needs of expeditions overseas. The "stationary" hospitals were intended to serve a long Line of Communications. The structure of the French, on the other hand was based on readily accessible Hospital Centres, their front line and rear hospital systems were very closely co-ordinated.

[54] E T C Milligan late Major in the R A M C, a graduate of Melbourne University who, at the outbreak of war, was engaged in special study in England and joined the R A M C., author of "The Early Treatment of Projectile Wounds by Excision of the Damaged Tissues," *British Medical Journal, 26 June, 1915* It will be recalled that the Battles of the Somme began on 1 July, 1916

Colonel (later Sir Henry) Gray, Consulting Surgeon, B.E F. (Rouen Base and Third Army), author of "Treatment of Gunshot Wounds by Excision and Primary Suture," *Journal of the Royal Army Medical Corps, June, 1915*, also *The Early Treatment of War Wounds* (London, Oxford University Press, 1919)

organisms which are spread loosely broadcast on the surfaces can be removed or inhibited in growth by antiseptics The more important natural protective powers of the healthy body in which these wounds occur are also placed at a great disadvantage, for no vigorous opposition can be offered by devitalised tissue, and the healthy tissue is separated from the loosely scattered infected material on the surface of the wound by the layer of devitalised tissue bounding the wound, and this tissue also acts as a perfect culture medium.

"*The Method.* This consists in the extirpation of the devitalised tissues. An anaesthetic is given where indicated [local or general]. . . . The *wound of the skin* is boldly cut out with a sharp scalpel. It should be so completely removed that a clean healthy incised wound replaces the contused and infected wound made by the projectile. There should be nothing of the old wound remaining. The *wound of the superficial and deep fascia* should be treated in the same way. The *wound of the muscle* is dealt with in the same fashion. It presents, however, more difficulties because of the retraction of severed fibres, and because of the distance of the depths of the wound from the surface of the body. This latter difficulty can be happily overcome in many cases by making larger incisions.

"Removal of loose and fixed bits of obvious foreign and dead matter is, of course, essential. Ample exposure and drainage of the wound is necessary, and those wounds which are too extensive after the above treatment to retain a drainage tube do better than those in which a tube is necessary on account of their depth and narrowness By this procedure the wound is put in the best possible conditions for the bactericidal actions of the tissues and the outpoured lymph. It is important to remark that it is not wise to impair the resisting and offensive powers of the artificially obtained healthy tissue surfaces by the use of strong or injurious antiseptics.

"*Results.* This method, when combined with the surgical essentials of perfect rest, cleanliness, and frequent suitable dressings has resulted in the healing of projectile wounds, without any appearance of pus in wounds of the skin and of the superficial fascia. In many wounds of muscle and bone, also, this gratifying result has been attained. In the treatment of some wounds of bone and muscle anatomical problems have prevented these principles of treatment from being thoroughly carried out, so that the results have not been as good There have been no cases of generalised blood infection, nor of any spreading infection in the neighbourhood of the wound."

Note by Major Milligan

In a note, furnished for the purpose of the present history, and pointing a moral not likely to be superfluous in future wars,[55] Major Milligan wrote:—

"Quite early in the war, in 1914, while working at a Casualty Clear-

[55] Colonel Gray says: "It is curious . . that the technique laid down for treatment of complicated types of wounds should have been so widely accepted as correct, although only after considerable delay, while that for the simpler types was neglected . . Several British and Colonial surgeons, however, practised the method in the early days of 1915 . . It was not blessed by the general body of English-speaking surgeons, however, until it was discovered that our French confrères had also satisfactorily demonstrated its advantages" (*The Early Treatment of War Wounds*, H M W Gray, *p 158*)

ing Station in Flanders, I was impressed with the idea that excision was called for. Opposition came from three quarters:—1. From the administrative officers of the R.A.M.C.; for it meant increase in staff, alteration of equipment and allotment of work, and more accommodation in order to submit the greater numbers of wounded to anaesthesia and operation. 2. From some consulting surgeons, who felt that it was unjustifiable to submit a man already badly wounded to further trauma even with a scalpel. Undoubtedly confidence in antiseptic treatment, and fear of spread of infection after operative interference, made some surgeons bitterly hostile to the procedure. 3. From junior medical officers who disliked the comparatively uninteresting work of administering the large numbers of anaesthetics required for carrying out excision of wounds.

"Opposition was so great locally that I first carried out excision of wounds under local anaesthesia, and general anaesthetics induced by myself and continued by an orderly; and this often at late hours and unknown to those in authority. At the request of a Consulting Surgeon of the Army, who opposed this treatment, my Commanding Officer ordered me to discontinue surgery, and only allowed me to return with the request that I should cease excision of wounds. . . . Sir Anthony Bowlby, the chief consultant of the B.E.F., expressed himself in agreement with my publication at the time. Sir Henry M. W. Gray, to whom War surgery owes so much, was carrying out the treatment independently at the Base in France, and soon afterwards advocated it energetically at the front. Under pressure of these opinions, and from their own convictions, many surgical specialists now took up the treatment, and the necessary administrative alterations were made by the R.A M.C. for carrying it out.

"1. All early operative work was delegated to the Casualty Clearing Stations which were altered accordingly.

"2. Surgical Specialists and Anaesthetists were appointed to organise the surgery of Casualty Clearing Stations.

"3. Accommodation was made to enable four to six surgeons with their teams to operate at the same time so that large numbers of wounded were dealt with, teams working in shifts night and day during active fighting.

"The success of all antiseptic treatment depends on the preliminary excision of the wounds; as did also the good results of the Carrel-Dakin treatment; . . . and [it] paved the way for primary and secondary suture of wounds."[56]

Transition to new method

The technical experiments of Gray, Milligan, and doubtless hosts of others in the British Service were the reflections of action being taken along various lines, the general purpose of which was to procure *asepsis* in contaminated wounds. Of these lines of action the most important were the dissemination and co-

[56] A report of an address by Major Milligan, delivered in 1917, will also be found in the *M J A, 10 March, 1917, p 201*

Some details of the technique necessary to the success of excision and of *debridement* will be given in *Vol III.*

ordination of knowledge by extension of the system of *consultant surgeons* to the Armies in the field, and the creation of *surgical teams*. The arrangements for the Battle of the Somme included, indeed, a general move up of immediate surgery to the C.C.S. with the deliberate purpose of forestalling infection. During this great series of battles unlimited opportunity presented both for experiment and for the diffusion of knowledge.[57] From this time onward the surgical centre of gravity shifts to the front. Very gradually, in the B.E.F., "antiseptic" methods of treatment become adjuvant and secondary, being replaced, as the method of election, by "asepsis."[58]

The transition stage is illustrated by Fifth Army procedure during the German "Alberich" withdrawal to the Hindenburg Line.[59] A Circular Memorandum by Consulting Surgeon, Fifth Army (Colonel Maynard Smith, A.M.S.), 2nd April 1917, says:

"In practically all severe wounds admitted to C.C.S. it is found necessary to give anaesthetics to enable the damaged muscle, fascia, etc., bordering on the wound to be excised and foreign bodies removed, and to enable the surgeon to provide sufficient drainage. This is a preliminary to any form of treatment whether by 'Carrel,' salt pack or any drier method of dressing. It is this measure alone which diminishes the danger of severe anaerobic infection. The early and thorough adoption of this line of treatment (which is now the universal practice in casualty clearing stations) is interfered with if anaesthetics have been administered shortly before their arrival at the C.C.S." [They should be given] "only where the medical officer considers it absolutely essential and . . . when an anaesthetic has to be given for such an emergency operation, an attempt should be made to carry out the complete operation mentioned above."[60]

While effective operating was thus moving up from the Base Hospital to the C.C.S, urgent operating was moving rearwards, from the

[57] For the means whereby technical improvements were translated into practice *see pp 395-6*

[58] The "antiseptic" and the "aseptic" schools have fought, each for its pet abstraction, oblivious of the fact that the purpose of each is to promote, by direct action against the microbe, the efforts of nature in her fight against infection Continental surgeons faced the verbal issue clearly if not very helpfully. Thus M. Depage (Interallied Surgical Conference) "On utilisera uniquement les pansements secs: qu'ils aient été préparés par la méthode *aseptique* (*chaleur*) ou par la méthode *antiseptique* (*action chimique*), peu importe" (*Archives de Médecine et de Pharmacie, Tome lxviii—1917, p. 49.*) Such narrow usage seems unhelpful A wound through the protective layer of body cells must if possible be kept or made aseptic, *i e* free from pathogenic germs. By action promoting asepsis we seek to exclude germs from the wound, by antiseptic measures—heat, light, chemicals—we attack the germs directly

"Infected" and *"contaminated" wounds* These terms as applied to wounds were often used indiscriminately, but clinically the distinction was fundamental *The time limits which distinguish contamination of the wound from infection of the tissues determined the structure of the medical scheme of evacuation.*

[59] *See Chapter vi*

[60] To obviate the necessity of their use in fractured femurs the Thomas splint was advised and instructions for the first time given as to the method of its use in first aid—even "at times" at a R A P

Field Ambulance to the C.C.S., as is evidenced by the following incident. On 11th April, 1917, the officer commanding No. 45 C.C.S., wrote to D M S, Fifth Army, that cases from the 13th Australian Field Ambulance had been anaesthetised and partly operated upon at the field ambulance and "had to be re-anaesthetised at the C.C.S." He sent a list of cases "excised and drained" and "excised and dressed" at the field ambulance. *13/4/17.* D.M S. Fifth Army writing to D.D.M.S. I Anzac, required an explanation and referred him to the "instructions" *19/4/17.* O.C., 13th Field Ambulance (Lieut.-Colonel J B. St. Vincent Welch) replied to the following effect: Seven officers attended to 771 cases. "We had six tables in commission all the time and thus did not hold up any which would have reached the C.C.S. earlier." The serious cases were numerous and the medical officers believed that the general washing up and placing patients in pyjamas, excising of wounds, and draining had been of assistance. "We always found that recent wounds can be excised without anaesthetic and with no pain to the patient, later they appear to become sensitive again."

The last step : immediate suture of excised wounds

In the meantime, chiefly in the French Army, individual surgeons had been experimenting—as did Larrey in the 18th-19th century—with the possibilities of immediate suturing. In the British Army in August, 1916, Rutherford Morison envisaged the immediate closure of wounds in connection with his B.I.P.[61] In the French Army *débridement* was widely exploited with the same end in view.[62]

End of experimental stage

The "new surgery" of the Great War cannot better be summed up than by quoting the conclusions unanimously arrived at in the Interallied Surgical Conference of March, 1917.[63]

"(1) It is desirable that the organization of the Medical Service should be so directed as to permit of continuity in the supervision of the treatment of the wounded men.

"(2) At the first aid stations, and especially in the trenches, surgical measures should be restricted to the minimum. They should be limited to dealing with complications which might prove immediately fatal in

[61] Used for this purpose B I P gave poor results, but as an accessory to *débridement* it maintained a place throughout the war in the "delayed primary suture."

[62] In particular by René Lemaitre. "It is generally conceded that the first primary sutures were performed in July of 1915, by René Lemaitre. From July, 1915, to July, 1917, in 1,046 primary sutures, he had 944 complete cures, 39 partial cures, and 13 failures. . . . From July, 1917, to February, 1918, Lemaitre performed 1,618 primary sutures, with 1,555 complete cures, 44 partial cures, and 19 failures." *American Official Medical History, Vol. XI, Pt 1, p. 296,* quoting *Medical Bulletin, Paris,* 1918, 1, Supplement, March, 292.

[63] *Archives de Médicine et de Pharmacie Militaires, comptes-rendus de la Conférence Chirurgicale Interalliée pour l'étude des Plaies de guerre*—1st Session 15-16 March, 1917, pp. 103-4. A summary of the discussions at this and the next conference was published in the B E F in October, 1917, as "General Principles guiding the treatment of Wounds in War."

character, and to the protection of the wounds from repeated contamination. The wound is never to be explored or washed, and should be covered by a dry dressing either sterile or antiseptic in character.

"(3) Rapid transport to one of the casualty clearing stations is essential.

"(4) It is an advantage if each of these units has one or more advanced sections nearer to the firing line, for the reception of patients seriously wounded (such as those suffering from shock, profuse haemorrhage, wounds of the chest, abdomen, etc.)

"(5) All wounds of war must be considered to be either contaminated or infected.

"(6) The object of treatment should be:—(a) To prevent development of infection if the wound is still in the stage of contamination, or to procure sterilization if infection has already developed. (b) To permit of secondary suture, when sterilization is realized.

"(7) In the primary treatment of the wound, excision of contused and lacerated tissue and the removal of fragments of clothing or foreign bodies must be considered as the rule, except in certain cases where the patient cannot be kept under supervision.

"(8) When the wound has thus been properly prepared, primary suture may give good results, especially in the case of wounds of the joints. Primary suture is not to be undertaken unless the wound is only of some hours' standing (at the most eight hours), and only when the surgeon can retain the patient under his own observation for fifteen days.

"(9) If primary suture be not undertaken, secondary suture should be performed when the clinical signs indicate that the wound is surgically sterile.

"(10) The progress towards sterilization should be systematically controlled by a series of bacteriological examinations, and a 'curve' should be constructed to allow the degree of sterility to be determined.

"(11) When patients have to be hurriedly evacuated, and definite preparation of the wound postponed, a dressing, the action of which should continue during the period of transport, may be usefully applied. Further researches on this subject are needed.

"(12) Several methods for the progressive sterilization of wounds are available, which allow of the routine practice of secondary suture."

THIRD STAGE: Exploitation March, 1917–March, 1918

The year 1917 offered unrivalled opportunity for the try-out of methods which experiment had shown worthy of further exploitation, and for implementing these by extension of the system of casualty clearing stations and making the work in the field ambulances subservient to theirs; the effort in the ambulances was now more particularly directed to treatment of the man rather than of the wound. The huge casualties of Arras and Third Ypres[64] coincided with

[64] During 1917-18 1,140,398 wounded were admitted to British casualty clearing stations in France (*British Official Medical History Statistics, p. 27*)

the extreme developments of stationary warfare This circumstance made it easier for the C.C.S., its equipment and establishment, and in particular the use of specially trained operating teams, to be developed to the utmost so as to ensure that as many as possible of the wounded who required it should receive operation under anaesthetic.[65] In particular, the possibility of the immediate or early closing of wounds was exploited to the utmost. "Experimental stations" in the various armies[66] investigated the possibilities of excision with suture—"primary" and "delayed primary";[67] and of various antiseptic and lymphagogue accessories, flavine, B.I.P., salt pack, etc., which have already been described, although experiment with them continued actively throughout this stage.

The situation at the end of this stage is shown in the report of the Surgical Specialist of No. 2 A.C.C.S. (Lieut.-Colonel Balcombe Quick) for February, 1918.

"During the month," it says, "both Lieut.-Colonel Quick and Major Barton have visited the Research Centre—No. 10 C.C.S., Remy Siding —to see the work that is being done there in connection with the early closure of wounds. The object of this research has been to find out in what class of case, with how much safety and how much success, recently inflicted wounds may be closed after thorough excision; or, when it is not judged safe to close at once, whether early secondary closure is not practicable. A very considerable degree of success has been obtained, both by primary suture and by packing for 48-72 hours with flavine gauze and suturing at the end of this period. The balance of opinion at this centre appears to show —(1) that the excision is the essential feature of the operation, the actual antiseptic (flavine, B.I.P., ether,

[65] The proportion of patients operated on under anaesthetic in the casualty clearing stations varied very greatly with the conditions of the fighting. This is shown in the graph on *p 372*, which gives the experience of No. 2 A.C.C.S. Of the figures quoted 30 per cent received operative treatment Sir Anthony Bowlby (*Surgery, Vol I, p 239*) states that "in quiet periods in a casualty clearing station, medical officers put 50 per cent of wounded on the operating table, and, to avoid dangerous operations at the base, had to operate on 25 per cent" The figures for the Battle of Arras are placed at 24 per cent. In the Battle of Estaires (April, 1918) the proportion varied from 9 per cent on 9 April and 14 per cent on the 10th (2,615 cases) to 53 per cent. on the 16th (252) and 51 per cent. on the 19th (395), an average of 23 5 per cent for some 13,000 cases over two weeks The balance would require operation in the General Hospitals at the Base.

[66] No. 26 General Hospital at Etaples was the first of these and was set apart in June, 1916 Subsequently the First, Second and Third Armies set aside casualty clearing stations for research and experimental work in wound treatment in connection with antiseptics, excision, primary and secondary suture, and the prophylaxis and treatment of wound shock

[67] For the technique of these procedures *see Vol III* Here it may be said that by "primary" suture was meant suture at the time of excision, "delayed primary" suture was that done after a delay of 24 hours or so to permit evacuation to the Base—but not involving the approximation of granulating surfaces ("secondary suture")

etc) then applied being of secondary importance; and (2) that packing, with early secondary closure, is the safest procedure if early evacuation of the patient be necessary.

"For some time past we have been carrying out operations on the same, if rather a less ambitious plan, and the results have been satisfactory, and in no case, as far as I am aware, has harm resulted. It is perhaps a little doubtful if operations of this type, which take up a fair amount of time, can be carried out as successfully in times of stress."

FOURTH STAGE: 1918

On 21st March, 1918, Ludendorff struck. Thereafter, the war enters a new phase. The narrative of military events in that phase is found in the last section of this volume, and consideration of the fourth and final stage of wound treatment during the war is therefore deferred to a later page.[68]

The Treatment of the Wounded Man

The results of wounding *per se* to the wounded man were, as we have seen, pain, haemorrhage, and vital depression ("collapse" and "wound shock"). It is obvious that if "excision" or any other form of surgical intervention was to serve the seriously wounded man, treatment of these direct effects was of extreme importance. Its several therapeutic activities were to him as vitamins are to infection.

The problem of pain

Though perhaps the most conspicuous weapon of warfare, the infliction of pain is not in itself the most important.[69] But its association with wounds is so general as to make alleviation an important humane duty of a medical service in modern warfare.

The immediate nervous and psychic effect of a severe wounding was a "primary shock" in which the element of pain might be inconspicuous. The local analgesia produced might permit of the removal of shattered limbs and of much manipulation without obvious pain, though possibly to the patient's detriment. And though after reaction had set in, the pain from wounds might at times be great—even to make men beg for death—with effective management it might even in the worst

[68] *See Chapter xiv (pp 782-7)*

[69] The only weapon used in the Great War in which pain *per se* was the sole effective agent was the gas diphenyl-chlorarsene, the inhalation of which through the nasal passages even in a concentration of 1 part in 200 million of air, though devoid of any risk to life or serious after effects, produced for a short time such agony as wholly to disable

wounds be surprisingly moderate.[70] "Management" includes the whole complex of movement and treatment—"pain" may in effect be a reactive demand for rest as well as a reflex call to action. Hilton's testament of "Rest and Pain" has full support from the war.

Pain and "Shock" One of the most striking features of very severe wounding was the progressively diminished general sensibility to pain and stimulation that was associated with "secondary" wound shock.[71]

Measures of relief. The influence of rescue on *psychic pain* has been referred to.[72] The one conspicuous and permanent measure for the relief of physical pain of wounds was to *remove its cause, i.e.* the wound itself when acting as a *noxium*. If furnished by the ideal method, as by excision and primary suture, relief might be immediate and absolute; and even far less effective measures of treatment if combined with *rest*, often wholly replaced anodynes. Foreign bodies, if not producing tension, were often left for a more convenient season without causing pain. The rôle in war of "anaesthesia," local and general is dealt with in *Vol III.*

Morphia. As in civil medicine, opium, chiefly in the form of morphia, was the most important drug in the military pharmacopoeia. It was given at the direction of the R.M.O. or other officer, usually in ¼ to ½ grain hypodermically from a 5 per cent solution. The technique of its "exhibition" was one of the most important aspects of front line work, many men died from its misuse, many others sustained great needless pain. The action taken to ensure the co-ordination of procedures at each stage of evacuation by the Field Medical Card included the administration of morphia and A.T.S. and was the subject of the first entry in the long train of "records and returns" which followed the wounded man from R.A.P. to "Con. Camp" and ended with the Medical Board Paper (*Army Form W. 179*).

The following from the war diary of No. 3 A.C.C.S. (Lieut.-Col. R. D. Campbell), February, 1918, brings this matter of morphia into the general scheme of evacuation.—

"It is undoubted that, in spite of moderately favourable weather, wounded cases have arrived frequently in poor condition. That this is due to delay in collection and transport I cannot agree, as for all stretcher wounded admitted in this month, an average of 6 hours

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[70] The pain from an ordinary severe bullet wound of a limb not involving a long bone is described by Capt. Frank Kerr, an Australian who was wounded on 8 Aug., 1916, on the Somme while serving with the R.A.M.C. ". . . Dressed all wounded found in open . . getting into communication trench, seen by snipers . . Hot needle sensation in right hip and concussion down bone to foot—knocked into trench on to left shoulder and temporarily paralysed left arm. Sensation as if hot fluid being poured all over limb—grab femoral artery. . . . Crawl along trench on one leg to find stretcher. Car to Mametz (F. Amb.) then to Doullens (C.C.S.). Uncomfortable ride, quiet night, wound drained and dressed *9 8 16*. Feeling of absolute bliss. Wound painful at times. *11.8 16* Left for Rouen, very comfortable."

[71] Professor Sherrington explained this phenomenon by the interesting hypothesis that the ingoing impulses are "blocked" by an increase in the natural resistance at the synapse between the afferent nerve cells or neurones lying wholly within the central nervous system. Sherrington's view that this is a protective reaction seems difficult to accept for secondary shock on clinical grounds, which suggest rather a morbific (exhaustion) effect of the trauma producing the morbid state. (*cf British Official Medical History, Surgery, Vol I, p 89*.)

[72] *See pp 275-6.*

10 minutes has elapsed between wounding and arrival at this C.C.S. In many cases, and notably in cases of urgency, only three hours might elapse between wounding and arrival, in spite of the fact that the C.C.S. is about ten miles behind the line. The factors which have been operative in producing the generally unsatisfactory condition of patients on admission are in my opinion:

"(1) The severe type of case admitted. . . .

"(2) Too frequent handling. . . .

"(3) The very limited use of Morphia. Out of 66 stretcher wounded only 10 had had morphia, and in each case only one dose. In only two was the dose of ¼ gr. exceeded. This abstention from the use of Morphia is the direct result of the present teaching in the Army, largely based on the 'acidosis' theory. While realising that some months ago Morphia was given in excess, I am not satisfied that the pendulum has not now swung too far the other way, and think that the influence of intolerable pain in the aggravation of shock should be considered."[73]

Haemorrhage

The means prescribed by teaching and tradition and implemented by equipment for the control of haemorrhage are briefly referred to later. The only significant development in this connection in the war, but one of major importance, was the scientific and very extensive use of intra-venous infusion of saline fluid and transfusion of blood for the treatment or prophylaxis of its graver effects. The matter is so intimately related to the treatment of "wound shock" that it may properly be examined in that connection.

Vital depression

In the course of the war the term *"wound shock"* came into general use to identify the clinical syndrome associated with the collapse of the vital powers which may follow on the sustaining of serious physical injury. The physiological and therapeutic problems presented by it were of great complexity. The reason for this may readily be discerned in the fact that the clinical syndrome thus identified derives from the very sources of organic life. The self-sustaining chemical actions and reactions and corresponding physiological processes that are the physical component of life are of immense complexity and diversity; and it might well have been foretold that their degradation, whether gradual or rapid, to the simplicity and quietude of death, would be characterised by a corresponding complexity in the resulting disorders of function not readily amenable to discrimination by clinical analysis into specific "syndromes," "disorders," or "diseases."

[73] It is perhaps permissible in this connection to refer to recent work on the prevention of wound shock by spinal anaesthesia—proposed in the war

That such prescience were fully justified in relation to gradual decay, the never ending problems of "chronic disease" as met with in peace give ample proof. The Great War, first in the history of medical science, showed that it is scarcely less true of the rapid failure of the various vital functions brought about by physical injury, such as severe wounding. One of the most striking features of medical work in the war is to be found in the initial emergence of the pre-war concept "surgical shock" as a specific and unique syndrome, "wound shock," and its subsequent gradual resolution in a complex of pathological degradations. These, under continued adverse conditions, might move inexorably to an irreversible master-failure in a reduction of the total blood-volume to below 60 per cent. and its stagnation in the peripheral circulation indicated by a persisting fall of systolic blood-pressure to below 80 mm. of Hg.; further descent would lead to total heart failure and death. The identification of the causes that might bring about such an impasse, and the detection and exploitation of any opportunity for therapeutic intervention, constitute a remarkable episode in the history of scientific medicine. Until the last years of this present decade the subject remained much as left by the war and its immediate aftermath of war-engendered experiment. As with its *vis-à-vis*, the problem of streptococcal infection, if with less dramatic results, the past few years have seen a renewed interest and experiment; so that indeed on the scientific side the interest of war experience is chiefly historical.[74] From the orgy of clinical observation on unanaesthetised animals (battle-casualties) and corresponding series of laboratory experiments on anaesthetised animals, (cats or rabbits in England, and dogs, in America and on the Continent) the concept "traumatic shock" emerged from the war an almost crudely clinical

[74] The whole subject of "Shock" is much in need of comprehensive analysis and re-integration of relevant facts and current ideas regarding its essential nature and pathogenesis. The evolution of the general concept "shock" as connoting specific clinical syndromes each with a corresponding morbid anatomy and—to coin a needed term—morbid physiology is a peculiar and not particularly illuminating one. In effect, we say "Shock"—of various designations—is caused by the shock of a "shock." Lieut.-Col. Sir F. W. Mott, F.R.S., in 1917-18 investigated "the changes in the central nervous system occurring in various forms of shock"; the material employed including: "Brains of fatal cases of shell shock, with and without burial, and probable gas-poisoning. Brains of three cases of fatal wound shock. Brain of shock from extensive burns. Brains of anaphylactic shock. Brain of fatal shock from contusion of heart. Three brains of animals injected with histamine. Brain from death under anaesthetic." (*Medical Research Committee's Report No. 26, dated 14 March, 1919, pp. 44-5.*)

one, reflecting on the pathogenic side a curious congeries of causative and contributing agencies and their effects, such as psychic and physiological "pain," and their reflex effects such as acapnia; "excitement" and fear and their related glandular (hormonic) reactions; haemorrhage, with resulting anoxaemia, and acidosis; thermogenic failure; cardio-vascular failure; neurogenic failure; septic toxaemia; other intoxications as by an "H" substance. On the other hand the technique developed for the prevention and treatment of the morbid states concerned was very exact and successful. An account of war research will be found in *Appendix No. 14*. It must suffice here to define the syndrome and note the progress of ideas on the matter as reflected in official instructions.

The Nature of Traumatic Shock From early in the war the clinical syndrome to which the term "wound shock" came to be applied was somewhat vaguely conceived as having a dual constitution as "primary" and "secondary." Precise definition and discrimination between the two did not however reach the plane even of clinical exactitude. The indiscriminate use of the word "shock" had, indeed, brought about a veritable "Babel," whereby causes and effects, morbific agents and morbid states, were confused. We may perhaps trace the genesis of the idea of a "primary" and a "secondary" type of wound shock in every-day experiences of the front. The first picture presents a robust and healthy soldier in a state of collapse—pallid, forehead bedewed with cold sweat, *facies* anxious and apprehensive, pulse imperceptible, himself presently to become unconscious—the cause of the condition being the fact that he is about to receive a hypodermic injection of T.A.B. or is being given first aid for some trifling wound. A second picture presents a similar man seen within a short time of the receipt of a serious wound. The clinical syndrome of vascular hypotension, faintness, and collapse might again be present as a temporary phenomenon; to pass off with reaction. A third experience showed the wounded man who, leaving the R.A.P. in good condition arrives at the C.C.S. pallid, cold, collapsed, requiring major acts of resuscitation before reaction may be induced. The superficial resemblance between the psycho- and neuro-genic collapse after wounding, and the clinical syndrome characteristic of "secondary" shock as commonly understood[75] (which reflects and "is proportionate to the sum of the intensities" of a congeries of morbific agencies) led to the creation of a clinical artefact, "primary" wound shock, as a distinct morbid entity, instead of a functional disorder, reflecting chiefly the psycho- and neuro-genic elements in vital collapse. At the

[75] It would seem that this confusion may have come as well from the other end (so to speak) by the confusing of "secondary" shock with the condition so known in the earliest days of "shock"—the 1870's—wherein death ensued many days after the injury (see *e.g.* O'Shaughnessy, *B.M.J., 13 April, 1935, p. 793*). The official "Manual of Injuries and Diseases of War," *Jan., 1918*, is content to confound this confusion, so the clinical picture is clear, thus:—"*Wound shock.* The condition known as shock is familiar to all. A precise definition has yet to be found.

end of the war the idea of wound shock as a continuous development from morbid processes set in train at once by the wound was accepted as a proper, if a provisional, basis for treatment

The onset and course of this terrible condition[76] has conveniently been described[77] as falling in three types or groups: (i) compensated, (ii) partially compensated; (iii) uncompensated. In the first type of case the patient's general condition is good with no symptoms of distress except for the local pain of the wound and general weakness He may be pale, the pulse rate 90-110, systolic blood pressure above 100 mm., and the blood volume not below 80 per cent. In the second group the patient's general condition is not so good. "There is usually a history of a smart haemorrhage. He is very pale, restless, thirsty, and vomits readily. The extremities are cold and partially anaesthetic to painful stimuli. The pulse-rate is rapid, 120-140, and difficult to count; the systolic blood-pressure is, as a rule, below 90, usually 70-80 mm Hg. The blood volume ranges between 65-75 per cent." In an uncompensated case the patient is in an extremely serious condition; as a rule restless, very thirsty but liable to vomit at once if given fluid by the mouth. The extremities are very cold to the touch, the pulse cannot be felt, the blood pressure has fallen below 60 mm. Hg. On auscultation the heart-rate will be found to be 120-160. The blood volume is below 65 per cent of the normal.

Professor J. Fraser[78] sums up the situation in the severely shocked man as a therapeutic problem:—

"With the establishment of a low blood pressure, something in the nature of a vicious circle comes into play. . . . It will continue to a fatal issue [or] until some link in the chain is broken and the error of the blood pressure is overcome."

The following notes on the four official statements from

. . . Pure shock, that is a state of extreme depression of the vital functions, without apparently adequate cause and possibly ending in death, has been met with. On the other hand, shock as seen in war is usually the result of one or more of the following factors. . . . Shock may be (a) primary or (b) secondary (a) Primary shock comes on almost immediately after the receipt of the wound The patient passes into a state of collapse. . . . At this stage the pulse rate and blood pressure may or may not show a great departure from the normal (b) Secondary shock manifests itself later . . . Both (a) and (b) are greatly aggravated by loss of blood, sepsis (*sic*), and mental perturbation." Gray (*loc cit. 1919, p 81*) finds it "necessary to distinguish between two conditions, namely, *primary shock*, or the collapse immediately supervening on the infliction of a severe wound, and *secondary shock*, which develops later as the result of such factors as exposure to cold, pain, haemorrhage, movement, anxiety, exhaustion, and all the other harmful influences associated with a long journey to the casualty clearing station"

[76] Thus Prof. John Fraser whose war work was of outstanding merit—"Operation shock or surgical shock . . . is one of those factors which have delayed and curtailed the evolution of surgical progress. Were it possible to eliminate its appearance, the surgical horizon would correspondingly enlarge . . In the surgery of childhood and of accident, and in that most extreme form of accidental surgery, the surgery of war, surgical shock has ever played a formidable part" (Sixth meeting of the International Society of Surgery. *British Journal of Surgery, 1923-4, Vol. 11, p. 410.)*

[77] By Capt. N. M. Keith, R.A.M.C., "Blood volume in wound shock," *M R C Reports, 1919, Series 26, p. 39.* The idea of *reaction* is preserved

[78] *British Official Medical History, Surgery Vol I, p 97*

headquarters B.E.F. on surgical procedure brings the subject to the beginning of 1918. So far as such official pronouncements may do so, these reflect the constantly changing picture of current practice at the front. There in the last phase of the war, largely through the influence of the Consulting Surgeons medical practice reacted to advances in knowledge with a facility scarcely approached in peace.

(1) In *"Circular Memorandum No. 6"* (March, 1915) the term "shock" does not appear. Reference is confined to the statement that "men who have been left lying out for a day or two are often so severely collapsed that it is advisable to use subcutaneous injections of saline solution, and to administer food and stimulants before attempting to dress the wounds."

(2) The official *Memorandum on the treatment of injuries in war* (July, 1915) devotes a single paragraph to "the condition of wounded men" "The majority of gunshot wounds," it says, "do not inflict very serious injury, and so do not cause material shock or collapse"—a statement which perhaps reflects the restrictions of rescue work at this time—but "in every convoy there are always some men in a serious state of collapse." The "causes" of this had by this time been clearly identified. Normal saline by subcutaneous or intravenous injection, or per rectum "if collapse very severe," was commended.

By this time the casualty clearing stations had become the chief operating centre, and the modern technique of war surgery was developing. "'Moribund' patients were put into warm beds"; in special wards. 1916 and "The Somme" were, however, tragic for the wounded man. To the terrors of transport to the C.C.S. far in rear, was added the fact that the peculiarly British fetish, saline infusions, dominated the situation. The tragedies that lie behind the term "most disappointing," applied by the British Official Historian to the results, can readily be visualised against the background of our *Chapters IV-VII.* Though Professor Bayliss' historic paper on the use of colloidal infusions was published in August, 1916,[79] and in February, 1917, the Medical Research Committee issued a special memorandum on "Surgical shock and allied conditions," neither Australian records nor the British history disclose any official publication until the following, in October, 1917:—

(3) *General principles guiding the treatment of wounds in war* was based on the conclusions adopted by the Interallied Surgical Conference of May, 1917. Here we find "traumatic shock" defined as 'a disturbance in functional equilibrium, characterised by reactions of the depressing class, which may even extend to death," the "essential elements" of which are discerned as "a fall in the body temperature and the arterial blood pressure" The treatment set out features "alkaline infusion" against "acidosis"; neither gum-saline infusion nor blood transfusion are mentioned.

August, 1917, saw the formation by the Medical Research Committee of its "Special Investigation Committee" for the study of "surgical

[79] *Proceedings of the Royal Society, B Vol 39, 1916.*

shock and allied conditions"; and about the same time, the initiation in the armies in France of the campaign of research in surgical treatment to which reference has already been made. Thereafter events move with increasing momentum. An event of major importance was the attachment from the American Expeditionary Force of men of world-wide repute in this subject.

(4) The *Manual of injuries and diseases of war* issued in January, 1918, contains ten pages devoted to "wound shock" and another two to "transfusion of blood." Part of its reference, in relation to "primary" and "secondary" shock has been quoted.[80] The treatment prescribed was designed to combat "three main conditions" (a) loss of body heat, (b) a low blood pressure, and (c) a decreased alkalinity of the blood; and was divided into that to be adopted in (a) the "forward area," and (b) the casualty clearing station.

Here, for the present, the matter may be left and the reader referred to *pages 659-64, 782-7,* and to *Appendix No. 14.*

Stages of Treatment During Evacuation

It is hoped that the reader will have derived from the foregoing some useful information concerning the problems associated with the pathology of wounds and their treatment by general surgery during the Great War. But no valid concept of military surgery on the Western Front can be obtained unless full allowance is made for the two factors which most of all determined its clinical application in the field, namely, *military exigency* and *medical organisation.*

(1) *Military Exigency.* In heavy engagements the rush of casualties made movement more urgent than treatment. The surgical centre of gravity was forced back again to the base, and only the most severe and urgent types of wound were then dealt with in the zone of the field formations.[81]

(2) *Medical Organisation: Co-ordination of Procedures.* As the war progressed the treatment of wounds and of wounded men developed into an ordered and progressive campaign of surgical intervention, interposed with increasing deliberation and precision, at critical stages in the clinical situation, or in convenient eddies in the course of the stream of casualties moving from the front line in France to the hospitals in Britain. The procedure at each point, and in each type of trauma, was determined by accumulated tradition, which gradually crystallised in official instructions. More and more exactly these various stages were determined by the *needs of the case* rather than by the *structure of the medical system.*

With the proviso that the facilities for treatment conformed,

[80] *See footnote pp 337-8*

[81] *See footnote 65 on p 332, footnote 31 on p 407, and pp 621-22.*

perforce, closely to the military "situation"[82] the surgical procedures proper to the various stages of evacuation of an Australian from the Western Front may roughly be defined as follows:—

The elements in early treatment

1. "First aid" was given at the hands of the regimental stretcher-bearers and at the R.A.P. where also, as well as at the ambulance relays and collecting post, pain was assuaged and some mental and physiological rest, sustainment, and warmth were often provided.

2. Surgical emergencies were met, A.T.S. administered and measures for the prevention of "secondary" wound shock and first-aid treatment of gassing carried out, sustainment (warmth, fluid, and food) provided, and if necessary rest secured, at the A.D.S. and Field Hospital (M.D.S.); or at an advanced operating or "shock" centre for special "untransportable" cases.

3. Contingent on the military situation, effective operation—such as excision and primary suture—was performed, and the treatment of secondary wound shock and of gas wounding carried out, at the advanced operating centres, the C.C.S., or the Base Hospitals.

4. Secondary surgery, and after-treatment, were carried out at the Expeditionary Base Hospitals and hospitals in England; and the former also undertook:—

(a) Primary operation, particularly in slighter cases during "rushes" of wounded, (b) the completion of delayed primary suture; continued treatment of salt pack, B.I.P. and Carrel-Dakin cases; (c) surgery of foreign bodies, (d) surgery of secondary "septic" infections—in particular by the strepto- and staphylococci; (e) surgery of special types of wounds, such as femurs, spinal and head cases, and extensive and multiple woundings unfit for the Channel crossing.

5. "Consecutive" surgery (as it may for convenience be termed) such as the consecutive treatment of fractures and the surgery of sequestra, foreign bodies, fistulae, and sinuses, the empyema stage of chests; secondary amputations; the secondary consequences of cerebral, vascular, neural and tendon injuries, were undertaken in the General Hospitals in Britain.

6. Convalescence took place in the Australian and British Auxiliaries; which also dealt with cases coming under headings 5 and 7.

7 Reparative—orthopaedic and prosthetic—surgery, and artificial replacements, were carried out chiefly in special hospitals in Britain, such as Southall and Sidcup, and in Australia.

8 For Australian soldiers interim treatment in preparation for the last-named—as massage, electrical stimulation, and remedial exercises; and also "vocational training" and "re-education" were carried out at No. 2 Command Depot, on hospital ships and hospital transports.

Leaving the major surgical problems special to the C.C.S.,

[82] Readers of *Vol I* will recall instances of overlapping—as in the work done by field ambulance on the "black ships" at Gallipoli. Apparently the same conditions obtained in the first phase of the war in France. Only at the relatively static extremes, the front line and the home base, were the factors in the situation more or less stable.

Base Hospitals, and hospitals in Britain to be referred to in the succeeding chapters, we now pass to a review, necessarily cursory and incomplete, of the treatment of wounds and wounded men at the various posts and stations between the front line and the C.C.S.[83] Certain therapeutic problems, however, namely the procuring for the wounded men of rest, warmth, fluid and food—in brief the problem of vital maintenance—entered into the situation at every stage, and a word must first be said about these.

Rest. "The therapeutic value of rest has been recognised by surgeons of all periods. It constituted the fundamental principle of Hunter's practice."[84]

"The most important elements in combating the development of profound secondary shock are rest, both mental and physical, and warmth."[85]

"In every case the infected man will need to be kept at rest; and the really heavily infected will require to be kept at *absolute rest*."[86]

Of all therapeutic measures this was in the war the most difficult to achieve. Its great importance was at times lost sight of—as in the *furore* for rapid evacuation which in 1917 followed the discovery that sepsis might be prevented by early operation. From the front line to the C.C.S. the promotion of rest, local and corporal—as by careful handling, effective splinting, timely postponement of movement or of operation, and alleviation of pain—often made the difference between the success or failure of subsequent treatment. That the quest for rest only too often fails is one of the most poignant agonies of war. It could be promoted by exact training and routine, by forethought in the maintenance of equipment, such as splints and stretchers, and of transport; and by effective *liaison* between the officers responsible for movement and treatment respectively.

Warmth. Experience in France emphasised the profound therapeutic importance of a clear recognition of the fact that two distinct factors are concerned in body heat—(a) the internal production of heat, and its conservation, and (b) the artificial supply. Thus unwarmed blankets were of little use to a man whose thermogenic powers were in abeyance; so were hot drinks without conservation, as by dry clothes, effectively applied blankets, and "ground sheet." The following list of appropriate measures reflects every-day experience on the French front—

Positive (by external supply). Food and oxygen for internal com-

[83] Apart from the strictly surgical manuals no official handbook was provided to guide medical officers in their field work. This serious hiatus in training and instruction was met by special action in each army. A handbook *The Treatment of Wounded Men in Regimental Aid Posts and Field Ambulances*, compiled for Third Army by Col. H. M. W. Gray, A M S., and Capt. K. M. Walker, R.A.M.C., and printed in the field on 8 Dec., 1917, was a model of what such manuals should be. It is not proposed to enter here into details which should be available in convenient form in official handbooks

[84] Sir Arthur Keith, *Menders of the Maimed, p. 25.*

[85] Colonel H. M. W. Gray, *Early Treatment of War Wounds, p. 6*

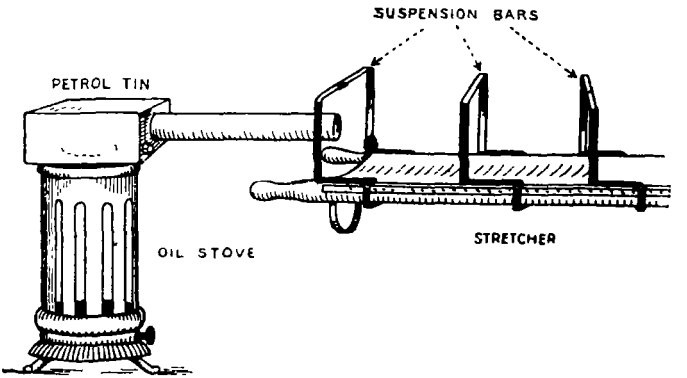
[86] Sir Almroth Wright, Official Memorandum, May, 1916, *Treatment of Infected Wounds, p. 19*

bustion. Administration of warmth by hot drinks and hot food, clysters and saline infusions; or of warmed air, from fuel and primus stoves and car exhaust; hot bottles and bricks, and warmed blankets.

Negative (by conservation). Blankets, dry clothes, ground sheet, shelter, such as dugouts, huts and tents.

The supply of oxygen in the form of blood is dealt with under transfusion.[87] In heat *conservation* apart from the external temperature the most serious adverse factor was wet, and mal-use of blankets. To be effective *the technique of the blanket* called for procedure as exact as the application of the Thomas splint and it should equally be a part of the routine drill of the Medical Corps. The supply of blankets to the R.A.P. lay with the bearer division and Battalion Q.M. The duty of forming dumps of these supplies lay equally with units, Division, Corps, and Army.

For every type of hurt or stage of treatment no act of sustainment was of greater importance than the "administration" of artificial warmth. Probably the most effective mode of administration of heat was by hot drinks; less so by parenteral intravenous infusions. In the Great War the oil stove was an invaluable item of equipment, and an article of this nature should be a liberal issue at every level of evacuation. With its help it was possible even in the R.A.P. to apply



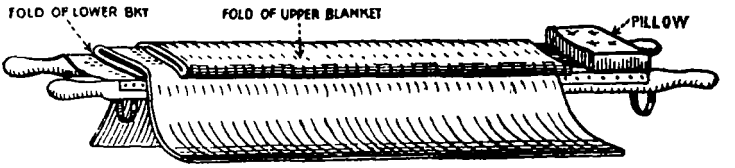
A METHOD OF APPLYING HEAT BY HOT AIR

The "Cradle" is made from Thomas Splint suspension bars. Hot air is led from an oil stove to the cradle by means of a two gallon petrol tin, adapted as in the drawing

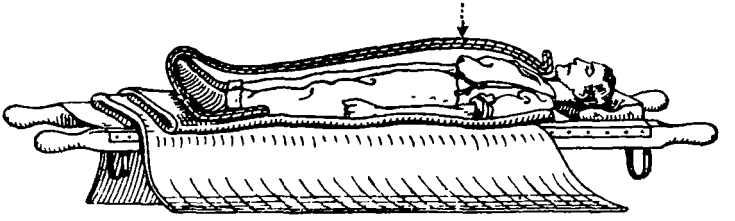
From 'The Early Treatment of War Wounds," by Colonel H. M. W. Gray

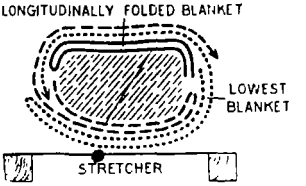
artificial heat as in the manner illustrated. At the M.D.S. or shock centre, and especially at the "resuscitation hut" at the C.C.S., it could be used with even greater effect. The use of stoves to warm dugouts, huts and tents, and that of the car-exhaust to warm the motor ambulance, were measures of first-rate importance.

[87] *See Appendix No 14*



LONGITUDINALLY FOLDED BLANKET





THE TECHNIQUE OF THE BLANKET.

This was to meet a prime need in preventing wound shock, the maintenance of body heat. "The patient should be stripped of wet outer garments and placed on a dry stretcher on trestles with a primus stove underneath This stretcher is prepared with two blankets folded three times lengthwise, so that there are four folds beneath the patient and one hanging down on either side to complete the hot air chamber Thus while dressings and splints are applied the patient is being warmed. The third blanket now covers the patient, and hot water bottles are applied." (D.M.S., First Army "Suggestions for prevention and early treatment of Wound Shock", dated 2 Nov., 1917.)

Diagrams reproduced from "The Treatment of Wounded Men" (1917), by Colonel H M. W Gray, A.M S , and Captain K M. Walker, R A M C , and 'The Early Treatment of War Wounds" (1919), by Colonel Gray

The actual technique of the blanket and hot-air cradle will doubtless be exactly described and figured in all military medical training manuals, and only a brief note is required of the practice on the Western Front. The figures here shown illustrate the practice at the end of 1917 in the British Third Army, from which most of all the Australian Service drew its inspiration. The procedure described was to be followed from the front line to C.C.S.; warmth was to be applied in conjunction with the blanket technique. A sheet issued by the D.M.S, First Army in November, 1917, figures a stretcher on trestles with the side folds of blanket let down to form a hot-air chamber beneath the stretcher.[88] Prophylaxis was based on the premise "that two varieties of wound shock may be recognised: (a) primary, the direct result of the wound; and (b) secondary, induced by cold and the disturbance of transport"; and that "by appropriate means (a) can be reduced and (b) prevented or minimised."

Fluid and Food. Together with warmth, the chief physiological need of the wounded man—and always an urgent one—was for fluid, a need which haemorrhage and the sweat of battle greatly increased. A good "second" to these was the call for glycogen. This was reflected in the soldier's preferences: hot tea, with plenty of sugar, was better liked and was more often retained against the nausea of impending "shock," than were beef extract, cocoa or condensed milk. To neutralise the acidosis found in declared "shock," alkalis were given—as sodium bicarbonate in tea. The artificial administration of fluid and food such as glucose-saline by intravenous infusion is dealt with elsewhere. Alcohol had little place, if any, in the treatment of wounded men For the "walkers," solid food in plenty from the "Soyers" cookers; and here also Red Cross "amenities" had a legitimate and useful place in the problem of "medical comforts"

Treatment at divisional posts and stations

Next to the actual effects of his injury, the journey from the trenches to the C.C.S. was the most potent factor in the fate of the wounded man and nothing that might contribute to his safety and comfort during the journey was so trifling as not to merit consideration The good work of an ambulance might be said to rest on attention to these details rather than on efficiency in the performance of surgical operations. What follows should be read against such a background of details, and in the light of previous chapters of action.

Treatment by the Regimental Stretcher-Bearers. This was only less vital than the rôle of the bearers in transport. The first field dressing was usually applied by the wounded man himself or by a comrade; but effective first aid—arrest of

[88] The method is also figured in *Report No 2 of the Special Investigation Committee of the M R C, p 86, Dec, 1917*

serious haemorrhage, immediate splinting, if necessary improvised, and effective protection of the wound by "shell" dressing and bandage—was the duty of the stretcher-bearer.

These processes have already been described and discussed in the narrative, in which there has been also noted the fact that dressings applied by regimental stretcher-bearers often went through unchanged to the A D S. The statement of the R.M.O. of the 12th Battalion, Major W. W. S. Johnston, has already been quoted —

"The R.M.O. looked at the dressings when brought in, but more often did not touch them The bearer squads had tourniquets but no morphia, and became very expert at splints (including the Thomas splint) and dressings."

It is pertinent here again to note that these men did not belong to the Medical Service, and that their only training was that given by their R.M.O.

Treatment by the R.M.O. A Regimental Medical Officer[89] says :—

"At the R.A.P. in battle the great thing is to get the wounded away—not what you can do for them; fix them up and get them away with a hot drink and ¼ grain of morphia—see to haemorrhage, splints, morphia, hot drinks, and evacuate."

The performance of such urgent surgery as haemostasis by ligation or clip-forceps, plugging or occlusion of "sucking" chest wounds by a flap and removal of the dangling limbs[90]—the first stage in the surgical campaign; the selection of cases for transport by stretcher—the first stage of *triage*—and the keeping of records; the general oversight of first aid; the inspiring of his personnel; the maintaining of supplies and *liaison*

[89] Capt J. C M. Harper, R M O , 28th Bn

[90] The following from A A.M C. records is relevant to various aspects of wound treatment —

"One chap, named Iredell, was brought in with his right arm shorn off at the shoulder. The upper arm had been blown clean away, and his shoulder was exposed like red beef clean cut with a cleaver The forearm, including the elbow, was attached by a few threads of tissue Dr Ross said, 'Cut it off, Sergeant,' and with a scissors I snipped off the forearm The hand, forearm, and elbow, were completely intact, the piece of shell having simply blown away the humerus, biceps and surrounding flesh. Iredell was a fine stamp of a man, and, though conscious, never batted an eyelid The Doctor picked up artery and vein with a couple of nickelled forceps I then bound up the lot with shell dressings and wool and sent the poor chap on" (From *Aid Post Chronicles* (unpublished), by Sgt J R Edwards, *p. 72*, 20 Sept , 1917)

From his "B. 103" and a personal note by Mr Iredell, Dec , 1938, we find that the wound was sustained at about 4 p.m. on Sept. 20 and the aid-post was reached about 7 He was attended to at the C.C S , and evacuated at once Operation 1 Oct , 1917. Now has "about 4 inches of stump," is bimanual, and is "able to 'carry on' and can do anything on the farm (except make money)!"

with the bearer division; and the making of provision for hot drinks and "comforts"—all these were functions of the R.M.O. in battle. His most useful contribution to the welfare of the wounded was probably that of inspiring his personnel and training his bearers in bandaging, splinting, immediate haemostasis, and above all in the prevention of shock by skill and care in handling, assiduity in the use and replacement of blankets and by ensuring skilful transport. In the British system, the R.A.P. formed a focus through which must pass, as through a bottle-neck, all the wounded from the unit's front. It is open to question whether this system of collecting was always to the advantage of the wounded.[91]

First Aid Technique—Haemorrhage The most important act of treatment to the wound at the aid-post, A.D.S., or M.D.S., was to ensure that haemorrhage had been effectively controlled. As the most important factors in "wound shock" and sepsis, "haemorrhage and sepsis go hand in hand" (Gray).

In the early part of the war the amount of blood *per se* that might be lost without mortal hurt was under-estimated; natural haemostasis was under-rated[92]; and the tourniquet was much abused.

It was found by Captain Winn at Pozières that patients arrived at the R.A.P. bleeding despite the tourniquet. He found that the tourniquet, by obstructing the venous circulation, promoted bleeding, which he stopped by removing the constriction. At this time, largely through the co-ordinating activity exercised by the Consulting Surgeons, not only operating surgeons in the Field Ambulance but R.M.O's and Regimental bearers came to appreciate the danger attending the use of this implement and the narrow time-factor of safety,[93] and the crudities of Pozières and Arras do not appear in the records of 1918. The use of the tourniquet, and of voluminous "dressings" changed at each halt, gave way to plugging, local pressure by bandage, or the use of haemostatic forceps, left *in situ* by the R.M.O. and replaced by ligation at the A.D.S. or C.C.S.

The final developments will be described in the narrative of 1918.[94]

First Aid Sepsis. By the end of 1917, though the ritual gesture

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[91] It often entailed serious risk of drawing enemy fire In the French Army professional first aid was less exactly centralised

[92] It is recorded of Hieronymus Braunschweig (1497) that he commended as a treatment for haemorrhage to put the patient in the dark so that he could not see the bleeding, and tell him that it had stopped Major-General R M. Downes (in "What Medicine owes to War and War owes to Medicine," *p.* 5—published in *R.A.M.C. Journal, Dec., 1936*, and *M. J. A., Jan., 1936*) recalls the use by the ancient Egyptians of pads of "fresh flesh—no doubt to stop haemorrhage—a method we relearnt in the Great War"

[93] The incidence of gangrene in limbs on which the rubber tourniquet was retained for over 4 hours was placed as high as 80 per cent On the other hand, "blind groping" for a bleeding vessel was generally condemned as useless, even dangerous, and a well applied tourniquet preferred

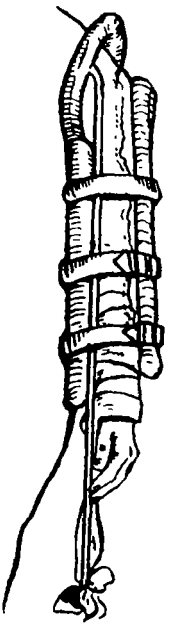
[94] *See Chapter* VII

of painting the skin with iodine or picric persisted and was perhaps of some service against coccal infection, it was well understood that the function of the field personnel was to get the wounded man to the C.C.S., and that the application of "dressings" was for the purpose of protection, haemostasis, and rest. "Antiseptic" "dressings" went out of favour—the mode of application was found more important than the material. Liquid paraffin to prevent caking came into vogue in some Armies.

First Aid: "Shock." "Primary"—neuro-genic—shock was an obvious commonplace of battle and was treated by commonsense methods—rescue and rest, a smoke, hot tea, morphia. Strychnine and camphor were popular early in the war, but dropped out But although the campaign of research brought out the importance of the work done at the R.A.P. and A.D.S. in preventing "secondary" wound shock, the possibilities of the aid-post in this respect were commonly over-estimated. Among the chief aids to advance were the Thomas splint, the technique of the blanket and primus stove, and early treatment of "chests." Most potent of all was the improved co-ordination of all elements in the service of succour, of which special note is made in chapters of the next section (1918).

First Aid "Dressings." As foretold by Fessler in 1910, the "First Field Dressing" was wholly inadequate for the majority of wounds in this war. Stretcher-bearers accordingly carried supplies of "shell dressings." The R.M.O. indented on the field ambulance for his supply of dressings—an important responsibility of the ambulance, which sometimes sterilised and sent them up in improvised containers [95]

First Aid: Fractures The Femur. "My experience of the rifle splint," wrote an R.M.O. (Major M. V. Southey), "was that it was damnable and so was any other splint but the Thomas." And it cannot be too strongly stated that, excepting the treatment of wounds by excision and primary suture, no greater advance in wound treatment was made in the war than the use of the Thomas splint in the front line to prevent shock. The unedifying history of this advance has already been stressed.[96] Of the use of this splint in the



Small Thomas Splint for arm, as applied (From "The Early Treatment of War Wounds," by Col. H. M. W. Gray.)

[95] Wool gauze and other dressings were for the most part supplied to the B E F by the War Office in large packets unsterilised—a wasteful and dirty system In the French Army it would seem dressings were sent out in packets of suitable size and commonly sterilised

[96] *See Index.* Some points on the technique of the use of this splint in the war are given elsewhere. For neglect to use it in civil ambulance practice see *M J A, 24 Nov., 1934, p. 678*





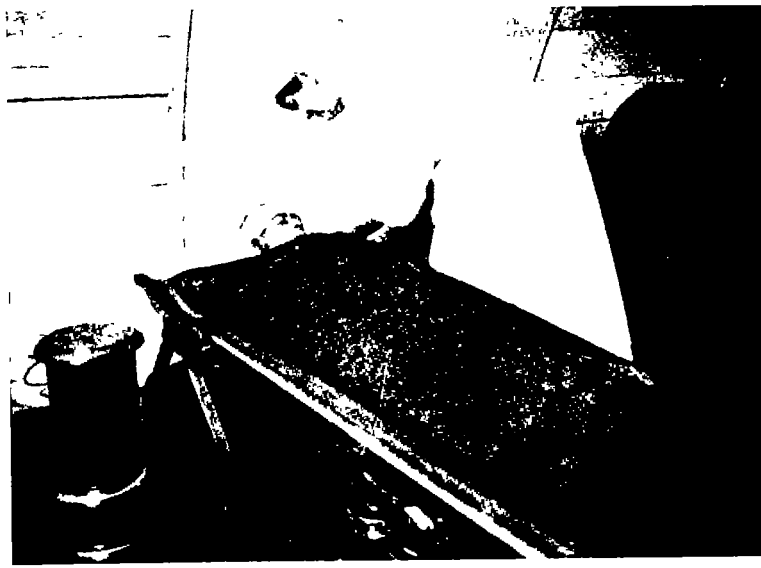


39-40-41. A DEMONSTRATION AT THE OLD A.D.S., YPRES, OF THREE STAGES IN THE APPLICATION OF THE THOMAS SPLINT

See also *Diagram at p 943*

Aust War Memorial Official Photos Nos E5252 5253-5251 Taken in June 1919

To face p 348



42. PREPARING A PATIENT FOR OPERATION AT No 1 A C C S, OULTERSTEENE, IN NOVEMBER, 1917

Note the heating by primus and kerosene stove.

Aust War Memorial Official Photo No E1305.



43. A WARD IN No 2 A C C S. AT TROIS ARBRES, STEENWERCK, NOVEMBER, 1917

Aust War Memorial Official Photo No E4023

To face p 349

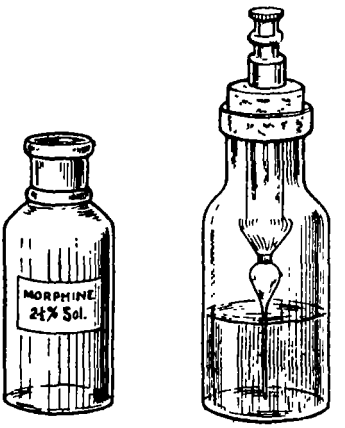
Palestine Campaign, the officer in charge of the Desert Mounted Corps Operating Unit[97] writes:

"In one of the Amman raids, one of our colleagues, then a combatant officer, received a gunshot fracture of the thigh. He was put in a Thomas splint by Vance and travelled all the way to Jerusalem, some of the journey on a camel cacolet, the roughest ride imaginable, yet he had an excellent result. At the same time a brave New Zealand officer died at my feet about two minutes after his arrival at Jericho simply because he had travelled with a fracture of the thigh unfixed."[98]

It is interesting to note that Sir Alexander MacCormick was one of the first, if not the first, to advocate strongly in the Great War the use of the Thomas knee splint for the transport of patients with fractures of the femur due to gunshot wounds. It is claimed that he actually bought and took across to France, early in 1915, the first Thomas knee splints used for transport purposes in this war.[99]

Humerus. An effective "first aid" splint for the humerus was found to be the patient's chest, and the most useful apparatus a roller bandage. For the forearm an internal angular splint was found to make the best of this bad job—the *bête noir* of the orthopaedist. Gooch splinting was an important factor in first aid.

First Aid Equipment (*1*) *Morphia.* The official equipment of the R.M.O. included a hypodermic syringe with two stout platino-iridium needles and several tubes of morphine tartrate in ½-grain tablets, with a glass-stoppered phial for mixing. Apart from the syringe itself it was not a workmanlike outfit. Moreover, exact instructions as to the use of morphia in the field were at first entirely lacking, and among the many "rule of thumb" procedures recommended was the evil practice of "a tablet under the tongue"[100]



Hypodermic morphia outfit for field work, as used in Third Army. (From "The Early Treatment of War Wounds.")

(*2*) *The bandage.* That the "roller" bandage was in far more general use than the modifications of the "triangular" was probably due to the fact that, properly applied, it serves more effectively the purpose of *rest.* Training in its use and proper place in first aid as against

[97] *See Vol. I, p. 636*

[98] "Fractures of the shaft of the Femur," by Lieut.-Col. J. Colvin Storey, A.A.M.C., *M.J.A., 24th Nov., 1934*

[99] See "The primary treatment of compound fractures of the lower limb," by George Bell, *M.J.A., 22 Oct., 1932, p. 501*

[100] The question whether the soldier himself might carry an opiate was officially *taboo.* It was however widely debated in the Australian force before The Landing.

those of the triangular was "the first duty" of every R.M.O. An over-tight bandage, which contracted when wet on a swelling limb under a splint, was, as the records show, the cause of many disasters.

The Relay Posts and Collecting Posts

For the severely wounded man his journey from the R.A.P. to the A.D S. was critical of life and death. Treatment, confined to *adjustments, haemostasis,* and *sustainment,* was in battle carried out under stress of great urgency; the preoccupation of bearer officers in problems of movement and supplies at times interfered with their attention to treatment.

Dressing Station and Field Hospital

"With the progress of the war," says the *British Medical History,*[101] "the actual direct treatment applied to wounds in field ambulances became limited to the application of a simple protective dressing and adequate splintage; partial attempts at disinfection and repeated changes of dressing had been found to be productive of more harm than good. In fact, in the latter part of the war, the first field dressing applied by the regimental bearers was often deliberately left in place until the patient arrived at the casualty clearing station."

In general this statement is approved by the experience of the A.I.F. An experienced officer,[102] for example, writes:

"The chief business of a Field Ambulance is evacuation, its second business is again evacuation, and its third also. This cannot be sufficiently stressed. The ambulance may be tempted to do more professional work than it should, but it must not be forgotten that its chief aim is to form a link between the ever-changing front and the more or less fixed points where better conveniences exist for elaborate treatment. Though the ambulance officers may do a good deal of emergency surgery, still it must be remembered that this may not be done at the cost of rapid evacuation, and only to ease suffering or save life. The best ambulance is the one that gets its wounded out the quickest."

From 1917 onwards the guiding rule was that, apart from certain clearly defined essentials of first aid and surgical emergency and from some special types of wounds, until the casualty clearing station was reached treatment should be directed to *the man,* not to *the wound*: to procuring comfort, the alleviation of pain, promoting natural resistance, and conserving strength, without interference with movement to railhead by any attempts at a deliberate *restitutio ad integrum.* In this attitude (it is important to note) was no place for "mark

[101] Lieut.-Col. C. Max Page, *British Official Medical History, Surgery, Vol. I, p. 194*

[102] Major James Sprent, 13th Field Ambulance

time"; it was essentially active, a continuous campaign of constructive surgery based on a sound foundation of principles and practice built up with infinite pains and at cost of untellable sufferings by clinical observations and experiments on men and animals; and inspired by a vision which reached beyond the C.C S. and Base Hospital to the orthopaedic and prosthetic problems of Roehampton, Sidcup, Southall, and the Base Hospitals in Australia. At no stage in that long course of surgical action was a combination of the triune forces of repair —reason, instinct, and the *vis medicatrix naturae*—more needful than in the posts of succour that intervened between the several stages of movement from the field of battle to the C.C.S. And in none was this sought with greater earnestness or achieved with greater success.

The following accounts, written for the Australian War Memorial adequately describe the work done in the field ambulance stations.

"A Main Dressing Station," writes Major Sprent, "is placed where routes of evacuation converge, conveniently close to the front. If too far back men die of exhaustion coming down, if too far forward . . . Red Cross protection cannot be expected from the most chivalrous enemy. . . .

"At the M D S men are made safe for the long route back to C.C.S. Urgent amputations are performed, tourniquets removed if not already done at the A D.S., vessels tied,[103] better and more elaborate splints are applied. Only the most exhausted cases are kept any time. Here operative surgical interference becomes feasible, anaesthetics are given, and a good unit can achieve asepsis. All cases are sent on shaved, clean, splinted, dressed and docketed. No field dressing, tourniquet, or improvised splint should pass the M.D.S. The clerks keep a careful record of all cases."[104]

The routine by means of which these functions could be conveniently carried out is described as follows:—[105]

"Make every effort to *avoid congestion,* which is bound to occur unless care is taken to prevent it. To avoid congestion the following essentials must be observed:—

[103] Warnings were issued by the consultants against prolonged endeavour to find bleeding points at the field hospital. The application of pressure, or tourniquet placed in position for adjustment by an orderly if required *en route*, were alternatives proposed, or the case might be retained for operation in a forward post.

[104] These records were kept in the Admission and Discharge books. The clerks also render the prescribed casualty wires and returns. (The penultimate sentence should be taken "by and large")

[105] By Major J. H. B. Brown This should be read in conjunction with the account given (*pp 175-8*) of the work of the M D S. at Pont d'Achelles in the Battle of Messines.

"(a) The maintenance of an *In* and *Out* circular track for motor cars, so that all vehicles are moving the same way and do not have to turn round in their tracks.

"(b) Walking wounded, gassed cases, and stretcher cases to be kept separate and treated by separate staffs in separate departments, and to be evacuated to C.C.S. by a separate system of Transport.

"(c) Admission and Evacuating Rooms and staffs running same to be separate and distinct.

"(d) Painted notice boards to be placed in prominent positions with directing signs to assist in the carrying out of paras. (a), (b) and (c)."

Walking Casualties (Sick and Wounded). The walking wounded dressing station is "most conveniently situated at the M.D.S. though often at the A.D.S. or sometimes set apart by itself."

"Casualties passed first into the Admitting Room where every case is seen by a Medical Officer, the Field Medical Card is filled in, A.T.S. given, and they pass into the Dressing Room, where all wounded men are seen by an Officer who orders re-dressing if necessary. Thence they pass to the Evacuation Room to await transport, and are fed and made comfortable"

Stretcher cases "are carried to the Admitting Room by a special unloading party. Every case should be seen by a Medical Officer who writes on the Field Medical Card the diagnosis (in block letters), disposal (whether to C.C.S. or D.R.S.), and appends his signature, all other particulars having been filled in by the clerk. In this room every wounded man is given A.T.S. (1,500 units) by a specially trained orderly." [In a rush the serum is pooled in a sterile basin. A note of the injection with date is entered on the F.M. Card and a large T marked with indelible pencil on the patient's forehead.] "Any morphia administered is recorded on his card with exact time and dose.

"From the Admitting Room cases pass to the Dressing Room where 1 to 4 tables may work. Every case is looked at by a Medical Officer who re-dresses if necessary. . . .

"After being dressed, cases pass to the Evacuation Room where every man should get a hot drink, food, and cigarettes. A buffet is usually run by the Y.M.C.A."

Gas Centre—Disposal of Gassed Casualties. [This, Major Brown states, should be sited as a special adjunct of the M.D.S. In view of the great importance of gas warfare the subject will be dealt with specially in *Volume III.*]

The Resuscitation Centre "All urgent cases of shock or haemorrhage are at once sent to the Resuscitation Centre either from the Admitting Room or from the Dressing Room."

"Triage" and the "untransportable case"

The British system for effecting what the French and Americans called *triage,* the distribution of casualties to their appropriate treatment centres has been described in the previous chapter

The question whether Field Ambulance or C.C.S. should be

responsible for the effective treatment of what the French and Germans termed the "untransportable case" was a matter of debate throughout the whole of the war. The fact that British policy strongly favoured concentration on the casualty clearing station makes it desirable to defer the consideration of it till the next chapter, which deals with the work of that unit.

SYNOPSIS OF CHAPTER XIII

EVACUATION THE CASUALTY CLEARING STATION

EVOLUTION, FUNCTION, AND WORKING OF THE C.C.S.

1. Function—strategy and tactics for the C.C.S
   Problem of the "Untransportable case."
   March, 1915. before the C.C.S.
   Revolt from laissez faire.
   Early experiment: 1915.
   The Somme: "Abdominal centres."
   The tragedies of "Alberich."
   Field Ambulance or C.C.S?
   The advanced C.C.S. in 1917.
   C.C.S. strength in British offensives.
2. Structure: establishment and equipment of the C C.S.
   Personnel.
   Surgical teams.
   Equipment, transport and housing.
3. The interior economy and working of a C.C.S
   Interior Economy—the departments.
   (a) Command and administration.
   (b) Clinical activities. Female nursing staff X-ray department. Pathological department.
   (c) Quartermaster's department.
   (d) Pharmaceutical department.
   The working of a C.C.S.
   The receiving tent. The dressing tent.
   The C.C.S. group: rotation of duty.
   Technique for operation Evacuation
   Clinical Organisation.
   The surgical division.
   The task of classification and disposal
   Treatment of the wounded man.
   Factors in "Resuscitation."
   The medical division
   The C.C.S. and return to duty.
   The rôle of the C.C.S. in the prevention of disease.
   "Clearance."

THE AUSTRALIAN CASUALTY CLEARING STATIONS ON THE WESTERN FRONT, MARCH, 1916-MARCH, 1918.

Some "Imperial" adjustments.
The Units—Nos. 1, 2, and 3 A.C.C.S.
April, 1916-May, 1917.
In the Flanders Offensive.
The Winter of 1917-18.