

ORTHOPEDIC
SUBJECTS

MILITARY SURGICAL MANUALS
NATIONAL RESEARCH COUNCIL

ORTHOPEDIC SUBJECTS

*Prepared and Edited by the Subcommittee on Orthopedic
Surgery of the Committee on Surgery of the Division of
Medical Sciences of the National Research Council*

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MILITARY SURGICAL MANUALS
NATIONAL RESEARCH COUNCIL

VOLUMES IN THIS SERIES

- I. MANUAL OF STANDARD PRACTICE OF PLASTIC AND MAXILLO-FACIAL SURGERY**
- II. OPHTHALMOLOGY AND OTOLARYNGOLOGY**
- III. ABDOMINAL AND GENITO-URINARY INJURIES**
- IV. ORTHOPEDIC SUBJECTS**
- V. BURNS, SHOCK, WOUND HEALING, AND VASCULAR INJURIES**
- VI. NEUROSURGERY AND THORACIC SURGERY**

FOREWORD

THE Medical Department of the Army has been confronted with the necessity for enormous and rapid expansion paralleling that of the armed forces. The state of war has greatly increased the task of furnishing adequate medical care for Army personnel since battle casualties are added to the already wide range of diseases and injuries that must be treated.

Expansion of the medical establishment of the Army is entirely dependent on entry into the service of individuals from civil life. While most reserve officers have had a varying amount of military training, practically all medical officers will encounter problems in the military service entirely foreign to their previous experiences. These problems are by no means confined to those of an administrative nature; many are distinctly professional. The military situation imposes certain restricting factors which render impracticable some procedures that would be considered ideal in civil life. The goal of furnishing the best possible treatment to all individuals is the same in the Army as in civil life, but the means to attain that goal may differ materially.

There has been a marked tendency to specialization within the medical profession since the first World War. This tendency is fundamentally sound but does serve to increase the problems of many individual medical officers in time of war. Specialization cannot be followed to the same degree in the military service as in civil life. While many highly qualified specialists in the various fields of medicine and surgery will serve in like capacities in the Army, this cannot invariably be true. The great burden of medical care will fall on medical officers outside the highly specialized fields. It is thus essential that nearly all medical officers be familiar with the principles of military surgery. Recent advances in therapy have resulted in radical modification of certain principles of treatment that were formerly considered sound.

This series of texts presents in compact form essential up-to-date and reliable information regarding military surgery. The various sections have been written by outstanding authorities in their respective fields. They have been prepared for publication under the auspices of the Division of Medical Sciences of the National Research Council.

These texts will prove a highly valuable source of professional information for any surgeon desiring a knowledge of the principles of military surgery. Their application is not confined to military medicine, for most of the wounds and injuries of modern warfare may be duplicated in civil emergencies. The condensed form and avoidance of debatable points will render them very convenient for quick reference as well as for more mature study.

These volumes represent an important addition to the field of surgical texts. The individuals instrumental in their preparation have made a distinct contribution to civil and military medicine by their assemblage and presentation of this timely professional information.

JAMES C. MAGEE

Major General, U. S. Army
The Surgeon General

The naval medical officer is often faced with medical or surgical situations with which he must deal entirely alone and without the opportunity for consultation and assistance from other members of his profession. He may be the only medical man on a ship in the middle of an ocean, and any surgical emergency must be met by him and him alone. He cannot refer the case to a specialist; he himself must do everything that is necessary. It is important that he have the best assistance that professional books and journals can give him. A book such as this manual, which contains practical and essential things, readily accessible, is a real help to a medical officer and patient in this situation.

ROSS T. MCINTIRE

Rear Admiral, Medical Corps
Surgeon General, U. S. Navy

INTRODUCTION

THIS volume is one of a series developed under the auspices of the Division of Medical Sciences of the National Research Council to furnish the medical departments of the United States Army and Navy with compact presentations of necessary information in the field of military surgery. The individual manuals are prepared under the auspices of the various subcommittees of the Committee on Surgery of the Division of Medical Sciences of the National Research Council and are edited by the Committee on Information.

The first four volumes cover the following subjects: plastic and maxillofacial surgery; ophthalmology and otolaryngology; abdominal and genito-urinary injuries; and orthopedic subjects. Succeeding volumes contain material on the following: burns, shock, wound healing, and vascular injuries; and neurosurgery and thoracic surgery.

The Committee on Surgery includes Drs. Evarts A. Graham, Chairman, Irvin Abell, Donald C. Balfour, George E. Bennett, Warren H. Cole, Frederick A. Collier, Robert H. Ivy, Herman L. Kretschmer, Charles G. Mixer, Howard C. Naffziger, Alton Ochsner, I. S. Ravdin, and Allen O. Whipple. The Committee on Information includes Drs. Morris Fishbein, Chairman, J. J. Bloomfield, John F. Fulton, Richard M. Hewitt, Ira V. Hiscock, Sanford V. Larkey, and Robert N. Nye.

Most of the detail of the editorial work has been done by Dr. Richard M. Hewitt, assisted by Dr. A. B. Nevling, in the Division of Publications, the Mayo Clinic, Rochester, Minnesota.

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SECTION I

UNUNITED FRACTURES

Paul B. Magnuson, M.D.

HIGHLIGHTS IN TREATMENT OF UNUNITED FRACTURES

1. Secure the cooperation of the patient and have his mind in agreement with that of the surgeon that there is no short and easy route to union.
2. Eliminate all systemic disease which would interfere with general health.
3. Surround the injured bone with healthy tissue (skin and muscle) and remove all bone debris, fibrous tissue, and infected material.
4. Bring the patient's health to a maximal point before bone work is attempted; this includes nourishment, metabolism, circulation, muscle tone, and strength around the injured parts.
5. Secure adequate immobilization of fragments and institute physical therapy locally at the earliest possible time.
6. Avoid cross-strain and torsion in handling, after operation.

CHAPTER I

FUNDAMENTAL PRINCIPLES AND ROENTGEN- OLOGIC EVIDENCE

IN a consideration of the causes and treatment of nonunion of fractures no generalized statement can be made which will hold true in even a majority of cases. The individual factors of each case, as always in medicine and surgery, must be carefully analyzed. The patient as a whole is as important as in any other diagnostic problem; his physical characteristics, his health, his temperament, all must be considered. No two human beings are alike, although each may be normal. Therefore, before the cause of nonunion in a particular case has been established, or before a method of treatment has been chosen, all factors must be studied. Unless this is done the percentage of cures will not be as high as it should be; things will be overlooked which should not be overlooked, and results will not be as satisfactory as would be the case were careful thought given to the cause, the preparation for treatment, and the treatment itself.

To evaluate the factors which contribute to nonunion the fundamental principles underlying the repair of fractures must be understood. This important groundwork can be briefly covered by quoting the report of the Fracture Committee of the American College of Surgeons, which represents the consensus of a large group of men particularly interested in the study and treatment of fractures. The headings have been added to the quotation, the end of which is indicated by three asterisks.

Pathology of Bones in Fractures

The local lesion in fracture cases is of paramount importance in establishing the general principles of treatment. When bone is broken there is coincident tearing of bone and soft parts—endosteum and periosteum—with vascular and lymphatic ruptures and thromboses. There may be laceration and contusion of muscle, fascia, and skin. There is death of bone, as well as of injured soft parts. The tissues are infiltrated by blood, lymph, and inflammatory exudate

as well as transudate because of mechanical circulatory interference. This infiltration of the tissues causes the swelling and pain of the part, and is increased by handling of the extremity and movement of the fragments of bone. It is of significance that the blood, lymph, and inflammatory exudate rapidly clot, and that the two latter are even richer than blood in fibrinogen. Within forty-eight hours this extensive fibrin shows active organization by cell growth, and is replaced by organizing tissue.

Pathology of Soft Parts in Fractures

The tissue of the soft parts and the bone that have been killed by the trauma are autolyzed by ferments furnished by the death of the cells, and tissue fluids in the region of the fracture are permeated by a calcium compound derived from autolyzed bone. There are some who hold that the source of calcium is the blood stream. This process is slow and occupies several days. The swelling and infiltration reach their maximum in eight to twelve hours, and then circulatory disturbance from pressure and thrombosis adds an actual edema to the picture. The clotting of blood and exudate leaves a residue of their fluid contents which gradually diffuses toward the surface. This residue is important because the more fluid, whether exudate or transudate, present at the site of fracture the less efficient is the organization of the fibrin. In addition to this common picture there may be associated injuries of contiguous muscles, nerves, vessels, joints, tendons, and tendon sheaths, which must be considered as part of the lesion.

Process of Normal Bone Repair after Fracture

The actual mechanism whereby calcium is deposited in the tissues to form bone is unknown, as is the chemical form in which that calcium exists. But the rest of the process is sufficiently well established to give a definite idea of what happens: After the fracture lesion as previously described has appeared, the bone ends and the surrounding soft parts (soft parts of bone, and extraskkeletal tissue which has undergone laceration and is present at the fracture site) are bound together by the interlacing mesh of the fibrin from clotted blood, lymph, and inflammatory exudate always present at the site of fracture. There is a certain amount of edema. Within a few hours fibroblasts appear in this fibrin clot as the beginning of the formation of granulation tissue. The more fluid element present, the less effective and rapid is the cell proliferation. Within forty-eight hours this organization has proceeded to a considerable degree.

The growing tissue is infiltrated with the calcium derived from autolyzed dead bone either in solution or in colloid state. The cells forming this tissue are derived from the soft parts of the bone—endosteum, marrow reticulum and periosteum—from the soft parts around the site of fracture, and from the lymphocytes infiltrating the part as a result of the inflammatory reaction. Within seventy-two to ninety-six hours this mass of cells, while loose meshed and friable, becomes an organized tissue uniting the ends of the bone and the adjacent soft parts. Unless there exists such mechanical obstruction as interposition of tissue, all fractures heal in this manner. This is the manner in which the healing process occurs for any wound wherever situated.

Deposit of Calcium

Calcium is then deposited in this newly formed living tissue, which then constitutes early callus formation. The deposition of calcium has been observed as early as seventy-two hours in sections removed from actual fractures. The calcium is apparently derived, for the greater part, from the calcium freed by autolysis of dead bone, and not from the blood calcium. The process then goes on to progressively denser concentration of deposited calcium until the callus becomes hard bone. With use and the action of normal stress and strain over a period of months this bone arranges its lines and channels to form the normal histological picture of bone. It frequently takes a year or more for the completion of this process.

In the meantime the organization of granulation tissue proceeds in the fibrin mesh throughout the affected soft parts and becomes organized tissue within a week. The effectiveness and rapidity of growth of tissue are dependent upon efficient circulation in the parts from which the cells are derived, and as stated above, is retarded and limited by excessive fluid exudate at the site of fracture.

Granulation Tissue

Healing by granulation tissue takes place in all fractures except where mechanical obstruction exists between the fragments. The slow deposition of calcium in the tissue produces so-called delayed union, whereas its absence produces so-called nonunion. Delayed and nonunion are more apt to occur in certain bones and certain portions of these bones even when all other factors are equal. Certain sites of fracture in some bones are therefore characterized by a prolonged "healing time" as the usual and expected result. Therefore, in addition to the other factors cited, the time needed for sufficient ossifica-