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Progress in Surgery

The War Injuries of the Upper Extremity

Volume Editors

J. Engel and I. Kessler, Tel-Aviv

Series Editors

M. Allgöwer, Basel

S.-E. Bergentz, Malmö

R.Y. Calne, Cambridge

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Volume Editors

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Vol. 16

Series Editors

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U.F. Gruber, Basel



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Foreword

The editors are proud and happy to welcome the two host editors for volume 16, *Joel Engel*, Sheba Medical Center, Tel-Hashomer and *Isidor Kessler*, Kaplan Hospital, Rechovoth. Both authors are members of the Tel-Aviv University, Sackler School of Medicine. Unfortunately, war surgery has not lost its threatening actuality in many parts of the world and even nowadays there is no guarantee that mankind will be spared large-scale conflicts in the next decades. It is therefore most important to learn from the experienced how to deal with these compound injuries of the upper extremities rather unusual in our civilian way of life and very common under combat conditions. The editors and their contributors deal with the subject very comprehensively and competently and the editors of *Progress in Surgery* hope and believe that this volume will receive the attention it certainly deserves.

M. Allgöwer, Basel

Preface

The 1967 Middle East conflict (The Six-Day War), the War of Attrition from 1969 to 1971 and the October 1973 War caused over 10,000 injuries on the Israeli side. By a decree of the Israeli Ministry of Health five Hand Surgery units were created to take care of the wounded, very much like the five units established in the US during World War II. This fact created a situation where rather few people gained rather extensive experience.

The mortality rate among injured soldiers in World War II was 4.8%, in Korea 2.5% and in Vietnam 1.0%, which was also the mortality rate in Israel in the 1973 War. This rather low mortality rate is attributed mostly to a more efficient and rapid evacuation of the wounded from the battlefield to the hospital. We believe that achieving good results has to do with this factor more than any other.

This book is written by a group of authors from the various disciplines involved in the treatment of the war wounded: Hand Surgeons, Orthopedic Surgeons, Plastic Surgeons, Vascular Surgeons, Rehabilitation and Physical Medicine people, etc. Their contributions form part II of the book. Part I was written by nonsurgeons who worked in close contact with the surgeon. The reader will find, for example, a chapter dealing with treatment and prevention of infection by antibiotics. It goes without saying that the best way to prevent contamination of explosion wounds in our view is to abstain from fighting fellow men.

This is not meant to be a comprehensive work, but is intended rather to illuminate the most frequently encountered problems of war surgery. The subjects dealt with relate only to special aspects of war surgery. A basic knowledge of the surgeon in the field of soft and bone tissue of the upper extremity is taken for granted.

The reader will encounter in the book *War Surgery* in its broadest sense, from a single bomb exploding in a supermarket to a large-scale armed conflict.

Naturally, the wounds inflicted by a high-velocity missile treated in an overcrowded hospital in wartime will be dealt with in a different manner than the low-velocity bullet fired from a revolver during a robbery, or a home-made bomb exploded in a movie by guerillas.

Army men know that the best way to lose the next war is to study the previous one. We surgeons have the advantage that in Medicine, progress is a continuous process, and the knowledge acquired may be applied occasionally during wartime. It is hoped that this book will be a useful tool in such an event, and not be a historical document only.

The editors are grateful to their respective staffs who assisted in preparing this book. Gratitude is also expressed to our wives for their encouragement and patience.

Joel Engel and Isidor Kessler, Tel-Aviv

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Military Medicine

Eran Dolev

Medical Corps H.Q., Israel Defence Force

As wars are an essential part of the history of mankind, military medicine is an important branch of medicine. Physicians were to be found in the fighting units of ancient times, and surgical procedures on the battlefield are recorded. During the Middle Ages several medical corps were formed, one of the most well organized being that of the Byzantine army.

The foundations of modern military surgery were established by Ambroise Paré (1510–1590), who was one of the first surgeons to treat gunshot wounds. Paré was the first to demonstrate that gunshot wounds were not poisoned. He invented the technique of ligating blood vessels which allowed him to perform amputation of limbs. Paré was the first to ex-articulate the elbow (1536) and to introduce the use of artificial limbs.

Dominique-Jean Larrey (1766–1842) was a surgeon who gained most of his experience during the Napoleonic Wars. He introduced 'First aid' on the battlefield, and organized the system of evacuation of the wounded by ambulances. He also established field hospitals behind the battle lines.

The Civil War in the United States was the last war in which the concepts of asepsis introduced by Lord Lister had not yet been applied. This explains the high postoperative mortality rate — 24.8% — among the soldiers who had limbs amputated. In the Civil War two crucial points in military medicine were demonstrated: the significance of the primary care of the wounded, and their evacuation from the battlefield.

During the wars of the 1870s in Europe, the principles of Nelaton and Lister were applied for the first time. The military surgeons considered early debridement of battle wounds as the most important step during treatment, combined with antiseptic procedures.

The inclusion of plastic and reconstructive surgery within the scope of military medicine was established during World War I. The specific field of hand surgery was founded during World War II by Sir Archibald McIndoe in Britain.

While his contemporaries used tannic acid to treat burns of the hands, he began to treat them with saline and early grafting. This policy saved the function of many hands. The introduction of penicillin during World War II brought an end to the epoch of deformations due to infections, and allowed the opportunity to develop the reconstructive surgery of the hand.

In 1943, Dr. Sterling Bunnell was appointed as a special adviser in the field of hand surgery to the Surgeon General of the US Army. During the rest of the war, Dr. Bunnell founded nine centers for the special treatment of hands, for the US Army.

No doubt the founding of the several national and international associations of hand surgery is a result of the great developments and achievements of this subspecialty during World War II.

The Evaluation of Battle Wounds

The usage of special weapons determines the subsequent specificity of battle wounds, not only according to the damage, but also to the causative agent. Knowing the causative weapons, one can estimate accurately the damage to several organs. Conversely, a study of gunshot wounds reflects accurately the development of weapons and tactics.

The Civil War in the United States serves as a typical example of the 'pre-armor' era: 94% of the wounds were caused by rifles, 5.5% by shrapnels and the rest by 'cold' weapons.

The Six-Day War in 1967 is a good example of a modern war in which armored brigades were the main formations, with still many elements of infantry, some of them fighting in inhabited areas. In this war 60% of the wounds were caused by fragments. The 1973 Yom Kippur War was practically an armored unit war, and the percentage of wounded due to fragments was 85%.

The mortality rate among the wounded on the battlefield is a function of the tactics and the weapons which are used, and the level of efficiency of the medical services in the front and rear areas. The rise in the number of wounds caused by fragments, most of them shrapnel, means a relative decline in the percentage of head and trunk injuries which are often immediately fatal. The statistical result is a higher percentage of limb injuries.

Although the causative weapons and tactics were essentially the same in the 1967 and 1973 wars, there was, in the latter, an increased proportion of wounds of the upper limb out of the total number of limb injuries: 71.0% in 1967 compared to 77.2% in 1973. This phenomenon may be attributed to several factors. The introduction of fireproof overalls reduced the number of burns of the trunk and lower limbs, while those of the face and hands increased in relative and absolute terms. A major change in military tactics also played a role: clear-

ing minefields which in the past was done by infantrymen became a function of the armored units. Thus, the numerous cases of injuries to the lower limbs are disappearing in modern warfare. In general, the value of infantry declined in the 1973 war, which accounts in great part for this change in the distribution of injuries.

Some Psychological Aspects of Hand Injuries

Benjamin C. Cohnen

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The hand in man serves not only as a functional unit necessary for his daily activities, but also as a sensory unit, supplementing and complimenting the other sensory organs such as the eyes, ears and nose. When sight or hearing is impaired or lost, then it becomes a very sensitive and important sensory substitute. In addition, the hand is used as part of a daily means of communication and therefore is very much on view, and any change of appearance is quickly noticed.

It is no wonder, therefore, that injuries or loss of part of or a whole hand or both hands can produce severe psychological sequelae, often overlooked or minimized, but which can be of far-reaching importance. At many previous meetings and lectures on hand surgery, it is surprising to find that very little attention has been paid to the very important psychological aspects of hand injuries, and over the past few years it is something which I have tried to underline and in particular the fact that the surgeon must not only treat the hand which has been injured or maimed, but also the patient as a total human being. In these days of super-specialization, and with the various pressures which are constantly being exerted upon the physician and surgeon, it is only too easy to focus attention on the injured part or the diseased system and pay little or no heed to the patient as a whole. In the treatment of hand injuries no less than the treatment of injuries elsewhere in the body, one must always be aware that one is treating a whole human being who has suffered an injury or loss of an important part of his body and which indeed may be to him the most important part of his body.

In considering the hand, we often think of it only as a functional organ providing the means of carrying out certain intricate tasks and duties which allow man not only to produce all the marvels of the present century, but also serves to make him an independent individual with regard to the many aspects of daily life and thus distinguishes him from all other creatures on earth.

It is not to be denied that the prime function of treatment of the injured or mutilated hand is to restore to it the maximum functional ability possible, and

thus allow rehabilitation of the patient to his normal occupation in as short as possible time and with the least possible disability. Nevertheless the appearance of the repaired hand and its restoration to as near-normal as possible is a significant factor in the very important social rehabilitation not only of the patient, but also his close family and associates. Too little attention has been paid to the patient's own self-image with regard to the normal appearance of his body as a whole. In this context we must consider the impact of any change in the appearance of the hands with regard to the patient's contacts at home and at work.

The pattern of psychological changes which may occur in patients who have suffered severe and mutilating hand injuries which result in either loss or deformity or scarring of large or even smaller parts, will vary with the social status, sex and age of the patient, together with, quite often, his ethnic origins. The recognition of these factors is most important, especially when one notes that there is often a reluctance of patients to expose an injured limb, to remove a bandage from an injured part, or use the reconstructed hand. This reluctance can often be traced back very simply to the fact that the patient either does not like the appearance of the hand, or is worried about what his family or associates will think about it.

It has been recognized by many eminent writers on surgery of the hand that treatment of the hand is not complete until the patient is totally rehabilitated, and in this context it means not only totally rehabilitated from a functional point of view in a worthwhile occupation, but also in his contacts socially and within his home. It is in the latter situation that one finds that there has been a great deal of neglect and for this reason it is most necessary that the surgeon treating the patient should at least meet with the close relatives and assess their reaction to the severe injury or deformity that results from the hand injury, as well as that of the patient. It is too often forgotten that in the marital situation, the function of the hand is very important and is used in a totally different way from that used in order to perform the normal daily tasks.

One only has to watch how the hands are used and the means by which communications can be made with them, to realize how important they are in conveying certain feelings and emotions, including those of an extremely intimate nature. Observations of young children and parents show how the hand is used as a form of close contact and reassurance. At the same time the hand may be used in the form of a loving caress where there is a softness of touch and, imparted from the fingertips, a sense of love, security and fulfillment.

A gentle caress or the firmness of pressure of the hands in all age groups can be used to convey a depth of feeling, emotion and sensitivity and communicates sympathy, affection or loving kindness. Few will deny the tremendous depths of empathy which can be expressed by the use of the hand in various ways. The feeling transmitted through the fingers is something which has been expressed throughout history, such as in the entwined fingers symbolizing togetherness and

affection, and the pressure of a hand in a handshake, conveying sincerity and warmth by the nature of pressure exerted by one hand upon the other. It is extremely easy to gloss over or forget that in marital life, the caress of the hand plays a vital role in the intimate relationship between man and wife and that the varied pressures and movements of the hand, by their variation, convey a depth of feeling and desire which no words are able to express. It therefore does not need much more elaboration to underline the readjustments which must be made by man, wife, boy and girl should the hand or hands be mutilated.

Having observed and treated large numbers of civilian hand injuries over nearly two decades, the writer has become deeply impressed with the psychological significance of such injuries. Subsequently, having dealt with many unilateral and bilaterally mutilated hands, as a consequence of the Yom Kippur War, the writer has even been more deeply impressed with the need to consider the psychological consequences of hand injuries rather than the pure functional aspects.

In the light of such observations, it is felt that we should devote more time to the individual patient, showing an understanding for whatever loss he may have incurred and helping him to overcome this in the best possible way. For this reason it is underlined once again that in the treatment of any injured patient, in particular one with injuries of the hand, the patient should be treated by one surgeon and that this surgeon should be his constant mentor and guide from the day that he is injured until the day he is totally rehabilitated. A bond is therefore built up between patient and doctor, and any problems which may occur, be they of a functional, sociological or psychological nature, can be discussed because of the mutual bond of trust which is developed under such circumstances. There is no substitute for gentle understanding of the various problems which confront patients in the various age groups when they suffer the loss or maiming of a limb, particularly when it is such an important sensory and functional organ as the hand.

Deformities of the hand following injury have no less a psychological impact on the patient and his relatives than a deformity of the face, and the impact of such an injury on the body image of the patient and his relatives is something which must be constantly borne in mind. The hand is on view almost as much as the face, and hands are so expressive and often used for expression that any deformity or disfigurement is soon brought to light. The effect of this upon the patient is so readily observed by the reluctance, especially in the younger age group, to exhibit the injured member, and only constant encouragement and understanding can help the psychological, social and functional rehabilitation of such a patient. The person who is ideally fitted to carry through this onerous task is of course the surgeon who is treating him.

Wound Ballistics

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Introduction

Ballistics, the branch of mechanics dealing with the motion of projectiles, is divided into three main areas:

(1) Interior ballistics, which is concerned with the behaviour of missiles in the gun barrel. This applies only to missiles fired from barrelled weapons such as pistols, rifles, machine guns, mortars and other artillery pieces.

(2) Exterior ballistics, which is the study of the motion of missiles through air. This applies to missiles fired from weapons, fragments of shells, bombs and grenades, and secondary missiles set in motion by the action of the primary projectile on environmental structures.

(3) Terminal ballistics, which is the study of the penetration of media more solid than air by missiles and the interaction between them. Wound ballistics is the subdivision of terminal ballistics dealing with penetration, motion and effects of missiles on animals. In the broadest sense, it covers all types of mechanical injuries, and describes the events leading to a wound in mechanical and biological terms.

Wounds are classified as follows: non-penetrating — contusions or abrasions without penetration of the skin by the primary wounding agent, e.g., blast injuries; penetrating — an injury with an entrance and no exit wound where the primary wounding agent is retained in the tissues; perforating — an injury with entry and exit wounds, where the primary wounding agent is not retained in the tissues; incision — the wounding agent exits in opposite direction to its entry, e.g., stab wounds; laceration — tears, generally produced by agents acting tangentially to the surface of the body; mutilation — trauma causing excessive loss of tissue, loss of an anatomic part or serious disfigurement, e.g., crush injuries and avulsions of limbs.

In modern wars the most frequent types of injury are the penetrating and

perforating wounds. In the 1973 Arab-Israeli (Yom Kippur) War, almost 40% of the injuries were of these two types, followed by non-penetrating and laceration wounds (33.5%), burns and blast injuries (both about 10%), and crush injuries (7.5%). The present chapter deals with the ballistics of penetrating and perforating wounds caused by missiles from common military weapons.

The study of wound ballistics, which is over a hundred years old, was first methodically researched only at the turn of the century (19, 20). Some works on the subject appeared between the two World Wars (32), but the major early contributions date to the period of the Second World War when the pioneering works of *Callender* (6), *Callender and French* (7), *Black et al.* (5) and *Harvey* and co-workers (14–18) were published. Since that time a considerable amount of research has been carried out on this subject, important to all military surgeons, protective garment designers and munitions manufacturers. The most important text is the volume on wound ballistics of the series 'Medical Department, United States Army in World War II' (13, 17).

Types of Missiles and Firing Weapons in Warfare

War injuries are generally caused by two types of missiles — bullets and fragments. Bullets fired from small arms have a definite shape, and all phases of their ballistic behaviour can be fairly accurately determined.

A special case of missiles not fired from small arms but with fixed ballistic characteristics are flachettes, which are tiny darts discharged at extremely high velocities from special bombs and shells. Another special case of bullets is the shot-gun munition which is usually composed of multiple metal spheres in a cartridge; these, however, are not generally used as war weapons due to their relatively low wounding capability.

Fragments include those produced by the explosion of gun and mortar shells, bombs, grenades and landmines, as well as secondary missiles produced by the action of a primary missile on whatever structure it encounters. These do not, as a rule, have a definite shape and therefore their ballistic behaviour cannot always be precisely determined. Some modern fragmentation munitions produce a pre-determined number of fragments of definite shape, but their ballistic properties are not easy to calculate. Thus, most researchers in wound ballistics use bullets for their investigations, and our knowledge regarding their injury-producing characteristics is the most extensive. Moreover, in order to further eliminate shape factors, a large proportion of the research was done using steel spheres.

The large majority of injuries sustained in modern wars is caused by fragmentation munitions, and most of these are the result of the fragments themselves rather than the blast and incendiary effects. In the 1973 Israeli-Arab (Yom Kippur) War, about 63% of all wounded soldiers were injured by fragmentation