the fragments, the patellar clamp may be employed with gratifying results.

After the reading of this paper, Dr. Miller demonstrated by lantern slides certain of the facts brought out in the paper, giving the details of the cases referred to in the lantern slides.

SOME ASPECTS OF THE TREATMENT OF COMPOUND FRACTURES UNDER CIVIL AND MILITARY CONDITIONS.

By DAVID CHEEVER, M.D., BOSTON.

ONE must be an optimist indeed who hopes and believes that out of the brutal chaos of the present war may come some good to suffering humanity; yet we doctors may dare to indulge in optimism, for surely, from the unprecedented experience and mass of data now being accumulated by the surgeons of the warring nations, progress is certain to be made in the control and prevention of disease. Sanitation, the extermination of flies, lice, mosquitoes and other intermediate hosts of infection, the prophylaxis of epidemic disease by vaccination or inoculation, the study of the control of infection in wounds, the healing of wounds, advances in the knowledge of the physiology of various organs, especially the central nervous, the cardio-respiratory and the digestive systems, gained by opportunities for observation offered by the traumatism of warfare, are examples of fields where progress is already recorded. Among the special problems, few are more pressing than those presented by compound fractures, the treatment of which in warfare is sadly lacking in authoritative standardization, though doubtless in civil practice much more uniformity exists.

Simple fractures (excluding fractures of the skull) present chiefly the largely mechanical problem of the promotion of repair of various parts of the skeleton, and to a less extent the combating of shock or the conditions which may attend the enforced invalidism of the patient; compound fractures present the possibility of a much greater degree of shock (perhaps associated with hemorrhage) and the problem of wound infection. This latter condition, with its attendant possibility of death, must take precedence in its demands over all other considerations of treatment, for methods, however skilful in fixation and immobilization, which do not yield precedence to the proper primary and subsequent treatment of the wound, are almost sure to result in disaster. Fortunately, in most instances, the two objects are not incompatible, though some afford the most perplexing and baffling difficulties with which surgeons have to deal.

Only those whose experience or recollections

go back to the pre-Listerian days can have any graphic conception of the miracle wrought by antiseptics. Then such an injury meant the serious consideration of amputation as a primary measure, or resort to it, sometimes too tardily, during the course of the case; now the expectation is justified that a compound fracture will do well. In civil practice, such an injury presents usually but trivial difficulties, compared with those under conditions of warfare. Commminution of the bone is absent or moderate in degree; the wound is apt to be small and the soft tissues not devitalized by trauma; the infection from skin, clothing or soil may be of a slightly virulent type; prompt treatment and disinfecting measures are applied before the infecting organisms have time to multiply; the prompt arrival of aid (in civilized communities) minimizes shock from hemorrhage, pain, exposure and hunger, and the problems of transportation are usually not significant. The treatment of these conditions (except as relates to wound disinfection) is so generally standardized that but few suggestions may be offered. First, in cases presenting a comparatively small wound, where the bone-end, after perforating the skin, has retreated to its normal bed, it is usually wiser not to enlarge, explore, and disinfect the wound, but to assume that serious infection has not taken place, and keep careful watch for its appearance. My own practice is to seal temporarily the wound with sterile gauze, while the surrounding field is cleaned with soap, water, alcohol and some disinfectant solution, touch the edges of the wound with iodine, insert a very shallow gutta-percha-tissue drain, and apply a wet antiseptic dressing of hypochlorous acid or bichloride of mercury (the biniodide may be better since it is said not to coagulate albuminous fluids). If infection is present, Nature, here, as elsewhere, will probably succeed in localizing it under the favorable conditions surrounding our patient, and close observation will give ample warning for interference to be effective. I feel certain that the routine exploration of these small wounds and the applying of gross efforts at disinfection with swabs and scrubbing brushes, do more harm than good. The second suggestion that I offer is that means of internal fixation, especially bone-plates, are by no means contraindicated by the infection of wounds of compound fractures. In such lesions of bones near the surface, such as the tibia, ulna, radius, humerus and clavicle, where satisfactory position cannot be obtained by external splints, which afford free access to the wound for purposes of dressing, bone plates may be applied as temporary internal splints, intended to be removed when union in good position is assured, usually three or four weeks. The external splinting and dressing of the wound is thus enormously simplified. The wound should be packed open by gauze within gutta-percha tis-

sue, and dressed, when necessary, with scrupulous care. In spite of the packing, the tissues sometimes will heal completely over the plate. No anesthetic (save possibly a little novocaine infiltration) is required for its removal. The writer has thus plated, without untoward results, the tibia, ulna, radius and clavicle. The humerus should usually be susceptible to the same treatment. The deep position of the femur may contraindicate it.

The compound fractures caused by the projectiles of the present war present special features, the most important of which may be enumerated. The comminution of the bone may be extreme, so that several inches of the shaft are reduced to splinters. The high velocity rifle bullet at close range imparts its own terrific momentum to the bone fragments and scatters them; this effect is enhanced by the explosive action of the zone of compressed air preceding the bullet. At longer ranges, when its velocity is less, its flight more steady, and the oscillation of its base has ceased, it may make a clean perforating hole through bone. The writer has thus seen the clavicle cleanly perforated without fracture, by a German rifle bullet. But, again, towards the end of its flight it becomes more destructive, the heavier base tends to overtake the point, and the bullet somersaults on striking, inflicting serious wounds of soft tissues and bones. Shell fragments, according to their size, produce much comminution, and the round lead shrapnel balls produce either a comminution of the shaft without much displacement, or bury themselves in the cancellous tissue of the ends of the larger bones. The soft tissues are frightfully contused by the explosive effect of the high velocity projectile or the ragged shell fragment; the tissues are seriously devitalized over a wide area, and extensive intermuscular planes opened up, conditions most favorable to the multiplication of bacteria. And bacterial infection is almost certain to occur. The soil in the Western theatre of war, highly fertilized for generations by human and animal excreta, is teeming with bacteria, especially the spore-bearing anaerobes. The soldiers, living the life of moles, burrowing in earth and mud, are plastered with this infected soil. Consequently, every projectile piercing the foul clothing and dirty integument carries with it pathogenic organisms into the wound, and especially the shell fragments, rough and irregular in shape, are apt to punch out and push before them a wad of the various layers of clothing. Fleming,¹ working under Wright's direction, made cultures from twelve average samples of soldier's clothing fresh from the trenches, and found in 10 cases contamination with the bacillus of gas gangrene (*B. aerogenes capsulatus*); in five cases, streptococci, in four cases, the tetanus bacillus; and in two, staphylococci. In other words, we may conclude that a large majority of all cases are potentially infected with gas gangrene. Inci-

dentally, it is striking to reflect on the efficacy of the prophylactic injection of tetanus antitoxin, in view of the widespread contamination of clothing with *B. tetani*, apparently revealed by the above figures. In three months' service in Northern France during the past winter, the writer did not encounter or hear of any case of developed tetanus. Undoubtedly, the best hope for the future in the treatment of gas gangrene and infection by pyogenic organisms lies in the development of antitoxins and vaccines of equal reliability with that of tetanus. To the above enumeration of the unfavorable conditions attending these compound fractures, must be added the profound shock and exhaustion due to prolonged exposure to cold, wet, hunger, nervous strain, the frequently co-existing hemorrhage, and the length of time that may elapse before aid reaches the wounded man. Soldiers hit in the open cannot be picked up until darkness comes to give some protection to relief parties, and even in the trenches it may not be possible to convey them back to the field ambulance until nightfall. The totally inadequate first-aid dressing thus may be the only treatment, which may at best prevent further contamination, but cannot hope to affect the infection already introduced.

In the face of this almost inevitable and virulent infection, the first consideration must be its adequate treatment, and perfect mechanical immobilization of the fragments is at first of secondary importance. As Bowlby² points out, this aspect of compound fractures varies with the geographical situation of the battlefield. In the South African War, the virgin soil uncontaminated by manure, and the hot dry climate were strong factors in lessening the incidence of infection, factors aided by the fact that the blunt-nosed bullets of lower velocity of that period had much less traumatizing and divulsive effects on the tissues; and shell wounds, and consequently the carrying in of extraneous material, were much less common.

Granted, then, under the conditions at present existing in Europe, a compound fracture caused by a projectile, the rule is that proper drainage and disinfection must be carried out at the earliest possible moment. The only exception to this rule is the case where a high velocity rifle or machine gun bullet at medium range has passed through a limb, breaking the bone, but without showing the explosive effects described at other ranges. In such a case there may be minute perforating wounds of entrance and exit, already sealed up, without evidence of sepsis. The sharp-nosed bullet has pierced cleanly clothes and skin, and the tissues are not devitalized. Interference and drainage will complicate the fixation problem. Such a case may be left alone and watched carefully. Several successful cases of this type came under the writer's observation.

All authorities agree that in the great major-

ity of cases, an anesthetic must be given, the wound of entrance and exit thoroughly opened up, all contused, devitalized masses of muscle, fascia or fat radically excised, since it is in them that the bacillus of gas gangrene will most surely find a favorable nidus, and every nook and recess of the wound explored. Early interference is essential, for Carrel's³ studies have shown the comparative scarcity of organisms in the recent wound, and the unbelievable rapidity with which they multiply. From this point forward there is scarcely a step recommended by some whose utility is not denied by others. Shall comminuted fragments of bone be removed? Obviously not, if large and well attached by periosteum or muscle. Some authorities urge the immediate removal of all small fragments, whether attached or not; others practise it only in the case of wholly free fragments; others, among them Robert Jones,⁴ say that loose fragments may be taken out, cleaned and replaced, and may be expected to unite. The writer must confess that in wounds so universally and virulently infected, such a miracle seems hard to believe. In his own brief experience, fragments of doubtful viability invariably had to be removed, and before removal interfered with proper drainage, and seemed to prolong infection.

How shall the wound infection be combated? Everyone who treats infected wounds shares the disappointment experienced by the profession at large, when Lister's discovery failed to produce a means of destroying organisms in the tissues as well as in the test-tube. Skepticism as to the efficacy of antiseptic solutions in cleansing wounds has enrolled many surgeons among the followers of Sir Almroth Wright,⁵ who has sought to encourage and utilize the resisting agencies of the patient's own body fluids by the use of hypertonic saline solutions for irrigation or gauze packing of wounds. A copious outflow of lymph is provoked, which may be supposed to wash out the organisms which have already entered the tissues beyond the reach of antiseptic solutions, and inhibits their multiplication by the antibodies it contains. Moreover, the 5% saline solution is said to be actively bactericidal. When for the hypertonic solution is substituted a normal saline solution, leucocytes are attracted in greater numbers, and by their phagocytic action tend especially to clean up streptococcus infections. While many wounds under the writer's charge, after proper drainage had been instituted, did well under the hypertonic treatment, the very striking results reported by the originator were not often duplicated. The writer, like others, is compelled to acknowledge the comparative inefficiency of antiseptics in badly infected compound fractures, but he does not share the belief that such solutions act beneficially solely by the mechanical washing away of organisms. When used early before the organisms have penetrated the tis-

ues, they are of great effectiveness; when used later, they still destroy any free organisms, are on hand to attack others as they are thrown off from the tissues, and are useful in preventing infection from patient to patient. Granted that there can be found an antiseptic practically innocuous to the tissues and yet possessed of bactericidal powers, it would seem that its free use in infected compound fractures was the most rational treatment. Such an antiseptic seems to have been rediscovered in hypochlorous acid or its salt, hypochlorite of sodium. It is strongly bactericidal, apparently quite harmless to tissues, cheap, easily produced. In the writer's experience, badly infected compound fractures may be most effectively cleaned up, after incision, removal of all devitalized tissue, and establishment of proper drainage, by the free use of hypochlorite solution as constant irrigation or as wet gauze packing, frequently saturated and kept moist. Its harmlessness is shown by the employment in a number of instances of a solution of hypochlorous acid as an intravenous injection in septicemia, with good results.⁶

The number of splints devised to immobilize compound fractures is legion, and testifies eloquently to the imperfect character of the majority. In the writer's opinion, plaster of Paris, even when used in the most skilful manner, is inappropriate for these cases during the stage of their acute infection. Its dressings are heavy, cumbersome, take much time for their application, often do not provide effectively for extension, and, worst of all, it is almost impossible to keep them from contamination with wound discharges or irrigation fluids. In the secondary treatment of these cases, when bone grafting or other corrective measures must be tried, plaster finds its field of usefulness. The most universally useful type of apparatus is the Thomas knee splint, or one of its numerous modifications, such as the Page splint, in which the ring for counter-pressure is replaced by a curved piece, forming three-fifths of a circle. These splints are simple, cheap, easily made, and durable, and adapted for almost all fractures of either lower or upper extremity. Extension is secured by surgeon's plaster extension straps, applied in the usual way, which are then secured to the transverse bar at the distal end of the splint, forming a fixed extension. The limb is prevented from sagging by slings or gutters of perforated zinc or aluminum, which are adjusted to suit the individual case and interrupted, if possible, opposite the wound; or, if the latter is too extensive, these perforated strips of metal are sterilized by boiling, and applied directly beneath the wound, whose discharges pass through the perforations into the dressing. These splints allow of easy transportation, and when suspended to the horizontal bar of a Balkan splint, or better still, to one of the many ingenious travellers on a modified Balkan splint, they permit of the patient moving quite freely

about in bed without disturbing either the alignment or extension of the limbs. Certain fractures of the femur present special problems, which have been met, in the case of fractures of the upper third, by Jones' abduction frame, and in the case of very extensive multiple wounds, by the ingenious suspension hammock beds of Sinclair⁷ and others.

It is interesting to find that the use of bone plates as temporary splints in infected compound fractures in civil practice, as just recommended, has been duplicated and strongly urged by some observers under the conditions existing on the battlefields of France. Lake⁸ advises the plating of infected compound comminuted fractures of long bones, thus securing the maintenance of proper length, making external splinting unnecessary, and making the dressing of wounds and treatment of sepsis infinitely easier. During the first three or four days after the receipt of an injury, he makes vigorous efforts to diminish the sepsis, then the plate is applied and left for three to four weeks. He reports no ill results from infection of healthy marrow and finds that the screws do not loosen so prematurely as to impair the results. Pennell¹⁰ is even more radical, advising this procedure as a routine, and claiming that he has rarely had to remove a plate. The writer confesses that the degree and virulence of the infection and the extent of the trauma seemed to preclude this method in the cases under his observation, but in view of the good results reported, he believes that the method deserves a fair trial.

REFERENCES.

- ¹ Fleming, A.: On the Bacteriology of Septic Wounds, *Lancet*, London, 1915, ii, 638.
- ² Bowlby, Sir A.: Wounds in War, *British Med. Jour.*, London, 1915, ii, 913.
- ³ Carrel, A., Dakin, Daufresne, Derelley and Dumas: Traitement abortif de l'infection des plaies, *Bulletin de l'Académie de Médecine*, Paris, 1915, lxxiv, 361.
- ⁴ Jones, R.: Remarks on the Mechanical Treatment of Compound and Suppurating Fractures Occurring at the Seat of War. *British Med. Jour.*, London, 1915, i, 101.
- ⁵ Wright, Sir A.: Wound Infections and Their Treatment, *British Med. Jour.*, London, 1915, ii, 629, 670.
- ⁶ Smith, J. L., Ritchie, J., and Rettie, T.: A Case of Septicæmia Treated by Intravenous Injections of Eusol, *British Med. Jour.*, London, 1915, ii, 716.
- ⁷ Fraser, J., and Bates, H. J.: The Treatment of Acute Toxæmia Secondary to Gas Gangrene by the Intravenous Injection of a Solution of Hypochlorous Acid, *British Med. Jour.*, London, 1916, i, 85.
- ⁸ Editorial: Intravenous Injection of Hypochlorous Acid in the Treatment of Toxæmia, *British Med. Jour.*, London, 1916, i, 175.
- ⁹ Bryan, C. W. G.: An Interrupted Hammock-bed in the Treatment of Compound Fractures of the Hip and Thigh, *Lancet*, London, 1916, i, 25.
- ¹⁰ Lake, N. C.: The Plating of Gunshot Fractures, *British Med. Jour.*, London, 1915, ii, 44.
- ¹¹ Pennell, V.: The Radical Treatment of Septic Compound Fractures, *Lancet*, London, 1915, ii, 811.

DISCUSSION.

DR. ROBERT W. LOVETT, Boston: The part of the subject that I wanted to speak of in this discussion is the question of fracture of the neck of the femur and the difficulty of getting it to unite, because, of course, this is a difficulty that

we all are constantly meeting. The orthopedic surgeon, perhaps, sees the worst cases, because they are apt to come at the end, when everything else has failed, and in these cases he is naturally at a loss to know what to do, so that anything that can be done to diminish the number of these cases of non-union is most desirable.

One difficulty comes in the interpretation of the early x-rays, because in the x-ray we are apt to forget that we are looking upon the contour of two irregular surfaces, and it is very easy for the two shadows to overlies each other in such a way that there appears to be union. Many of these cases, however, when they begin to walk show by the stretching of the apparent union that there never could have been good union there, and I have seen many cases in which in the early stage the opinion was expressed on the strength of the x-ray that good union had occurred, yet where stretching began when walking was undertaken.

The experience in coxa vara which we have at the Children's Hospital bears somewhat on this question. Coxa vara, as you know, is a depression of the neck of the femur to a right angle with the shaft, and the routine treatment that we use in these cases is forcible abduction of the leg under anesthesia, with a view of inducing a fracture of the neck of the femur. In other cases we divide them with an osteotome in case they are resistant to the simpler method. Under these conditions we have an artificial fracture of the neck of the femur (slides shown here).

In a series of these cases it has been very definitely shown that we get a better position of the fragments if we add traction to abduction. With simple abduction the fragments tend to slip by each other, but with abduction and traction, as shown in the slides, we get excellent apposition.

It is not unlikely that this may have a bearing on the treatment of the fracture of the neck of the femur, where, instead of using simple abduction, we should probably get better position if we added traction to the abducted position.

DR. J. B. BLAKE, Boston: It is obvious that it is not possible to discuss intelligently so complicated and detailed a paper as that of Dr. Seudder and Dr. Miller upon simply one hearing. I anticipated that this would be true, and I was firmly convinced after hearing the paper itself.

There are two or three aspects of the subject of which I wish to speak:

1st. What is the fundamental condition in the injury described as fracture of the patella?

2d. What are the indications and the contraindications for operation?

3d. What is the technic?

In this lesion we deal not only with a fracture of the small bone, but also, and of more