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The Treatment of fractures : the principles and methods of closed reduction

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THE TREATMENT OF FRACTURES

The Principles And Methods Of Closed Reduction

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OUTLINE

INTRODUCTION

HISTORY

PRINCIPLES OF TREATMENT

- Physiology
- Pathology
- Principles : Gravity, traction, reduction, counter-traction, suspension, immobilization , massage movement .

METHODS OF TREATMENT

- First Aid
- Diagnosis
- The Compound Injury
- Open Versus Closed Treatment
- Reduction
- Immobilization
- Physio-therapy
- The Medical Treatment

INTRODUCTION

The problem of fractures of today with our increased speed of transportation and with an increasing use of machines in all pursuits is greater than at any previous time except perhaps during the World War. Certainly , it is true that the nature of the fractures seen in preponderance is determined by our high speed transportation. The crushed pelvis, the compound fractures of extremities with multiple fragments, the greater prevalence of fractures of both bones of the leg just below the knees of pedestrians and the fracture or dislocation of the neck of the femur in head-on collisions when the knee strikes the instrument panel are typical of this.

It will be the intent of this paper to present the principles of fracture treatment which are generally accepted and some discussion of the choice of one type of treatment in preferance to another. The scope will include only those means of treatment which every general practitioner should be able to employ and limited to the closed reduction methods. It is realized that open reduction is not necessarily a closed field to the general practitioner but it is believed that the majority of his cases can be successfully treated by the closed methods. The literature on treatment of fractures has been reviewed and an attempt is made to present an evaluation of the methods according to the various writers in the

subject. Obviously detailed descriptions of individual fractures are impossible and such as appear serve only to illustrate principles of general treatment.

There is a conception expressed by many authors on the subject (46) that there is no type of treatment that is applicable to every type and location of fracture -- but that one must consider first the location and nature of the fracture together with the normal function of the part and then choose the best means of placing the fragment in apposition, maintaining them and eventually restoring the part to the highest possible degree of function without danger of atrophy of disuse or ankylosis as a result of the method employed.

HISTORY

There can be no doubt but that man has always been confronted with the problem of fractures. There is considerable recorded and other evidence to show that he early learned to treat these fractures in many respects in a manner which compares favorably with the treatment of more modern times.

The idea of providing an exoskeleton for the broken endoskeleton was established early. The mummies of Egypt of 5 or 6 thousand years ago as examined by Dr. G. Elliot Smith, (72) show 1 fracture in every 22 mummies. Two of these bodies had fractured limbs with the splints remaining in place and these are the oldest records of splints applied in the treatment of fretures now available. One is of a fractured radius and the other of a fractured femur. In the later case the splint consists of four wooden pieces about 16 inches long and 1 1/4 inches wide applied about the thigh extending less than 3 inches above the knee and about 7 inches below the knee. Linen bandage wrapped about these wooden splints in opposing directions served for support. Obviously one could not expect to prevent shortening with such a splint and thus it was found that there was union with over-riding and shortening in most of the fractured femurs seen by Dr. Smith. The fore-arm fractures in all cases showed good results . The splint in the case observed was constructed of three pieces of rough bark padded with straw and bound with linen such as To

provide quite adequate support.

Another reference to fracture during the ancient period appears in the Bible. In Ezekiel chapter 30, verse 21, the Lord speaks to the prophet Ezekiel saying, ''I have broken the armoof Pharaoh, King of Egypt and it shall not be bound up to be healed, to put a roller to bind it, to make it strong to carry the sword. '' It is significant from this that some sort of binding with a roller, probably a splint, was used and further inference may be made that not all such cases were successfully healed.

The writings of Hippocrites (1) in his books on fractures and dislocations serve to show the extent of the knowledge of fracture treatment attained by the Greeks. I have listed the important achievements in the following:

(1). Gold thread was used to bind the fractured lower jaw to the upper jaw attaching the thread to the teeth.

(2). He advocated the immobilization of the extremity in the position of greatest functional ability and he deals at length in this respect as applied to the fracture of the fore-arm.

(3). He describes a type of splint for the lower extremity consisting of two rings, one below the thigh and fitting snugly against the thigh muscles and the other just above the ankle. Saplings or other elastic pieces of wood sprung between these rings served to push them apart and so push the two fragments apart.

(4). He describes the Scamnium, a sort of a ladder securing fixation at the shoulder and perineum and securing traction on the fractured extremty by means of windlasses. He states that manual traction is effective but not as dependable as that secured by mechanical means. He advises the use of a splint for the lower leg made of wood and made to conform to the contour of the leg. The splints are applied with extension maintained for a short time and repeated on the 7th, 9th, and 11th days. He warns against inadequate extension of fractured femurs and states that no harm will come from hyperextension since the parts will come back together again after the bandages have been applied. He says,'It is a great disgrace to exhibit a shortened thigh,' and so advises the use of a splint from the nates to the ankle.

(5). The Glossiconium was a fracture box making use of pulleys and a windlass to overcome muscle pull of the thigh. Attachment was made to the extremity by a clove hitch like the Collins (15) hitch.

(6). In regard to various fractures he gives the time for consolidation as 40 days for the humerus, 40 days for the tibia and 50 days for the femur.

(7). He advised the use of small iron levers in the reduction of compound fractures if such manipulations can be done early.

(8). An equivalent of the plaster cast was made by passing thin cloth through melted wax which hardened after the bandage was applied. This was applied while traction and counter-traction was maintained.

(9). An important principle which needs to be more emphasized today is this: 'Extension of fractured or dislocated bones is not to be delayed to the third day but is to be carried out on the first day'.

In conclusion of this it can be noted that all of the important principles were presented by Hippocrites except the use of continuous traction, open reduction and anesthesia.

Little is known of any developments attained by the Romans in the treatment of fractures and it is generally believed that they simply borrowed the methods of the Greeks. Greek slaves and freed men served as surgeons generally. Celsus,(76) of Rome at the time of Tiberius Ceaser wrote a book, ''Osteology, Fractures And Dislocations'',(40) Concerning the thigh we find:"We ought not to be ignorant however that a fractured thigh is shortened because it never entirely returns to its former state; and that the patient ever afterwards supports himself on the toes of that foot, which occasions great weakness; but it is much worse when the misfortune has been occasioned by neglect." This might indicate that adequate treatment was not always given to thigh fractures. And comparing this with the writings of Hippocrites one might suspect that Hippocrites either gave better treatment or that he did not always give a complete picture of the results achieved.

During the Middle Ages the treatment of fractures fell into the hands of a sort of specialist, the bone-setters, who must have possessed considerable skill and knowledge of the subject

for they were sought far and wide. (26) It was an heriditary profession and the most famous family of these is that of which Hugh Owen Thomas, the great orthopedic surgeon is a descendant. In this country the Sweet family of Rhode Island gained considerable renown for their ability to reduce fractures and dislocations. (47)

The Indians of North America and certain tribes of these in particular possessed considerable knowledge of the treatment of fractures and dislocations. A famous Zuni medicine man used a solution of Jimson weed taken by mouth to produce a deep sleep and relaxation of the muscles.while the fracture or dislocation was being reduced. Substances which were emetic and caused extreme nausea with an accompanying relaxation of muscles were used by other tribes. The Shoshones made a cast of rawhide soaked in water till pliable and then moulded to the fractured member and allowed to dry. Sheets of bark with windows cut over the wounds were used by the Winnebagoes and the Dakotas. In most of the tribes broken bones were immediately set and splints were applied. Stout saplings were cut long enough to immobilize the neighboring joints and were bound on firmly. Loskeil, (Loskeil, G.W.:History of the Mission of the United Brethern Among the Indians of North America), describes the treatment of dislocation of the femur in the case of a lone Indian hunter. This Indian strapped the injured limb to a tree and then pushed himself away with the other foot and with his arms and used appropriate rotation of his pelvis

until the head of the femur snapped back into place.(77)(14)

Probably the earliest complete book on fractures in later times is that of Sir Astley Cooper, (20) written first in 1823. He describes detailed treatment of all types of fractures and dislocations and cites numerous cases of his experience. Of particular interest are his methods of securing relaxation of muscles. Bleeding was the most used method. With the patient in the erect position the blood was let until there was syncope. Another method was to put the patient in a bath of 100 to 110 degrees Fahrenhiet until fainting was produced and then wrapping a blanket about the patient placed on a chair while the reduction was done. Nauseating doses of antimony of tartrate were also used to produce vomiting and the accompanying relaxation. He advocated the use of pulleys to secure traction in treating delayed dislocation of the hip and it appears that he had considerable success with this type of case.

The last century brought numerous new developments in the treatment of fractures. In 1827 Nathan Smith first used the long anterior leg splint in suspension treatment. Continuous traction was used probably first by Daniels in Georgia in 1827. This was secured with weights and pulleys. The first application of wires internally for the fixation of fragments was in 1827. Buck, in 1851 developed his method of extension which is now commonly used and bears his name. Hunt applied

sand bags to aid in immobilization of fractures in 1862. (47)

It is believed that Plaster of Paris for immobilization was first used in Arabia. (54) W. Eton visited the Turkish Empire in 1789 and found it used there then and determined that it had been used for ages. The first plaster used in the European countries was applied in wooden boxes around the extremity. Later blotting paper was added for thickening. Seutin working in Brussels in 1834 first split the plaster cast and there-by made it possible to loosen the cast or tighten it as the case might indicate. Matheyson,(54) a Dutch medical officer in 1850 first published a pamphlet on the use of the plaster of Paris bandages in fracture treatment. This consisted of coarse woven cotten with the dried powder in it. It was used in the Crimean war and was soon adopted by other armies. It soon gained in popularity and by the beginning of the next century it was in general use. Krause (54) developed the walking plaster in 1887. It consisted of a plaster encasement from the ankle to the tuberosity of the ischium with an iron hoop incorporated at the lower end and extending to the ground beneath the foot. The idea was borrowed in part from Thomas who first used the walking calliper.

Hugh Owen Thomas, (36) in 1860 first described his splint with which we are so familiar. He had established himself in the Port of Liverpool where he served as surgeon for 28 labor unions. Here he gained experience in the treatment of fractures. Sunday was set aside for the charity clinic. He had no hospital

connections and his splints and other appliances were made and fitted on the premises. He stressed enforced, uninterupted and prolonged rest. Realizing that the circular compression induced by plaster casts interfered with the true conception of rest he devised his splint which is now adaptable to more fractures of the long bones than any other .

John Hodgen, (23) a graduate of the University of Missouri, general practitioner, surgeon and teacher devised his splint in 1862. He emphasized the folly of urging any specific apparatus in the treatment of any particular fracture.

An important mode of fracture treatment was developed by Lucas Championiere. (12) (54) He considered particularly the attention which should be given to the soft parts. ''A moderate degree of deformity'', he says, ''is a reasonable price to pay for the absence of stiffness in a limb!' He condemned the prolonged immobilization which was in such universal use and emphasized the danger of anklosis. He taught that callus formation and union occur best when a controlled amount of union is allowed. ''Immobilization interferes with the nutrition of the bone and there is liability of spontaneous fracture.'' This represents a reaction to the trend which was evident at that time towards the bulky and prolonged plaster casts. But he probably swung much to the other extreme and for this he was criticized by Bohler,(10) and others who would employ the beneficial features of both methods.

In 1895 William Von Konrad Roentgem, (71) discovered the x-ray. With this began a trend among the surgeons to the attainment of perfection in the way of anatomical reposition of the fragments with oft times damage to the soft parts with out need in cases where good if not better functional results might have been secured with some slight degree of imperfection in the way of anatomical reposition. But it is certain that the ultimate value of the x-ray in the treatment of fractures can not be under estimated.

The modern era of open reduction received its impetus with the development of the Lane plate in 1910. (47) With this the fragments could be fixed in solid apposition thus placing the need for external immobilization at a very low minimum. Thus begun, the development of numerous devices; screws, pegs, bone grafts and other forms of internal fixation soon followed. Wiring of the fragments had been developed previously but it now came more into general use. Many of these devices proved of great value but some were dissappointing. It is only recently that the true value of all of these is being realized and the proper indications for the operative treatment are being developed.

In 1909 Steinman demonstrated his nail permitting direct traction on the bone. During the World War other devices including the 'ice tong' callipers, screws and pins were applied to this same end. Kirshner's wire developed also in 1909 was an improvement on the nail. It consisted of a stiff piano

wire which could be put through the bone with a drill. A stirrup applied to this provided traction and kept the wire tight. It made a much smaller opening than the pin and hence less danger of infection and less foreign body reaction.are its chief merits.(47) Recently this has been incorporated in a light plaster cast to combine continuous traction with plaster immobilization. (73)

Lorenz Bohler,(15) gained much knowledge and experience in fracture treatment during the World War and has since done much to popularize the functional, ambulatory plaster cast. The cast as he applys it is applied directly to the skin surfaces. It extends from the tuberosity of the ischium to the ankle and carrys the weight of the body to the ground . With this the limb is allowed considerable exercise of the muscles with out endangering the apposition of the fragments. He has thus combined in part the valuable features of immobilization with some of the mobilization features of Lucas Championiere.

The World War has served to initiate a new consciousness of the inadequacy in the previous treatment of fractures. This is especially true as regards the early and first care of fractures. The use of the Thomas and the Murray splints for the immediate application to all fractured extremities at the site of injury is becoming standard treatment. (28) Other features of first aid are being stressed. There is an increased use of continuous traction combined with various splints and plaster devices. These will be discussed more completely under treatment.

PRINCIPLES OF TREATMENT

The bony skeleton is essentially a system of levers and hinges acted upon by muscles with various attachments. Normally the muscles are balanced in their pulls upon these bones by the relative strengths of the muscles and by the resistance which the bone continually offers to the action of the muscles. In case of a fracture of the bone this balance is lost and certain groups of muscles are allowed to have a balance of power because the resistive force of the bone is lost. This may result in rotation, angulation and over-riding of the fragments.(45)

According to Wolff's law,(67) the structure of a bone is determined by the function of the part. That the body tends to build stronger that part of the bone along which the stress and force resulting from function are the greatest is often observed as a manifestation of this law. In fractures of the long bones with Over-riding and angulation, any normal function is impossible and hence any formation of structure due to the stimulation of function is impossible. If left untouched eventually a certain degree of function after union in the deformed position may result, but it is an altered function which is generally imperfect. But if the normal relationship of the fragments is restored, then with the possibility of a normal function, Wolff's law operates in the rebuilding of bone structure.

Gravity is continually operation in the maintenance of balance between bone and muscle. One needs but to hold up an arm or a leg for a few minutes to become aware of this. In the treatment of fractures one must consequently counter-act this force at points where the normal resistance to gravity is lost because of the fracture. This is best done by some type of suspension.

A brief review of the pathology of a fracture and of its repair shows clearly the necessity for early reduction. The following review is taken from the report of the Committee on Fractures of the American College of Surgeons, (27)

> The fracture consists of a tearing of the bone and the soft parts, endosteum and periosteum with vascular and lymphatic ruptures and thromboses. There may be lacerations and contusion of muscle, fascia and skin. The tissues are infiltrated with blood, lymph and inflammatory exudate as well as transudate because of the mechanical circulatory interference. This causes swelling and pain of the part, which is increased by the handling of the extremity and the movement of the parts of the bone. The blood, lymph and exudate soon clot due to the excess fibrinogen. With in 48 hours the fibrin shows organizaton by cell growth and is soon replaced by the organizing tissue. The interlacing mesh of fibrin and exudate is the first bridge. Within a few hours fibroblasts appear in the fibrin clot as the beginning of granulation tissue. This growing tissue is infiltrated with calcium derived from the autolyzed dead bone. Within 72 to 96 hours the mass of cells (lymphocytes and fibroblasts) which is loose meshed and friable becomes an organized tissue which then makes up the early callus. This process goes on to progressively denser concentration of deposited calcium until the calcium becomes hardened bone.

It can be readily seen that if the early reduction is done

Note: This description prepared by the fracture committee gives no indication as th the identity of the individual author of this part.

before the processes described above are started much time is gained. Early reduction is essential from another standpoint. The muscle spasm as a result of congestion, edema and trauma in the soft parts begins to appear a few hours after the fracture and reaches its maximun in about 10 to 14 hours. This spasm not only increases the difficulty of reduction but it tends to increase the deformity of the fragments and the injury to the soft parts. (73)

Traction applied to the distal fragment serves several purposes. It restores the imbalance between the muscle groups and the bone resistance because it forms a pull against the muscles in the same line that was supplied by the bone before the fracture. It thus overcomes or prevents over-riding and angulation. In many cases it reduces the fragments to the normal relation. If continued it soon tires the spastic muscles giving relaxation and as a result relieves the patient of much of his pain.

Counter-traction as a principle of treatment follows naturally for there can be no traction unless some adequate means is made to prevent the whole body from being dragged. It must be so arranged as to insure a constant non-varying resistance and in the same line as the traction. It must provide for a maximum of comfort to the patient and yet not be easily deranged by his movements.

Suspension serves primarily to counter-act the influence of gravity but it serves to rest the injured member and to aid in maintaining the immobilization -- preventing angulation and used in conjunction with traction.

Immobilization has for its primary object the maintenance of the fragments in a state of reduction until the repair is strong enough to support them. It is not enough to reduce the fragments (with a few exceptions) because the muscles still are not balanced with a solid bony resistance and displacement is apt to recurr. Immobilization serves further to prevent breaking up of the early callus before it has become hardened.

Massage (53) is of value only as the pleasurable sensation so produced tends to relax muscle spasm and vascular spasm. This allows the congestion to subside and so hastens the onset of the reparative stage. It should be used up to the point of pain, when, if it were increased spasm would be increased.

Movement although frequently harmful in the repair of fractures has a certain place. According to Wolff's law (67) the structure of bone is dependent upon function so in theory at least, if one can restore the member to functional activity the repair will be hastened. But motion must be delayed until the repair has started to such an extent that it will not be damaged by the movement. Joints when immobilized tend to become anklosed, muscles tend to atrophy , and so one must so arrange his treatment as to get active motion as early as is consistent with the reparative processes. With the development of the devices of immobilization that will allow early functional use of the member and yet hold the

fragments well enough to prevent the destruction of the repairing tissue, better results will be attained.(62)

METHODS OF TREATMENT

FIRST AID.

Within recent years it has become established that the proper first aid of fractures is of utmost importance. The initial insult to bone and soft tissues in most cases is not as severe as that produced by the manipulations and trauma of the transportation. The introduction of infection by such manipulations may be a deciding factor. Allowing the muscles to continue in their spastic state, pushing sharp bone fragments through soft tissues may produce considerable unnecessary and harmful injury. There is a paragraph presented by the Fracture Committee of theAmerican College of Surgeons (27) that is often quoted but which so aptly expresses the situation that it is deserving of further repetition.

> A man is struck down by an automobile thus breaking his leg. Except for the broken bone, without displacement, the original injury may be merely a slight periosteal tear and a mild contusion of the soft parts, but he is helped to his feet and the leg gives way and the fragments slide by each other, thus stripping the periosteum and tearing the muscles. He falls to the ground only to be picked up and carried to the sidewalk with the leg dangling. Larger blood vessels are torn and the ends of the bone come through the fascia, perhaps the skin and even the trousers. He is laid at rest with a coat beneath his head and surroundeddby people anxious to help. Someone sees that his leg is crooked and straightens it out. The exposed end of the bone re-enters the wound with a bit of trousers and the dirt of the street. He is lifted up and carried to a car or ambulance. This time someone carrysthe injured leg with

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Note: I am unable to determine which member of the Fracture Committee is the author of this paragraph.

better intentions than coordination and the ends of the bone are churned around in their bed of lacerated tissues and the contaminating organisms are disseminated through out the area.

During the ride and in the transfer to the accident ward or doctor's office unless he has been carefully splinted, there is more jolting and more damage. Would that his troubles were over but too often the story continues. Lack of sufficient protection as he is being anesthetized results in still more injury.

The problem of first aid is outlined by the Fracture Committee of the American College of Surgeons, (28) essentially as listed below:

(1). The avoidance of unnecessary movement. A delay of as much as an hour beside the road until a doctor or someone properly trained in the application of a splint can arrive will do no harm. Even in cold weather , if wrapped in a blanket, any exposure to the cold will not be as dangerous as manipulation.

(2). The treatment of hemmorhage if present. A tourniquet should be applied if there is more than an oozing of blood. This will suffice for a short time but it should be rreleased at least every half hour to provide blood to the limb.

(3). The patient should be kept warm. Warm blankets or coats should be put over him where he lies.

(4). If the patient is in pain the doctor should administer morphine as soon as possible.

(5). A splint should be applied. It is not necessary to make a positive diagnosis of fracture. The splint should be applied if there is any suggestion of fracture between

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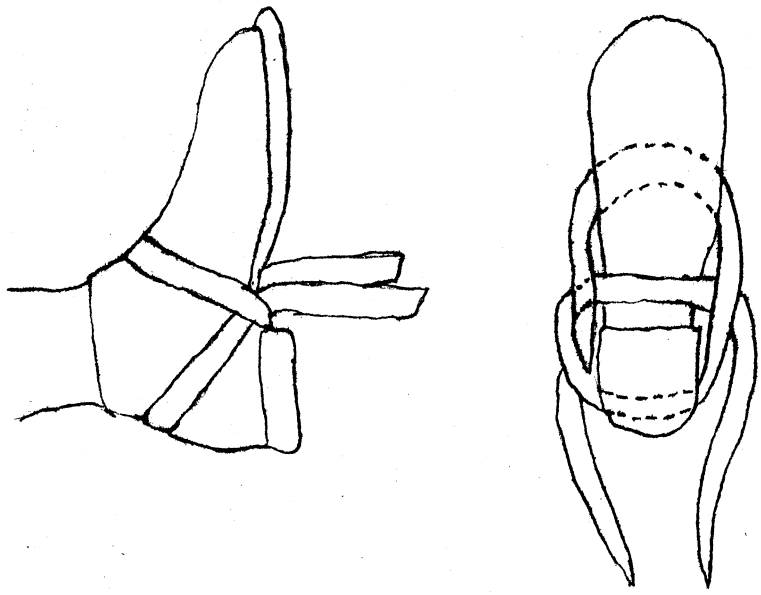
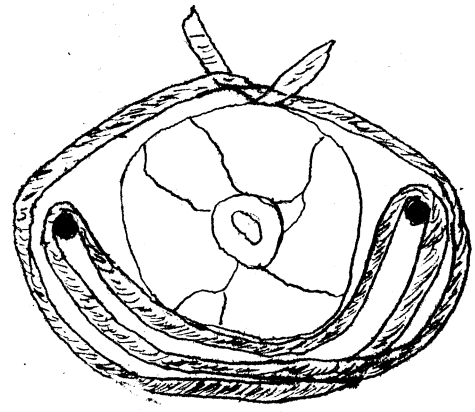
the hip joint and the foot and between the hand and the axillae. It should be used in both simple and compound fractures.

Every Doctor who is apt to handle fractures, every ambulance and first aid station should have available the Thomas splint or even better theKeller-Blake half ring splint and the Murray Jones hinged arm splint. (56) The methods of application as outlined by the U. S. Army, (28) The American Red Cross,(2) and the American College of Surgeons differ but little. If there is a wound or if a bone is projecting an antiseptic or sterile dressing should be applied, if available, before the splint is put on. The extremity issupported with traction andheld several inches above the ground by an assistant while the splint is being slipped into place. It is placed over the clothing in most cases. The ring must fit snugly against the tuberosity of the ischium or the axillae. Traction is applied over the shoe generally. The Army uses a non-elastic webbing strap providid with a buckle. A piece of muslin can be applied as a Collins hitch above the wrist or ankle. (15) Adhesive traction can also be used. The extremity must be supported in the splint. The RED Cross Manual uses six triangular bandages according to the diagram below. The limb may also be suspended with small towels fixed to the bars of the splint with large paper clips. The limb must be bandaged to the splint to prevent lateral movement. The end of the splint is suspended to the end of the stretcher or is held during transportation. A



Collins Hitch (15)



Bandage Support (28)
(Cross section)

foot-piece fixed to the distal end of the splint is advisable especially in long transportation.

A good deal in the way of education is needed before proper first aid will be given to all fracture cases. The training of police and ambulance squads in the proper application of splints is needed. E. P. Palmer, (60) has interested the Red Cross in setting up of first aid stations on highways and at air-ports. There are 135 of such in operation now.(59) (60)

The doctor has no small part to play in this matter. Every one who is apt to be called in such emergencies should be prepared. It is well to have a light canvas bag containing the splints that will be adaptable to most situations. A Murray splint, a Keller-Blake splint, Pieces of felt, Four 4 inch bandages, a foot rest, six towels, twelve towel clips and some sort of material for traction is a small out-lay from the stand-point of cost and yet will be sufficient for most situations. (56)

DIAGNOSIS.

When the patient is received at a suitable place for treatment, as complete and thorough an examination as is possible without additional injury should be made. Simple inspection will first reveal any gross deformty such as an abnormal position of rotation, flexion or extension. Often shortening is noted. The site of the skin injury is often a clue as to the type and location of the fracture. In the absence of deformity one is justified in running a finger-tip moderately firmly over the superficial portion of the bone until a spot is found

where the patient winces and involuntarily withdraws his limb. This generally marks the site of a fracture. (27) It is usually not necessary to move the extremity in an attempt to secure crepitus with the resultant pain and possible further injury. Measurement of the length of the two extremities from fixed landmarks serves as a valuable means of determining the existence of fracture or dislocation and the extent of the injury. One should never forget to look for fracture or injury in all parts of the body. It is especially important to check for loss of movements of a hand or foot which might indicate injury to nerve or tendon. A good history from the patent or an observer is valuable in the diagnosis. One can learn of the loss of function. A description of the nature of the accident may help to locate the fracture site and to estimate the degree of comminution of fragments to be expected. (32)

The x-ray examination, carefully done and on the basis of the preceding examination and history will complete the diagnosis and serve as a guide to the treatment. (35)

THE COMPOUND INJURY.

The wound is received at the hospital covered with a sterile or antiseptic dressing. While a sterile dressing is held over the wound, all dirt is removed from the adjacent skin with ether and the area is shaved, working always away from the wound. This area can then be cleaned further with soap

followed by ether and alcohol. It is then painted with the antiseptic solution of choice, tincture of iodine, tincture of merthiolate, etc.

A general anesthetic is now given and debridement is done. All traumatized muscle and fascia should be cut away until bleeding occurs. A careful inspection for the presence of severed nerves or tendons is made. All bleeders are tied. Some men use anesthetic ether in the wound, while others simply irrigate the wound with large amounts of warm, normal saline solution. If there is considerable injury the wound is left open. Carrol-Dakin treatment is used by some men but many others believe that the good initial cleaning and the irrigation with a considerable amount of warm, normal saline removes most of the infective material and that the resistive forces of the body will serve to cope with the remaining infection. Large and infected wounds should be left open with adequate drains until time is given for any infection to have made its appearance. Any evidence of infection such as swelling, redness and heat with an increased temperature and increased white count should demand opening and free drainage of the wound. (63) (24) (75) (28)

Tetanus and gas-bacillus anti-toxin, after an intradermal test for sensitization, should be administered early in all compound fractures. In most cases it should be repeated on the 4th or 5th day. (24)

OPEN VERSUS CLOSED TREATMENT

The decision between the open and the closed method of treatment of a particular fracture frequently must be made. There are some fractures which can be treated successively by either method and there are a few which can be treated only by the method of open reduction. Conwell, (17) states that in his work in the clinic of the Tennesee Railroad, Iron And Coal Company, necessity for open reduction is seen in from 3 to 5 percent of the cases. He emphasizes that if open reduction can be prevented the convalescent period is lessened, earlier repair is promoted and better functional results follow in the majority of cases. Speed,(74) says,''Though reduction may not be anatomically perfect, it is in a large majority of instances serviceable and leads to a happy final result.''

He believes that epiphyseal separation on account of growth requires perfect reduction.

The Fracture Committee of the American College ofSurgeons for 1931 of which C.L. Scudder, (79) is chairman presents the following as regards indications for the operative treatment:

> Operative treatment is indicated when a satisfactory reduction cannot be obtained and maintained by the non-operative means, provided there are no contraindications, and when the expected results of the open method is sufficiently better than that of the closed method to justify the additional risk. The operative method is recommended to those surgeons who have had special training and experience, who have the necessary skill and judgment and who have the hospital facilities and surgical armimentarium with which to do this work properly.

Ashhurst, (40) points out that in cases of joint fracture accurate anatomical reposition of fragments is quite essential for the establishment of good function and fractures near joints or into them are more often indications for open operation. He finds that in children there is more apt to be over-growth and excessive lengthening as a result of injury sustained in operation. He summarizes: '' In fractures of the shafts of the long bones it is sufficient to secure bony union without axial deviation and without appreciable shortening. The limits are much wider in adults.''

Scudder,(69) gives the following list of fractures which he believes are generally to be treated by operation:

(1). Most fractures of the joints with displacement of the fragments.

(2). Fracture of the tuberosity of the humerus.

(3). Fracture of the surgical neck of the head of the humerus with displacement of the head of the bone.

(4). Displaced condyles of the humerus not capable of being held by acute flexion.

(5). Fracture of the olecranon.

(6). Certain elbow fractures in adults.

(7). Certain metacarpal fractures.

(8). Certain carpal fractures.

(9). Certain fractures of the head and neck of the radius.

(10). Fractures of the radius with considerable deflection of the fragments toward the ulnar side.

(11). Ir-reducable fractures of the shaft of the femur.

(12). A displaced femoral condyle.

(13). Fractures of the patella.

(14). Certain spiral fractures of the bones of the leg.

(15). Certain meta-tarsal fractures.

(16). Certain fractures of the os calcis.

If one treated all of the above conditions by operative methods, he would probably have a higher percentage of operative cases than that of Conwell. This only serves to show that there is much variation of opinion as regards the matter.

In summary of the literature on the matter it appears that open operation in the hands of the average practitioner is dangerous. The chances for such results as infection with subsequent osteomyelitis, deformity, loss of time and money to say nothing of suffering, to the patient are considerable. Systemic disease, physical condition and extreme age should be considered. The nonoperative methods should be employed where ever it is possible.

REDUCTION

Kellog Speed defines reduction as the replacement of the displaced fragments into a position which favors prompt bony union and return of function.(73) There are a few fractures in which no particular reduction is needed. Fractures of the ribs, scapulae and skull (without depression) are among these.

The first essential in a successful reduction is that it be done early. There is little spasm and contracture of muscle that opposes reduction. Pain is lessened by the elimination of the sharp bone edges causing spasm of muscles. Ashhurst, (4) says: ''Water which is agitated constantly will not freeze.'' He thus condemns fepeated attempts at reduction in favor of early successful reduction.

Proper relaxation of the muscles is a second essential in reduction. Conway,(16) used local anesthesia in 1885. Bohler, (10) used it extensively and now it has been adopted widely. It is especially valuable in conditions where a general anesthetic would be dangerous, as in senility, cardiac cases, renal hypertension or with pulmonary lesions. Amounts up to 50 cc of 1 or 2 percent novacain are injected through sterile areas of the skin and into the hematoma about the fracture. Anesthesia results in from 3 to 5 minutes lasting 1 1/2 to 2 hours. Care must be taken not to introduce a quantity of solution sufficient to increase the pressure in the area of the fracture to one's disadvantage in the reduction. (73)

A general or spinal anesthetic is to be preferred in a good many cases and has the advantage of complete relaxation. Intravenous anesthesia is used more recently. It lasts long enough for short procedures and gives very good anesthesia.(29)

X-ray films are essential in the reduction of most fractures. (71) Adequate films must be made and in both planes. The interpretation of the films demands some experience in most

cases. One must be careful to include the whole field involved. In fractures in and about the epiphyses in children and adolescents one must bear in mind the time of union of these growth centers. Films should serve as a guide in the reduction and should be repeated to serve as a check of the reduction.

Direct flouroscopic visualization is becoming a part of the reduction of fractures, but few general practitioners have the equipment and training necessary to use it. There is considerable danger of over exposure to the operator, especially where continuous visualization is used during the reduction. Some men feel that it is better to use it just to check the progress at intervals and conducting the reduction in the light room. (32)(34)

Lucas Championiere, (62) reduced fractures by a method of gentle massage and mobilization. The principle of his method was to secure relaxation of the muscles by the long, continued gentle massage and then th reduce the fracture by gentle manipulations. Mennel, (69) in London is a more recent advocate of this method. Scudder, (69) in evaluating this method concludes that it is a time consuming method and in the hands of a few men particularly trained in its use it is very successful.

The simplest means of reduction is that of manual manipulation consisting of direct pressure over the fragments, traction, rotation and angulation. The ordinary reduction of a

Colles fracture of the wrist is typical of this. It is applicable to a good many fractures. Considerable advantage is gained by the adjustment of the posture of the extremity or of the body. Thus compression fractures of the bodies of the spinal vertebrae are reduced by hyper-extension of the back. Fractures of the distal third of the radius in which the pronator quadratus is pronating the distal fragment are easier reduced by placing the forearm in full pronation. One thereby avoids the opposition of the muscle by placing the member in a position in which the muscle can no longer oppose beyond its limit of contraction. Magnusson, (46) evaluates manual reduction of fractures in the following:

> The manual reduction of fractures in most cases is ill advised because the strength of the muscles attached around the fracture is greater than the force which the operator can apply with his manipulation. The operator's muscles tire and pass form tonic to clonic contraction. Jerky motion will irritate the tissues about the fracture and cause reflex spasm of the muscles.which further interferes with the proper reduction. Any effort of reduction should be steady, strong and prolonged to the point where the patient's muscles are tired and relaxed sufficiently to permit the fragments to be brought into alignment and this can be done only by mechanical means which relieves the surgeon of a strain and frees his hands to manipulate the fragments until the ends can be approximated and forced into contact.-- In every fracture provisions should be made for applying slow, steady and prolonged traction.

Immediate traction secured by mechanical means and combined with manipulation is often used. A block and pulley may be rigged up to increase ones force on an extremity. Some operators use a heavy loop bandage around their shoulder and

fixed to the extremity thus leaving the hands free for the manipulations. There are a number of fracture tables such as the Hawley table, (34) so constructed that they give support to the body, afford counter-traction, are easily adjusted and do not obstruct the activity of the operator. There are arms for the application of screw traction with the extremity fixed in immobile counter-traction. Improvements of this type of table include direct flouroscopic control during the manipulations incorporated in the table.(85)

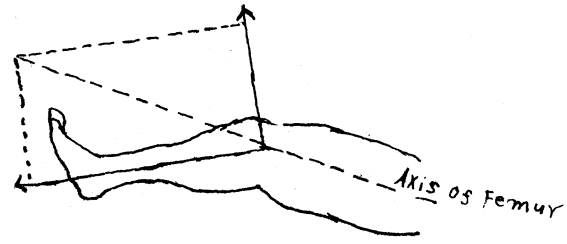
Prolonged traction as a means of reduction in its simplest form is seen in a method of reduction of which dislocation of the shoulder will serve as an example. The patient is placed on two tables such that the injured arm hangs down between them. The arm is allowed to hang until the muscles tire and eventually relax. The addition of a small amount of weight to the arm will often be necessary to secure adequate relaxation. The dislocation may then be reduced with ease. Buck's extension, (73) is widely used to secure prolonged traction. It consists of the application of wide strips of adhesive moleskin to each side of the extremity and with spiral turns of adhesive around this . A heavy sash cord attached to these strips passes over a pulley and is attached to a moderate amount of weight for continuous traction. The weight of the body may serve for counter-traction often aided by the tipping of the bed but it is probably better to secure counter-traction by means of a sheet around the body or through the groin and

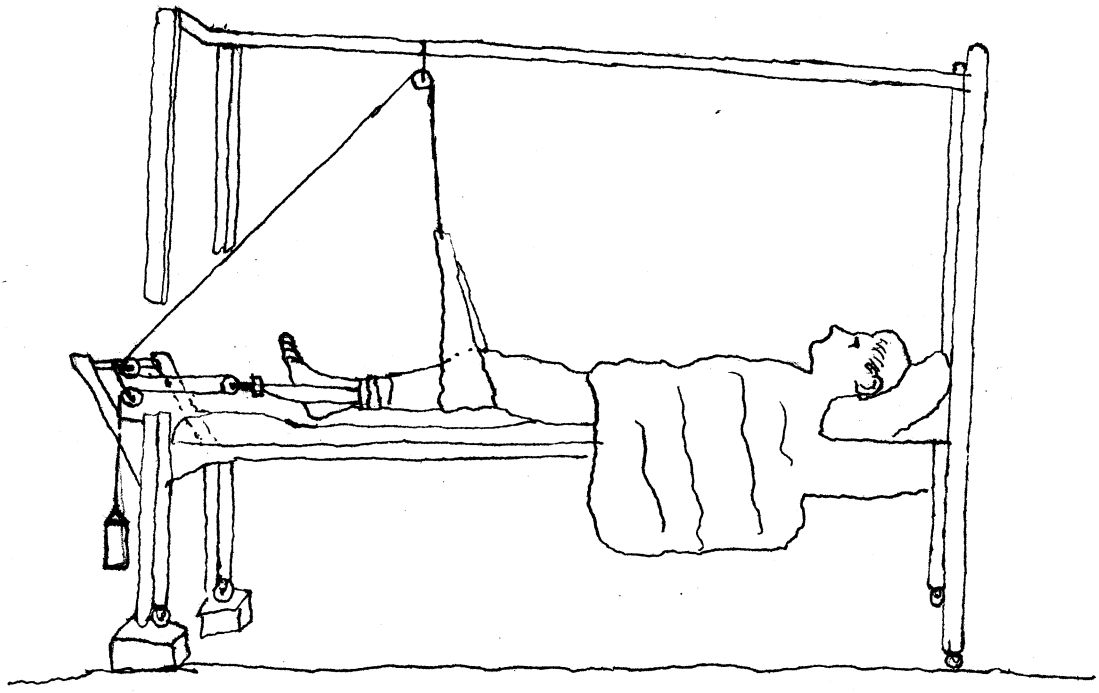
fixed to some solid support. Buck's extension applied alone has its objections. It is not a constant controlled amount of pull since the patient is not very well immobilized and the amount of friction between the limb and the bed clothes opposing the traction will vary. Lateral movement and rotation of the limb are not prevented. There is very little to prevent sagging at the site of the fracture.

The Thomas splint is used for traction in various ways. It may serve with Buck's extension merely to suspend the limb and prevent mobilization and sagging of the fragments. It may be supported by a weight and pulley device or it may be propped up on the bed. This splint may be applied as described under the emergency treatment, with the traction on the end of the splint and applied to the limb with Buck's extension tightened with a windlass or with weight, cord and pulley. Counter-traction is obtained in this set-up by the apposition of the ring of the splint against the tuberosity of the ischium. The splint may be supported by suspension or be propped up with pillows. Sometimes the Thomas splint is applied with Buck's extension from the distal end but with weight and pulley traction on the end of the splint and with no counter-traction against the body. Other men instead of applying weight traction to the end of the splint will fix the end of the splint to some solid support and then by tipping the bed such that the weight of the body slides back towards the head of the bed, secure traction of the splint. (73)

The Hodgen splint is made of large gauge heavy wire and is quite similar in principle to the Thomas splint except that it has no provision for counter-traction against the body. Its principle use is for the suspension of the limb with Buck's extension -- the body weight acting as counter-traction.

R.H. Russel,of65) of Melbourne Australia devised a method of traction for fractures particularly of the middle and lower thirds of the femur without the use of a splint. I have diagrammed it below.





RUSSEL EXTENSION (65)

It is claimed for this apparatus that the sum total of the two tractive forces, applied one above and one below the knee, is equivalent to the application of traction in direct line with the true axis of the femur. It probably prevents sagging at the point of fracture by virtue of the upper traction attachment.

The problem of the application of traction to an extremity is of considerable importance. Adhesive tape is widely used but it has its objections. Sinclair, (84) (45) has devised a method in which an encasement of a particular mixture of glue is allowed to harden on the lower part of the foot and extension is taken from this. Direct skeletal traction has many uses. The Kirshner wire (64), the Steinman pin and other devices such as ice-tong callipers, etc; are used.

Adhesive traction is applicable to more fractures than any other type of traction. Most men prefer to use it when ever it is possible. The Fracture Committee of the American College of Surgeons, 1931 (28) recommend that multiple adhesive straps be applied extending the full length of the extremity and be covered with a bandage firmly applied to prevent slipping of the straps and to insure close co-aptation to the skin. Adhesive traction is particularly to be preferred during the growing periods in which skeletal traction would injure the growth centers of the bones. In fractures of the femur in the adult it is often not possible to apply enough traction by adhesive over long enough time to give complete reduction. Likewise it is apt to be insufficient in the lower two thirds

of the tibia.(37) In cases with considerable abrasion to the skin and injury to the soft tissues skeletal traction is indicated because of lack of sufficient traction area for contact. Murray, (52) states that in his experience adhesive traction requires about twice as much weight as does the skeletal traction to pull the same amount on the bone.

Skeletal traction is gaining an accepted place in the treatment of certain fractures and every man who proposes to handle fractures should probably be prepared to use it. Scudder, (60) states that it as a safe and efficient method of applying traction. Conwell, (17) says,''Skeletal traction is not a panacea for the treatment of all fractures,''. He cites the disadvantages of an increased possibility of infection, danger of foreign bodies in the medullary canal and a greater danger of over-extension.with delayed union or non-union.

There are certain situations which may arise in the use of suspension traction devices which should be considered.

> (1). Over-pull caused by too much traction weight usually can be avoided by careful and frequent examination of the apparatus in the first few hours. It usually occurs early and it cannot be corrected by simple diminution of the amount of traction. Callus formation is delayed with resultant increased healing time and in a few cases operative procedure is necessary before union is secured. (8)

(2). Angulation of the distal fragment is rarely seen in cases where the traction is properly applied. Poor position in the suspension splint may cause this. The pin or wire through the distal fragment may be on a twist and so arranged as to pull the fragment out of alignment.

(3). Insufficient traction is perhaps the commonest mistake in the suspension traction treatment. The strength of the muscles of each patient must be considered as well as the amount of weakening as a result of the injury. One must be sure that the weight on the cord is effective and that the knot is not against the pulley. Adhesive traction should begin well above the fracture site in most cases. X-ray check-ups early will guide one in determining the effectiveness of the traction.

(4). An insufficient period of traction may result in the breaking up of the weak callus formation on release of the traction. It should be continued until there is clinical or x-ray evidence that union is sufficient to prevent slipping. There can be no fixed rule for every fracture because there is a difference in the nature as well as the amount of injury to the bone. (8)

IMMOBILIZATION OF FRACTURES

Traction suspension is also a means of immobilization. And so most of the methods described under reduction are also means of immobilization. It has certain advantages overthe plaster encasement methods. Physio-therapy in the form of massage and heat can be applied early and continued over the period of the immobilization. Compound injury, and surface wounds can be readily taken care of and watched in the open splint. This method has the disadvantage that it requires that the patient be kept in bed, usually in a hospital where the apparatus can be closely watched. This proves to be too expensive to be practical in many cases which can be treated satisfactorily by ambulatory methods.

Wood has been used for splinting in fractures for as long as we have any record of fracture treatment.(page 3) It still has many valuable usesthough many men feel that the plaster moulded splints are better and simpler to make. Certainly wooden splints may be carried and fixed on in situations where plaster is not available. Many maleable iron splints and aluminum splints are on the market. These can be readily moulded into varying shapes and as adapted to certain locations are valueable splinting materials. Simple bandaging if properly done serves for a few types of fracture as in certain fractured clavicles. (73)

Plaster of Paris has many varied uses in the immobilization of fractures. Moulded plaster splints are commonly used especially for fractures of the fore-arm. They are made by apply-

ing wet plaster bandages over the limb forming a shell and then allowing the mass to set. They are made as posterior, anterior and lateral splints. These are then bound to the limb when they are dry. They can be readily loosened or removed when pressure signs appear. Plaster encasements are applied by circular bandages and with some bandages length-wise over the limb. These were popularized by Bohler and in his hands were very successful. (10) There is considerable danger of swelling and edema if the encasement is applied too early. Small abrasions if covered by the cast may become infected and lead to gangrene without being noticed.

There are many modifications of the application of plaster chief of which is the ambulatory use. Bohler, (10) first developed this use. It consists essentially of a plaster encasement of the entire leg which gains support against the tuberosity of the ischium and being padded at that point. An iron stirrup is incorporated into the distal end which extends about an inch below the foot. The patient is up and about in from a few days to a few weeks after the application depending on the severity of the fracture and the caution of the man directing the work. Pridie, (61) of the Royal British Infirmary in London, lists these precautions in the use of these ambulatory plaster splints:

(1). The injured leg should be elevated when ever possible and not allowed to hang down and cause swelling.
(2). The injured leg is to be used as much as possible. The patient should walk a mile daily at the end of the first week. (I am sure that many workers with fractures

would be more conservative than this). If an arm is in the plaster the fingers should be kept moving. (3). If the plaster becomes tight it should be reported immediately.

Conwell, (17) is not so enthusiastic about early weight bearing in ambulatory splints. He recommends it only in certain fractures about the ankle with no displacement. He says, ''Pain will usually curb the patient in too much exercise encouraged by over enthusiastic doctors.''.

Patients treated with the ambulatory splints require much less care on the part of the doctor. They need not stay in the hospital and only need to report at frequent intervals. Often they can continue with their work. The movement in the cast is believed to take the place of physio-therapy.

The peg-leg cast consists of the incorporation of a wooden support in the cast which serves for walking. The leg is fixed in an abduction position and the peg-leg is fixed on the inner aspect of the plaster cast and extends to the floor. It is used for immobilization of the hip especially where abduction is desired. (85)

The Hoke traction plaster apparatus was first used by Hoke in 1914 but was first described by Thornton, (81). The principle as applied to the upper extremity is that traction is applied on the distal fragment with counter-traction applied to the side of the body. It consists of a plaster of Paris arm spica, (A plaster encasement around the waist and including the arm.)

with a ratchet windlass attached to the arm part such that adhesive or skeletal traction may be made on the distal fragment.

Kirshner's wires may be used in combination with plaster encasements in many fractures where danger of displacement is great. The part is held by pulley weight traction while the plaster is being fixed and hardened.

Bailey, (5) describes a modification of the method described above which is applicable to certain fractures as in the lower third of the tibia. A Kirshner wire is introduced into each of the fragments. Each wire is fixed in a device in the nature of a stirrup so arranged that a turn-buckle is inserted between the proximal and distal stirrups on each side of the leg. Traction is then made with the turn-buckles pushing the two stirrups apart until the fragments are in good position. Then the area is encased in a plaster cast fixing the wires solidly. When dry, the turn-buckles are removed and the wires thus fixed in the plaster remain to hold the parts in reduction.

PHYSIO-THERAPY IN FRACTURE TREATMENT

This adjunct to the treatment of fractures consists of two parts. There is the treatment that can be given early and the treatment that is instituted late.

Lucas Championiere, (62) was the first exponent of early physio-therapy. He developed the practice of light massage and

the application of heat even before reduction and in fact as a part of the reduction. Murray, (53) says that light massage and heat are of value only as they serve to relax muscular and vascular spasm and thus help to clear up congestion and to improve circulation to the part. They must be given only to the point of securing a pleasurable sensation and stopped when any discomfort is noted. Heat is applied in many forms such as the ultra-violet light, quartz lights, heating pads or simple hot soaked pads and baths. The patient must be drafted in to carry out his own physio-therapy in many cases. This is best done when open splints are used. He can be instructed to apply light massage several times a day. With plaster arm casts the uncovered fingers must be exercised continually to preserve the circulation.

In the late stage, the post reduction stage, physio-therapy must serve to eliminate the pathology before it can organize into scar tissue with anklosis and before the muscles atrophy from dis-use. Heat and massage are here valuable as before. More important is the re-establishment of active motion. Active motion by the patient is far more valueable than passive motion.but often passive motion only is possible at first. The muscles must be initiated passively first. Pulley devices which permit the patient to move his leg with his hands are used. Electrical stimulation is believed by some men to have a place in initiating the muscles which will not respond by voluntary control. The 'Smart' machine is a high frequency Faradic current so adjusted as to obtain muscle contraction without pain. (18) (82) (19)

THE MEDICAL TREATMENT OF FRACTURES

Ordinarily little attention is given to this aspect of fracture treatment and perhaps with good justification. Most persons who sustain fractures are in good health and little attention is needed to the medical treatment. But there are number of conditions which may be present in addition to the fracture and which should receive attention. Important among these are the following:

(1). Focal infection which may serve as a source for setting up osteomyelitis in weakened tissue ath the site of the fracture must be considered.

(2). Diabetes has an unfavorable influence on the progress of all infections. Poor circulation associated so often with the diabetes of elderly patients greatly retards the healing of fractures and predisposes to gangrene.

(3). Syphilus as it effects the bone may be responsible for poor healing and as it effects the nervous system it may give trouble in maintaining muscular movement of the fractured extremity.

(4). Endocrine disturbances with particular reference to the parathyroid glands and calcium metabolism may be a factor in poor callus formation.

(5). Arterio-sclerosis by the lessened blood supply must always be considered as a factor in poor healing.

(6). Anemia due to excess hemmorhage or any of the special types must be considered and greatly alter the prognosis as to time for healing.

(7). Tuberculosis particularly of the bone must be considered and when present alters the prognosis of any fracture in that area, (31)

The diet during fracture treatment needs no particular attention other than to supply sufficient protein, starches, fat, vitamines, an alkaline ash diet and fluids -- which a good normal diet will contain. Cuthbertson, (21) in a series of animal experiments with fractures produced in these animals used various diets. With diets defecient in all sorts of ways he was unable to show any decrease in the healing time. He found that the engestion of diets very rich in protein and of a high caloricvalue tended to reduce the marked loss of body protein that is normally seen in fracture subjects. Swart, (78) also experimenting with animals in an attempt to show the effects of irradiated ergosterol on the healing of fractures found no decreased time of healing that could be attributed to the lack of irradiated ergosterol in the diet, even in animals made ricketic by this dietary lack.

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