ELEVATION OF BURNED UPPER EXTREMITIES: A COMPARISON OF TWO METHODS

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We hereby recommend that the thesis prepared under our supervision by Adelaida Boothby entitled "Elevation of Upper Extremities: A Comparison of Two Methods"

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CHAPTER I

INTRODUCTION

Thermal injury is one of the most severe forms of trauma which the body can sustain. Burns are unique both in regard to the type and extent of tissue injury as well as skills required for successful management. The significant burn evokes a myriad of system responses; the magnitude of which is determined by the size and extent of the wound itself. Second- and third-degree burns manifest one of the most important of the physiologic responses which is the formation of massive edema.

High priority must be given to the prevention and treatment of the developing postburn edema of the upper extremity. The appropriate way to reduce any residual swelling is to elevate the arms above the level of the heart. Early treatment and comprehensive management of the upper extremity will restore optimal activity as early as possible.

A review of the literature reveals a significant lack of agreement on early postburn management to retard edema of the upper extremity. There are many impressions, but few controlled studies. Although there is a great deal of variance of the techniques used, it is the nurses' responsibility to maintain proper positioning of the burn patient at all times to promote healing and preserve the shape and function of the burn-injured hand. In this study a comparison of the influences of two methods of elevation to reduce edema in the upper extremity was performed.

Statement of the Problem

The problem of this study was to determine the effects of two mechanical methods for facilitating upper extremity elevation for reduction of edema.

Purposes

The purposes of this study were to:

1. Determine the effects of elevation with an expandable flexible material on reduction of edema
2. Determine the effects of elevation with a metal splint on reduction of edema
3. Compare both methods of elevation in relation to reduction of edema

Background and Significance

The hand is involved in a surprisingly high percentage of thermal injuries. Burns of the upper extremity are common because of their exposed position and because the hands are used to combat the fire. The importance of the hands to all activities make it necessary to include proper care in overall patient management. Time is a most important factor in treatment. Immediately after receiving thermal injury there is a production of edema, a transudate which produces a serofibrinous deposit on all deep structure. This is the enemy of normal function and eventually results in ankylosis of the joints and inhibition of the normal sliding of tendons (Kiehm 1959).

The volume and rate at which edema develops in the resuscitated patient appears to be proportional to the severity of the injury. In this aspect of the inflammatory reaction that follows a burn, there is an increased abnormal capillary permeability. Interstitial fluid is thus increased. The colloidal osmotic pressure differences between the capillary plasma and tissue fluid is diminished. In addition, intracapillary pressure and tissue pressure rises. As tissue pressure rises, venous return from the distal extremity decreases. When tissue pressure exceeds venous pressure, venous return is completely obstructed. This usually occurs at the level of the wrist in the arm and lower calf in the leg (Moylan, Inge, and Pruitt 1971).

Depth of burn is an extremely important factor that affects the volume as well as the composition of fluid losses from the circulation. In the first-degree burn, vasodilation is the only major change that occurs. Protein losses are insignificant and edema is barely perceptible. A second-degree burn is characterized not only by more severe capillary damage but also by damage involving a greater depth of tissue. The extensive fluid loss caused by a third-degree burn appears to be due to the injury of a large amount of tissue beneath and surrounding the area of full thickness skin destruction (Artz and Moncrief 1969).

The rate of edema formation and the volume present at any one time depend upon the time since injury, the area burned as well as the temperature and duration of the burn itself. The location of the injury is of some importance when the fluid losses are considered in burns of the same extent and depth. Burns of highly vascularized areas are generally believed to cause greater losses of fluid than comparable burns in other locations.

The losses are incurred most rapidly in the early period after burning. The rate of edema formation and fluid losses decline forty-eight hours after the injury at which time edema is maximal.

Swelling or edema affects the degree to which recovery of function in the burn hand can be expected.

Postburn edema of the upper extremity may cause severe functional and rehabilitation problems.

The swollen limb makes movement difficult and painful. The patient voluntarily immobilized his hand in a comfortable, nonfunctional position that produces venous and lymphatic stasis and more edema. The results of edema in the upper extremity include periarticular fibrosis, ankylosed joints, and tendon adhesions that necessitate future reconstructive surgery (Salisbury, Loveless, Silverstein, Wilmore, Moylan, and Pruitt 1973). Rarely is a full range of motion or even normal function restored to a hand that is severely or even moderately burned (Boswick 1970).

The greater the extent of a burn on the hand the more likely it is that there will be significant loss of function and anatomical deformities. This is especially true of burns that extend over the metacarpophalangeal and interphalangeal joints and burns that involve both sides of the hand (Boswick 1970).

Understanding the factors that are most likely to contribute to loss of function and deformities, it is imperative that comprehensive management of the burned hand be planned to restore optimal activity as soon as possible. To date, there is no method of therapy for upper extremity edema. Some authors recommended both passive and active motion of the burned hand immediately after the injury, preferably prior to maximal edema formation. Boswick (1970) stated that the motion prevents the sticking of tendons in the protein rich edema fluid of a burned hand. If motion is started early in the postburn period, the fluid will probably not accumulate to the degree that it would have if the hand were not moved. Gronley and Yeakel (1962) also advocated active exercise and the maintenance of the hand in the position of function in the period immediately after burning. Kruse (1960) recommended elevation and immobilization of the arm and a compression dressing for several days postburn. Most of the authors believed that elevation of the burned upper extremity is mandatory to hasten resolution of edema. Grand and Drummon (1964) believed that the arm should be maintained in elevation by suspension rather than by resting on an elevated support with the forearm extended well above and lightly secured to the elevation post. After conducting a series of studies, Moylan and his colleagues (1971) believed that active motion with elevation, if used early in selected cases, appears to relieve venous obstruction and maintain arterial flow, thus reducing the detrimental results caused by circulatory insufficiency associated with tissue edema.

The purpose of this study was to evaluate the influence of a new type of elevation device for burned upper extremity. This therapy consisted of a metal splint in which the arm is suspended and at the same time can be moved in a horizontal and vertical position varying the degree of elevation and position considered appropriate to each individual.

Hypothesis

For the purpose of this study, the following hypothesis was proposed:

There is no significant difference in reduction of edema between the elevation of burn upper extremity with a metal splint and expandable flexible material.

Definition of Terms

The following definition of terms were selected for this study.

1. Burn--the destruction of tissue due to any thermal, chemical, or electrical injury

2. First-degree burn--part or all of the epidermis has been destroyed

3. Second-degree burn--superficial and deep partial thickness; epidermis and part of the dermis are affected; the area is red or pink and usually with blister formation

4. Third-degree burn--full thickness; all the dermis is destroyed; the wound appears dry and may be pearly white or charred

5. Symmetrical burns--burns covering proportionally the same areas in the body; on both arms

6. Edema--a condition in which the body tissues contain an excessive amount of tissue fluid

7. Metal splint--metal bar forming a gutter where the arm is suspended for the purpose of elevation and motion

8. Expandable flexible material--Surgiflex

Limitations

The recognized limitations of this study were:

1. Patients did not have burns of the same magnitude

2. Mixed second- and third-degree burns could be present in the same upper extremity

3. Vascular circulatory dynamics varies with age

Delimitations

The following delimitations were established:

1. The population consisted of fifteen patients above eighteen years of age

2. Burn patients studied had second- and third-degree injury covering 60 percent or more of the total arm surface area

3. Patients included had received the established admission cleansing and debridement procedure

4. Patients were limited to those whose management required elevation of upper extremities for an average time of forty-eight to seventy-two hours

5. Patients were limited to those sustaining thermal and chemical burns

6. Patients with escharotomies were not included in the study

Assumptions

The following assumptions were made for this study:

1. Edema is an inevitable consequence of thermal injury

2. Elevation of the burned extremity for the reduction of edema formation is a commonly accepted medical practice

Summary

Burns of the hand are among the most difficult and frustrating problems that the burn team encounters. The various methods used in the management of burned upper extremities are difficult to evaluate because a great deal of variability exists. Furthermore, the motivation and biological background of the patient are likewise variable. This study was a controlled clinical experiment in reduction of edema resulting in improvement in the management of burn upper extremities.

Chapter II presents a review of the literature concerning epidemiology and a historical perspective of management of burns. Types of thermal injuries and the resulting abnormal vascular dynamics is summarized in this chapter. In addition, available information is presented on edema of the upper extremity and its resulting derangement. The procedure for the collection and treatment of data is presented in Chapter III. Chapter IV contains an analysis of data and findings. Chapter V presents a summary, recommendations, implications, and conclusions regarding the findings of the study along with suggestions for future studies.

CHAPTER II

REVIEW OF LITERATURE

Thermal injury is devastating not only in terms of required medical treatment but also from the socioeconomic point of view. Esthetic disfigurement and functional disability frequently results in the prolonged inability of an individual to return either to his family or to his previous occupation.

Thermal burns of the upper extremity may result in great disability and economic disaster for the victim. Even when limited in extent, severe functional disability may make job retraining or even make job performance impossible.

With the exception of burns to the cornea resulting in loss of visual acuity, burns of the hands result in the most incapacitating injury seen today (Brown 1973). The functional limitation of a burned upper limb is determined by the severity of the thermal injury. Infection, pressure necrosis, prolonged edema, and poor positioning may increase the patient's difficulty. Therefore, in the treatment of burns of the upper extremity, the principles of wound care including preservation of tissue, prevention of infection, maintenance of function and wound closure, must be observed throughout the course of hospitalization from the day of injury until final healing. The problems of rehabilitating and returning this patient to work can be overwhelming. To gain perspective, the following overview will include the incidence and morbidity of thermal injury.

Epidemiology and General Considerations

Incidence

Burns of the upper extremity are the most common site of injuries associated with thermal trauma. Seventy-five percent of the patients admitted to the Brooke Army Medical Center had associated burns of the hands (Brown 1973). During a one-year period, data from 119 hospitals participating in the Consumer Product Safety Commission's national electronic injury surveillance system revealed that of 11,759 burn injuries treated at those hospitals, 4,513 (38 percent) involved the upper extremity. Those sustaining the greatest number of upper extremity burns among those 4,513 patients were young adults and young children who use their hands in work activities and in the exploration of their environment. The most common cause of upper extremity burns in these 4,513 patients was contact with flame or a hot surface. The home was the most common environment for upper extremity injuries in all age groups, but above the age of fourteen, occupational and highway injuries became relatively more common (Salisbury 1976).

Burns of the hands are likely to occur because of their exposed position and as a result of utilizing them as protective mechanism in an attempt to cover the face or eyes or in an effort to extinguish a flame elsewhere on the body. Large numbers of casualties suggest that young adults and children who use their hands in work activities and in the exploration of their environment are more susceptible to hand burns.

Burns of the dorsum of the hand and wrist fingers are seen most frequently. Palmar burns occur less frequently and result primarily from electricity, chemicals, or direct contact with a hot object (Tanigawa 1974).

Optimal care of the patient with a burned upper extremity demands the expert attention of the entire team. A review of the history of the management of thermal injury will help to place in proper perspective some of the current modalities of therapy as well as importance of care.

Historical Perspectives

During the past decades emphasis has been placed on the general care of the patient, but relatively little attention has been given to the special problems of specific anatomic areas such as the upper extremity. Current philosophies of management of burns of the upper extremity are varied and many are controversial. Today the controversy over appropriate local burn wound management continues. Some authors prefer to treat upper extremities conservatively while others advocate early excision.

Local Burn Wound Management

The history of burn management describes many strange and valueless materials that have been applied to the burn wound. Hippocrates in 430 B.C. mentioned the use of bandages impregnated with old hog's lard (seam) for burns (Monafo 1971). He also used warm vinegar soaked dressings to relieve pain and later described the use of solutions of old bark for local treatment. Rhazes and Avicenna, relating ninth- and tenth-century Arabic writings recommended the use of refrigerants locally, which correlated with modern practice of cooling for alleviation of burn pain (Salisbury 1976).

Interest in burns increased in the thirteenth and fourteenth centuries following the discovery of the gunpowder. The first book devoted entirely to burns was written by William Clowes, an English military surgeon in 1591 (Monafo 1971).

Different substances were continuously tried on burns. Oils and waxes have been placed on burns since the days of the Roman Empire. Lister in 1875, advised boric lint and Carbolic acid. Tannic acid was used for the purpose of coagulating the wounds as early as 1858. Some years elapsed with modes of therapy that did not receive widespread recognition. Lisfrenc in 1935 recommended wet dressings containing sodium, calcium, and chloride (Salisbury 1976). In the early 1940's Osborn, Bunyan, and Hannay of Britain proposed the envelope method of treating thermal injuries of the upper extremities, utilizing rubber-coated silk fabric in a closed system with three to four irrigations per day, and achieved acceptable results (Salisbury 1976). This mode of therapy did not receive widespread recognition.

The exposure treatment of burns was first used by Copeland in 1877 (Salisbury 1976). In 1905 Sneve adopted the exposure treatment of burns, and did much that is in accord with present-day concepts. Sneve treated a granulating wound gently, with saline compresses, and avoided the cytotoxic effects of strong antiseptics mortality favorable even by modern standards (Monafo 1971).

In 1942, Koch and Allen advocated and popularized the use of Vaseline gauze, bulky dressings and immobilization of the extremity (Artz and Moncrief 1969). This technique of local care remained as the accepted approach until Wallace in 1949 reintroduced the exposure method in Great Britain. In America, Blocker reinitiated open-air therapy in 1951 (Salisbury 1976). Cannon and Zuideme, however, contended in 1959 that hand burns should not be exposed and that dressings should be left in place for five to seven days.

The discovery and availability of the sulfonamides, and penicillin, and in rapid succession after World War II, numerous other antimicrobial agents, led to extensive clinical trials in burns. The introduction in the mid-1960's of a series of new topical agents for extensive burn wound resulted in a decrease in mortality and morbidity of the thermally-injured patient. Mafenide, silver nitrate, and silver sulfadiazine are some of the topical agents used in the current therapy. The controversy over appropriate local burn wound management continues between the open treatment with Sulfamylon or silver sulfadiazine versus bulky dressings soaked in silver nitrate. Localized upper extremity burns have been treated successfully with the closed technique but upper extremity burns in patients who have sustained major thermal injury generally have been treated with the exposure technique because occlusive dressings therapy may promote burn would infection and conversion of partial thickness injury (Salisbury 1976).

Excision

Primary excision is a controversial topic in the management of the burn wound. Early excision was first recorded by Silnes in 1901, and subsequently by many others throughout the century (Salisbury 1976). In 1945, McCorckle recommended excision on the seventh postburn day and immediate grafting (Salisbury 1976). He excised localized hand burns in fifty-eight patients and obtained excellent results. In 1950, Ross advised early excision of isolated burns of the hands (Ross 1950). McDowell in 1953 proposed excision and grafting of only small, circumscribed burns (Salisbury 1976). He outlined problems of early excision which still exist today, judging the correct depth of the burn wound and achieving wound coverage. Moncrief in 1958 studied early excision in twenty-seven patients. He excised the burn wound one to seven days postinjury and grafted in two to fourteen days with satisfactory results. Moncrief, Switzer, and Ross in 1964 reported sixty patients in whom primary excision was performed. They concluded that primary excision was advantageous when performed in carefully selected patients. Primary excision remains controversial today, with proponents of early excision treating localized thermal injuries of the upper extremities operatively, whereas surgeons managing major thermal injuries tend to treat burns of the upper extremities more conservatively.

Skin Grafts

The successful return of function after thermal injury of the upper extremity is directly related to the development of skin grafting technique. Tilemake Caste in India have the early record of skin grafting (Salisbury 1976). Subsequently others demonstrated the techniques of utilizing the graft of skin.

The modern era of skin grafting began with the Swiss Surgeon, Reverdin in 1869 when he demonstrated the use of pinch autografts (Salisbury 1976). Around 1929, split thickness skin graft became popular and has remained as a method of treatment facilitated by the use of dermatomes.

With the development of dermatomes and the use of topical antibiotics, the modern trend has been toward rapid coverage of full thickness upper extremity burns. Split thickness skin graft is used to facilitate early mobilization and avoid contracture.

Management of the Edematous Burn Upper Extremity

Edema has long been recognized as an important phenomenon in thermal inflammation. Early mobilization depends on reduction of edema. Cope and More were among the first to demonstrate an increase in vascular permeability by determining radioactive colloid in the lymph from a burn leg and Sevitt showed extravasation of protein found by introducing Evan's blue into the wound shortly after burning (Foley 1970).

Throughout the years various modalities have been used to prevent the formation of edema. Back in 1799, Sir James Earle emphasized the use of crushed ice and water for the initial local treatment of burns, suggesting that cooling was a good analgesic and a method that prevented local edema and the formation of blisters (Salisbury 1976). In the 1940's, Harvey Allen advocated the "pressure" dressing as a method for prevention of wound edema (Salisbury 1976). Pressure dressings continued in usage but at present they do not have widespread recognition in the 70's. Moberg (1950) advocated constant elevation and splinting of the burn upper extremity to minimize wound edema.

To date, there is no method of therapy that has been accepted and established as the best type of therapy for upper extremity edema. Kruse (1960) advised elevation and immobilization of the arms and a compression dressing for several days. Authors like Boswick (1970) and Gronley and Yeakel (1972) recommended both passive and active motion of the burned hand immediately after the burn injury, preferably prior to maximal edema formation. Elevation of the upper extremity seems to be preferred by most of the members of the burn team.

Splinting

No historical perspective of burn management of the upper extremity could be complete without discussion on the topic of splinting. In 1607, Fabricus Heldanus described splinting techniques. He published a book entitled De Combustionibus in which he illustrated burn contractures and the splint used for correction of deformities. J. W. Turner in 1836 in Edinburgh mentioned the "position of function" that must be maintained for the most useful motion. Other authors as Bunner and Kock re-emphasized the importance of splinting in reconstruction of the hand and described the benefits of constant and prolonged tension on scar tissue in improving function of the hand (Salisbury 1976).

Mason in 1947 introduced the "universal splint" for immobilization of the hand in the position of function, and this is still the most widely used splint today (Salisbury 1976). Rush (1952) suggested internal fixation of phalanges to hasten healing and improve function. Gerdman in 1954 discussed the problems of prolonged immobilization of the hand and its disastrous effects on function. He emphasized early active exercise of the burned extremity. The techniques have been developed to what is most widely used today; splinting in the position of function with active mobilization as soon as possible following the injury.

Types of Thermal Injuries

Cutaneous Burns

Many of the pathologic systemic effects that can be demonstrated with thermal injury depend on the extent and type of the burn. The extent of the burn wound is expressed as percent body surface area involved and is vital information in evaluating severity of injury. The type of burn designates the anatomical level of the injury and is termed first-, second- or third-degree burn.

First-degree burns are superficial injuries involving only the epidermis and are characterized by pain and hyperemia with or without edema after approximately twelve hours or so (Monafo 1971). Second-degree burns extend through the epidermis into the underlying corium. They result from scale or flash burns, are intensely painful to pinprick and sensitive to air movement. The underlying dermis may vary in color from red to pale ivory. Blisters are produced containing a serous fluid. Spontaneous healing occurs provided no complications convert the injury to third-degree lesion. Third-degree lesion extends through and destroys all dermal elements. The skin is cold, hard, leathery, and insensitive. Capillary filling of the thrombosed vasculature is absent. Thrombosed subcutaneous vessels are sometimes visible. Coagulation necrosis of the skin produces a dry, leathery inelastic surface called an eschar.

In both second- and third-degree burns, there is a massive outpouring of protein rich fluid in addition to severe translocations in the distributions of water and solute. Every burn is followed by a period of reactive edema which compromises the circulation, the effects being particularly deleterious in the extremities.

Translocation of Fluids

The vascular system is profoundly affected by thermal trauma. The dramatic changes in circulatory dynamic begin in the immediate postburn period and are related to fluid volume and electrolyte changes. There is marked reduction in circulatory volume that is proportional to the extent and depth of the injury. Utilizing serial measurements of functional extracellular volume and blood volumes in primate flame burns, Baxter (1974) found that the rate of loss of extracellular fluid was surprisingly fast. A reduction of 38 to 50 percent in the functional extracellular fluid volume occurred within the first eighteen hours postburn.

Increased vascular permeability in the immediate burn area and to a lesser extent in the rest of the body produces a decline in intravascular volume. In subsequent experiments Baxter (1974) demonstrated that replacement of the lost volume with isotonic crystalloid fluid during the first twenty-four hours postburn restored the functional extracellular fluid deficit to within 10 percent of the control volumes and no further loss of the functional extracellular fluid volume occurred. The serum sodium concentration remained normal while plasma osmolality decreased only slightly (Stone 1971). Concurrently the concentration of sodium in burn edema fluid was found to be consistently in parallel with the plasma toxicity of administered fluids of different osmolality. These findings strongly suggested that burn edema is essentially isotonic with respect to serum sodium concentration. The studies of Baxter, Fox, and Lasker and Monafo (Jelenko 1975) demonstrated that the ratio of sodium to potassium in plasma fluid in the blisters and translocated fluid in burn tissue is like the ratio in normal plasma. Electrophoretic analysis of burn edema fluid showed that the protein concentration of edema fluid is a mirror image of the plasma containing proportionately as much globulin as albumin. Measurements of the fluid contained in the blisters formed in the burn area show that the protein concentration in the bullae can be as high as 4 to 6 grams per 100 milliliters. This amount of fluid and protein loss occurs immediately and also recurs as the fluid seeps. Fluids can be seen seeping through denuded collagen on the wound surface after the blisters are trimmed away, but most of the fluids are sequestered in the tissues beneath and around the wound. Monafo (1971) demonstrated in several studies that the majority of the fluid is sequestered locally and not lost in the environment. Baxter (1974) showed in several experiments that in the latter phase of burn edema accumulation, the majority of the sequestered nonfunctional edema fluid is contained deeper in the tissues.

Edema Resulting from Abnormal Capillary Dynamics

This fluid escaping from the capillaries and accumulating in the extracellular space produce the characteristic burn edema. Edema is a term applied to an excessive accumulation of fluids in the tissue spaces, and is due to a disturbance in the mechanisms of fluid interchange. Instead of there being a perfect balance between the inward and outward flow of fluid through the capillary membrane, there is a continuous translocation of fluids that will tend to increase the volume of interstitial fluid. The rapid early phase of edema formation is readily explained by the accompanying vascular damage and cellular injury extending to the depth of the tissue damaged by the thermal insult. The initial loss of vascular integrity is, however, replaced by microthrombosis within a few hours.

Explanation for the second phase of edema formation includes the denaturization of collagen which results in increased affinity for both sodium and water (Baxter 1974). Edema in surrounding tissues is assumed to result from the release of histamine, bradykinin, and other biogenic amines released from the injured tissue.

An additional factor which may play a role in the extensiveness of the edema is the high concentration of polymerized molecules of fibrinogen forming a gel-like edema which occludes both lymphatics and venules draining the damaged area.

The amount of fluids in the interstitial spaces depends upon the capillary pressure, the interstitial fluid pressure, the oncotic pressure, the permeability of the capillaries, the number of active capillaries, the lymph flow, and the total extracellular fluid volume (Guyton 1976). Change in any of these parameters leads to changes in the volume of interstitial fluid.

Obviously any factor that increases the interstitial fluid pressure may be high enough to cause excess interstitial fluid volume thereby causing edema. Knowledge of the pressures existing within tissues helps to understand edema formation and fluid exchange.

In several experiments Guyton (1976) demonstrated the relationship between pressure and volume in the interstitial fluid spaces in the human body. The pressure volume curve of the interstitial spaces explains conditions under which edema develops. One of the most significant features of the curve is that so long as the interstitial fluid pressure remains in the negative range, there is little change in interstitial fluid volume despite marked change in pressure. Edema will not occur so long as the interstitial fluid pressure remains negative. In several hundred measurements of interstitial fluid pressure in experimental animals, no edema was recorded in the presence of negative interstitial pressure. The pressure volume curve demonstrated that whenever the interstitial fluid pressure rises above the surrounding atmospheric pressure, the tissue spaces begin to swell. Therefore, the physical cause of edema is positive pressure in the interstitial fluid spaces (Guyton 1976).

Abnormalities in capillary and interstitial fluid dynamics can increase the tissue pressure and, in turn, cause extracellular fluid edema. Some of these derangements such as increased mean capillary pressure and decreased plasma colloid osmotic pressure are manifested in thermal injury.

From experiments with cat-hind paw, Arturson (1974) demonstrated several factors that lead to the formation of edema after thermal injury. These factors are vasodilation with increased transcapillary filtration pressure, increased microvascular permeability and increased extra-vascular osmotic activity. Vasodilation with decreased peripheral resistance is evident when arteriolar dilation occurs in areas of the body, causing the blood to flow rapidly through the locally dilated arterioles. These changes result in increased capillary pressure with increased transcapillary filtration pressure. Therefore, local edema results. Abnormal dynamics occur at the capillary membrane when the skin is extensively burned. Albumin is often lost from the plasma in large quantities and the quantity of plasma protein falls to abnormally low values. The major effect is markedly lowered colloid osmotic pressure. Consequently the capillary pressure far overbalances the colloid osmotic pressure, increasing the tendency for fluid to leave the capillaries and enter the tissue spaces. As a result, fluid collects in the tissue spaces, and the interstitial fluid pressure rises (Guyton 1976). In Arturson's experiments, the increased micro-vascular permeability with leakage of plasma proteins and increased transcapillary sieving of macromolecules was evident. The membrane becomes so permeable that protein molecules pass from the plasma into the interstitial spaces. The protein content of the plasma decreases while that of the interstitial spaces increase. If the damaged area is of sufficient size the permeability of the capillaries is observed also in the non-burned areas, therefore, an extensive burn can cause dramatic changes in the whole body.

Albumin is often lost from the plasma in large quantities when the skin is extensively burned. Arturson and Guyton (1974) implied that an additional complication is edema through the body because of lower colloid osmotic pressure. Consequently, the capillary pressure far overbalances the colloid osmotic pressure, increasing the tendency for fluid to leave the capillaries and enter the tissue spaces, and the interstitial fluid pressure rises. As long as the pressure remains excessively elevated, the tissue spaces continually enlarge, with the edema becoming progressively worse.

In addition to the physiological response causing the edema in thermal injury, the replacement therapy with large amounts of fluid required is an important factor contributing to the development of edema.

Edema in the Upper Extremity

Burn injuries of the hand involve a series of local pathophysiologic reactions, similar to those occurring throughout the body. From the preceding discussions of capillary and interstitial fluid dynamics, it is evident that several different abnormalities in these dynamics can increase the tissue pressure and, in turn, cause extracellular fluid edema. The most significant causes of extracellular fluid edema are increased capillary pressure, decreased plasma proteins, and increased capillary permeability.

When the mean capillary pressure first becomes abnormally high, more fluid flows out of the capillary than returns into the capillary, and, therefore, collects in the tissue spaces until the interstitial fluid pressure rises high enough to balance the excessive capillary pressure. If the pressure is above atmospheric pressure, the tissue spaces progressively enlarge with tremendous expansion of the extracellular fluid volume.

When capillary pressure increases, blood flows rapidly through the locally dilated arterioles. This abnormality occurs at the capillary membrane when the capillary pressure far overbalances the colloid osmotic pressure increasing the tendency for fluid to leave the capillaries and enter the tissue spaces (Guyton 1976). As long as the pressure remains excessively elevated, the tissue spaces and the interstitial fluid pressure rises.

Another abnormality occurring at the same time as changes in capillary pressure are developing is a markedly lowered colloid osmotic pressure of the plasma. The quantity of plasma proteins falls to abnormally low values. This abnormality affects the capillary membrane and adds to severity of edema formation.

The capillary membrane becomes so permeable that even protein molecules pass from the plasma into the interstitial spaces with ease. The protein content of the plasma decreases while that of the interstitial spaces increases (Guyton 1976). The tissue pressure rises in order to balance the changes in plasma and tissue colloid osmotic pressure occasioned by the breakage of protein. The elevated interstitial fluid pressure, in turn, causes progressive edema. The sequence of events after thermal injury are loss of capillary integrity, edema, and increase in intravascular pressure, resulting in impaired venous return, increased capillary pressure and further edema--a vicious cycle that leads to ischemia (Salisbury 1974).

Ischemic Necrosis

Although edema formation is inherent in thermal injuries, it should not be allowed to persist. The circulation in the extremities is profoundly affected. Vasoactive amines are liberated from the injured tissue and the capillary permeability is altered. This is followed by a period of edema which comprises the circulation of the extremity. There is a decrease in blood flow to the deep structures of the hand which results in ischemic necrosis of the intrinsic muscles.

Most of the interossei are in confined spaces bordered by the metacarpals medially and laterally and enveloped by fascia anteriorly and posteriorly. The arterial supply to the interossei may be extremely variable. The common volar digital arteries arising from the superficial volar arch and the volar metacarpal arteries from the deep palmar arch usually supply the intrinsic muscles and anastamose to form digital arteries. Coleman and Anson found that 60 percent of the metacarpal arteries in 650 hands terminated in the metacarpophalangeal joint. Since the volar metacarpal arteries which provide the predominant blood supply to the first and second interspaces may be end arteries, the muscles at this site are particularly at risk (Salisbury 1974). There is possible destruction of intrinsic muscles caused by ischemia. The ischemic necrosis of the muscle may result in persisting joint stiffness and contractures in surviving patients if this vascular compromise is not diagnosed in the early postburn period.

The diagnosis of early ischemia of the upper extremity is customarily made on the basis of (1) pain, (2) paresthesia, (3) paralysis, (4) absence of pulse, and (5) cyanosis with impaired capillary filling. Unfortunately, the presence of any of these signs may be masked in a burn patient with upper extremity involvement. After deep thermal injury, the skin is characteristically anesthetic and voluntary motion of the involved joints is painful.

Moreover, motion may be limited by the presence of massive edema.

The hand is generally grossly edematous and held in a relative intrinsic minus position characterized by extension of the metacarpophalangeal extension and flexion of the interphalangeal joints. There is moderate pain at rest which might also be due to thermal injury of the skin. Whenever the patient complains of such pain not relieved by analgesic, it can be immediately assumed that reactive edema producing constriction is the cause of the pain. Edematous fingers are likewise a clear signal that the circulation to the extremity is embarrassed even if the patient has no complaint of pain. Extreme diagnostic significance is the marked increase in pain when any of the involved intrinsic muscles are placed under stretch. This may be elicited by moving the finger from side to side while keeping the metacarpophalangeal joint at zero degree extension and the proximal interphalangeal joint in flexion. If this maneuver causes a marked increase in pain, it is termed a positive stretch test and is diagnostically significant (Bunnell 1973).

Ischemia of the involved intrinsics will eventually result in paralysis, but it is important to note that this is generally a late development in the ischemic process.

This generally coincides with a decrease in pain in the muscle and carries with it a poor prognosis as it generally indicates the onset of irreversible changes within the muscle.

Paresthesia over the median and ulnar nerve distribution in the hand are significant in that they give evidence of markedly increased intracompartmental pressures in the deeper self-contained compartments of the hand and wrist. The presence of this manifestation is considered indicative of the need for escharotomy.

Once the diagnosis of impending ischemic contracture is made, the treatment must be aimed at breaking the cycle of worsening ischemia. One can see how the cycle is initiated by the burn which causes massive swelling and edema. This edema causes increases in pressure in the subcutaneous and intracompartmental spaces to compress and collapse the thin walled veins and lymphatics and blocks the normal drainage pathways from the hand. The edema and interstitial pressure within the hand continue to build and may eventually cause arterial occlusion which is thought to be compounded by partial or complete obstruction of the collateral circulation secondary to reflex spasm (Storck 1976). The resultant ischemia then leads directly to muscle infarction and necrosis releasing significant amounts of myoglobin and potassium adding a potential for injury to an already taxed cardiorenal area. In addition, the increased pressure not only affects the vascular supply but also the nerves innervating the muscles and the muscle is subjected to the simultaneous double insult of ischemia and denervation.

Fibrotic Reaction of Edema

The protein-rich fluids escape from the vascular compartment and penetrate all structures of the hand. Edema fluid becomes localized in various fascial spaces and periarticular locations in the hand and may subsequently become organized by a fiberoptic reaction (Brown 1973). The edematous state is followed by excessive fibrous protein synthesis. The protein-rich fluid can be invaded by fibroblasts, become collagenous tissue, and form motion limiting adhesions. Important elastic tissues, delicate tendon sheaths, broad expanses of fascial coverings, and tough joint capsules become incarcerated in an unyielding fibrous tissue (Whitson 1971). Watson-Jones spoke of persistent edema as "physiologic glue" (Moultonk 1973). He was referring to the fibrosis of ligaments and joint capsules and consequent loss of joint mobility which follows persistent edema.

Changes Resulting from Prolonged Edema

The persistently edematous hand becomes the "frozen hand" (Whitson 1971). The position assumed by an acutely burned hand is fairly characteristic and consistent. The wrist is maintained in flexion while the metacarpophalangeal joints are hyperextended. The extent of flexion of proximal interphalangeal and distal interphalangeal joints is variable. This position apparently promotes the best relief of pain. However, prolonged immobilization of the hand in the comfort position will invariably lead to typical clawing of the hand.

Depending on the position in which the hand is maintained after injury, the effects of edema may be horrendous. With regard to this subject, the work of Peacock (1970) showed that the protein-rich edema fluid forms secondary to both transudation and direct capillary damage due to the inflammatory response evoked and is ultimately contributed to by bacterial infection. He postulated that this edema fluid becomes bound to deep connective tissue around the joints, around or in inter-osseous muscles, and in various planes of the hand. This binding implies that edema cannot be dispersed mechanically or by gravity. He assumed that continuous interphalangeal joint motion is essential to avoid stiffness secondary to the organization of this bound edema and consequent deep fibrosis in the planes of the hand. Whitson, Brown, and Peacock agree that it is essential not to immobilize the edematous hand any longer than is absolutely necessary. Adequate motion and elevation facilitate drainage and minimize the amount of induration and fibrosis of many of the intrinsic muscles of the hand.

Whitson and Allen (1971) advocated that early active motion and continuous elevation enable wound edema to subside by the fifth to seventh postburn day. Persistent edema beyond this period is secondary to prolonged dependency of the extremity, inadequate motion,or improper escharotomy. Treatment must be aimed to reduce the cycle of ischemia initiated by the edema leading to eventual muscle necrosis, fibrosis, and contracture.

Assessment of the Hand

The upper extremity is a very complex and versatile organ. The movements of the hand and arm are made to serve our social and economic and physical needs. All such movements are complex and involve all the muscles and joints of the hand, forearm, and upper arm.

To understand damage and adequate treatment, a basic knowledge of the normal hand is necessary. The primary role of the entire upper limb, shoulder, arm, elbow, forearm, is to place the hand in its proper position of function.

The term hand will include not only the carpal and metacarpal area but the thumb and four fingers as well. The hand is considered to have three surfaces: dorsal--the back of the hand, volar--the front or palmar surface of the hand; and radial side of the second metacarpal (Moultonk 1973).

The four fingers are index, long, ring, and little fingers. The three joints of each finger are referred to as MP (metacarpophalangeal), PIP (proximal interphalangeal), and distal interphalangeal. The joints between the head of the metacarpal and the base of the proximal phalanx allow flexion, extension, abduction, adduction, and a certain amount of rotation. The prime importance of the movements of the hand, however, is that they constitute the precision adjustment mechanism of the upper extremity in contrast with the coarse adjustment mechanism of the rest of the upper limb (Riodan 1974).

The basic functions of the hand which permit the executions of movements necessary for the individual to maintain independence in meeting the daily needs of life are helpful to be considered. Such functions are (1) precision grip (mainly median), (2) power grip (mainly ulnar), (3) percussive motion (as in typing or piano playing), and (4) hook action (for lifting and carrying) (Entin 1968). These fundamental functions require a complex interaction involving contraction and relaxation of intrinsic muscles and extrinsic flexors and extensors of the fingers and wrist.

Any voluntary act represents a combined action of several muscles. Muscles of the hand can be grouped as extrinsic and intrinsic. The muscle bellies of the former are located in the forearm, but their tendons play an important part in movements of the hand.

Muscles

The intrinsic muscles pertain to the muscles that originate within the hand and act upon the digits. These muscles flex the metacarpophalangeal joints and extend the interphalangeal joint and are comprised of the following groups:

1. The thenar group performs thumb function

2. The hypothenar group performs little (fifth finger) function

3. The interossei and lumbricals perform abduction and adduction of the fingers and combine with the extensor tendons for finger extension

Most of the intrinsic muscles originate from the metacarpals and are strongly sheathed. They are open to two hazards: fibrillar necrosis from unrelieved inner pressure and denervation caused by lethal pressure on the two nerves of motor supply (Grant 1974). All extrinsic muscles of the hand originate primarily in the forearm and pass over the wrist and carpal bones to insert into the digits.

Full flexion of all the joints is achieved by the extrinsic muscles. Clawing of the hand, flexion of the interphalangeal joints and extension of the metacarpophalangeal joints are exclusively achieved by the extrinsic muscles (Wynn 1973).

Nervous Control

The hand is a most important sensory organ and its skin, particularly on the palmar surface, is richly supplied with all types of sensory receptors. The nerve distribution of the hand is composed of the median, ulnar, and radial nerves. The distribution of these nerves is such that they are subject to frequent injury.

The median nerve passes along the forearm, wrist and enters the palm of the hand where it splits into two branches, the lateral (motor) branch and the sensory branch (Carlett 1971). The function of the median nerve is demonstrated by the impairment that results from a complete median nerve paralysis. The impairment is manifested by inability to oppose the thumb, inability to make a complete fist and atrophy of thenar eminence. When the nerve is interrupted at the wrist, there is weakness in abducting and adducting the fingers. Severance of the ulnar nerve at the elbow causes severe impairment.

The radial nerve enters the forearm just anterior to the lateral epicondyle of the humerus and divides into both a superficial and a deep branch. The superficial branch descends to the wrist and supplies sensation to the dorsum of the hand. The deep branch passes down the forearm as the dorsal interosseous nerve and supplies the extensors of the thumb and the fingers. In the upper arm it supplies the extensor carpi radiales, the triceps and the brachioradialis (Carlett 1971). Complete radial nerve palsy below the triceps motor branch causes (1) wrist drop, (2) inability to extend metacarpophalangeal joints of the fingers, and (3) inability to extend the distal joint of the thumb.

Blood Supply

The main arterial channels of the upper extremity consist of the axillary artery, the brachial, the radial, and the ulnar. The arteries of the limb are accompanied by veins having similar names.

The brachial artery enters the upper arm on the medial side of the humerus and is in close association with the principal nerves of the limb. Immediately distal to the elbow joints, it bifurcates into its terminal branches, the radial artery, and the ulnar artery.

The radial artery runs down the lateral side of the front of the forearm, supplying the muscles along its course. It reaches the wrist at the base of the thumb where its pulsation is readily felt. Leaving the radius, it runs downwards and backwards to the proximal end of the space between the metacarpals and it enters the palm very deeply. It is principally concerned with supplying blood to the thumb and index finger (Basmajian 1970).

The ulnar artery makes its way deeply to the medial side of the front of the forearm. It gradually becomes more superficial at the wrist, the palm and crosses the metacarpals forming the deep volar arch with the radial artery. The digital arteries arise to the index, middle, ring, and little fingers.

The superficial and the deep veins anastamose through the extremity by communicating veins. The superficial veins begin as a dorsal venous arch, on the back of the hand, where they form a pattern that varies from person to person. The deep veins have similar names as the arteries of the limb (Basmajian 1970).

Evaluation of Function

Function of the hand is intricately involved with motion, sensation, strength, edema, and pain. A treatment of patients with hand injuries must include assessment of these factors.

Motion is assessed in two ways: functional motion as evaluated by tasks, and pure motion as evaluated by goniometry. For evaluation of functional motion, the patient is asked to carry out tasks designed for specific purposes. Some of these are tested by asking the patient to pick up and use a pencil, to button a button, and comb his hair. These tests provide a quick functional evaluation. Although they are incomplete, they indicate problems which may require further evaluation (Perry 1974).

Pure motion is assessed by goniometry. Each involved joint is measured, both actively and passively, using a universal goniometer and standard methods of goniometry (Moore 1965). A goniometer is an instrument in the form of a protractor used to test range of movement of flexion and extension in the joints of fingers, wrist, and elbows. A difference in active and passive motion measurements may indicate muscular involvement tendon or interruptions or, possibly, psychological aspects of injury (Perry 1974).

Another major concern is the strength present in the hand. Usually strength of pinch and strength of grip are tested. The next phase of evaluation is a sensory examination. The patient is tested for light touch perception, which appears to be the minimum sensory activity compatible with functional use of the hand. The test for stereognosis is performed by having the patient identify various coins or objects with his eyes closed. Most sensory problems can be evaluated adequately with these tests, but if a question still exists, further testing is done to meet individual needs. The most important goal of every patient is to be able to perform his own activities of daily living.

Management of the Burned Hand

Once homeostasis has been re-established, most of the therapeutic objectives are similar for all burned patients. They are prevention of infection, protection of viable tissue, and preservation of function. However, in the hand epithelialization and contraction usually results in serious functional impairment (Peacock 1970). Therefore, prompt management of the burned hand is necessary for satisfactory functional results.

The most important consideration in the initial physical examination of the upper extremity is diagnosing the presence of vascular insufficiency. Severe constricting edema is characteristic of deep circumferential thermal injury, and if untreated may result in vascular compression and subsequent loss of the extremity. Cold skin and dusky fingertips are imprecise signs of local vascular insufficiency, because these signs can be due to decreased cardiac output. Edema,which can occur even in unburned tissue, is also an unreliable sign of poor peripheral flow.

The presence of radial or ulnar pulses does not guarantee that the burned hand is being adequately perfused, but the absence of deep palmar arch flow does necessitate escharotomy (Salisbury 1976). The ultrasonic flowmeter is a sensitive instrument in detecting peripheral flow and is used when pulses cannot be palpated with the finger or the stethoscope. Extremity pulses are checked hourly over the first forty-eight hours since pulses can be present initially but tend to disappear as resuscitation proceeds and edema increases. If peripheral pulses cease, escharotomy should be performed.

Mahler (1975) advocated that there is a definite indication for escharotomy in deep burns of the hands and fingers even when they are only semi-circumferential. A partially constricting eschar and the edema beneath it are sufficient to compromise vascular supply and lead to ischemia and gangrene. In addition, the venous drainage of the fingers and hand depend largely on the vessels running dorsally along the fingers and the back of the hand. In the deep semicircumferential dorsal hand burns, these vessels may thrombose and thus aggravate the edema caused by the burn (Mahler 1975). Moylan's study (1971) is in contradiction to this. He studied twenty-four patients who had circumferential extremity burns and made correlation of clinical signs and ultrasonic flowmeter measurements. Selected patients with clinical indication for escharotomy, but who had intact distal flow, as determined with the ultrasonic flowmeter, were successfully treated nonoperatively with elevation and exercise with good results. Therefore, he emphasized that if there is adequate flow and the limb is elevated and exercised and close observation done continuously, escharotomy might not be necessary.

Decompressive Escharotomy

Upper extremity escharotomy may be performed at the bedside without anesthesia because bleeding will be minimal and controlled by pressure or a collagen substance (Avatene). The incisions are made only through the eschar which is insensitive to pain. Once the constricting eschar is released, pulses should return immediately if the procedure was successful.

Although conventional escharotomy extending the full extent of the constricting burns may save the limb, this procedure may do little to increase blood flow to the deep structures of the hand. A study at the U.S. Army Institute of Surgical Research (Salisbury 1973) revealed the presence of intrinsic muscle necrosis in 66 percent of the completely burned upper extremities in which escharotomies had been performed, suggesting that conventional escharotomy does not protect the deep structures of the hand from ischemia to decompress the intrinsic muscles. The investing fascia may be incised after making small longitudinal incisions on the forsum of the hand in the first web space and between the metacarpals (Salisbury 1973).

At present the literature reveals a significant lack of agreement on early postburn management of the upper extremity. There are many impressions but few controlled studies. The actual modalities of treatment will be discussed with emphasis on elevation and positioning for reduction of edema.

Modalities of Treatment

There are many acceptable methods of local care of the burn wound including exposure, occlusive dressings, initial excision, and exposure with antibacterial cream. The form of therapy will vary with each patient based on depth and extent of injury, and different areas on the same patient may be managed by various techniques.

Antibacterial Agents

Wound protection may be achieved with topical chemotherapy. Antibacterial agents have produced a significant reduction in the fatal outcome due to burn wound sepsis. The surface of some large burns is literally sterile initially, provided there has been no gross contamination from soil or polluted water (Monafo 1971). Within forty-eight hours, bacterial contaminate the surface and eventually colonize the depths of the eschar. The bacteria population is not erradicated by effective topical therapy, but reduced significantly.

The injured hand should be debrided of all devitalized tissue. Devitalized epithelium and protein exudate are organic waste and serve only as culture media that support bacterial growth. The debrided wounds are washed with water and antibacterial soap and covered with the appropriate topical agents.

Silver sulfadiazine and Sulfamylon burn cream are the most commonly used for wound protection. In addition to their bactericidal or bacteriostatic effect, these topical agents are effective in softening crusts or eschars and allowing more active pain-free motion (Boswick 1974).

Mafenide acetate cream (Sulfamylon) is easy to apply and does not require the application of bulky dressings. Initially, the cream is spread over each patient's burn wound with sterile tongue blades or a gloved hand every twelve hours. Because the burn wound is not covered with bulky dressings, frequent inspection of the wound may be performed. Physical therapy exercises may be performed with the cream in place. The disadvantage of mafenide includes discomfort immediately after application, carbonic anhydrase inhibition, hypersensitivity to the drug, and delayed eschar separation.

At present, the most commonly used topical agent is silver sulfadiazine. It is effective against most gram-positive and gram-negative organisms. Like mafenide acetate, it allows for wound exposure, facilitates physical activity, and does not require bulky dressings for application. However, it is not painful on application, and does not appear to induce carbonic anhydrase inhibition, hypochloremia, hyponatremia, or significant acid base disturbances.

Other chemotherapeutic agents used for wound protection are providone iodine cream (Betadine) and silver nitrate soaks. Betadine ointment is water soluble and nonstaining. It makes the eschar translucent in its appearance, which can help to determine whether the burn is partial thickness or full thickness. It is used prior to tangenital excision because the eschar is hardened and removed easier (Boswick 1974).

Thick bulky dressings are required for the application of silver nitrate soaks. Although silver nitrate is effective against the entire spectrum of organisms, it does not penetrate the burn wound. If the burn wound is heavily colonized, silver nitrate is of questionable value.

Biologic Dressing

After the eschar has separated from the burn wound, either healing or the development of granulation tissue occurs. The granulation will accept a split thickness skin graft. The graft will cover the granulation tissue, restore a barrier against infection, and limit the fluid, protein, and electrolyte losses.

Although the patient's own skin is clearly the best biologic dressing, situations frequently arise in which autografting may be inadvisable. First, the patient may be too sick to tolerate the operation or anesthesia involved. Second, in a patient with large area burns, donor sites may be limited. In massive surgical excisions, the use of "biologic dressings" is often the only possible means of providing temporary skin coverage to the large denuded areas. This temporary coverage is widely used in early coverage of partial thickness which has not been treated surgically. Porcine skin is mostly used for partial thickness coverage. Human cadaver skin (allografts), amniotic membranes, and the heterografts have provided effective substitutes for autograft in protecting the wound from invasive infection and in testing the readiness of the wound for autografting.

Excision

The technique of primary excision and grafting is very important. In localized third-degree and deep-dermal burns of the upper extremity, where functional consideration is of paramount importance, surgical excision may be of particular usefulness (Moncrief 1964). In carrying out the excision several points are well to emphasize which apply specifically to the excision of upper extremity. It is important to preserve as many veins as possible. This is of particular importance on the dorsum of the hand where impaired venous return may result in edema of the fingers. This preserves the perivascular lymphatics upon which adequate drainage of the hand depends. Without adequate drainage persistent edema occurs resulting in extensive fibrosis and limitation of motion even when the skin coverage is attained early (Moncrief 1964). The excision is performed to a depth sufficient to insure removal of all devitalized tissue. The time at which grafting is carried out depends on the general condition of the patient and the surgeon's decision.

Modalities of Therapy for Reduction of Edema

It has been the clinical impression of those charged with the care of the burned patients that persistence of the burn edema is one of the greatest factors which endangers the rapid and complete return of function to the burned hand. Because function of the hand is dependent on good motion and edema is incompatible with good motion, reduction of edema must be a primary goal of treatment. In an effort to substantiate this clinical impression, Moncrief (1964) studied specific patients and demonstrated that when the edema persisted for more than thirty days most of the patients did not recover adequate functioning of their hands. Those who regained full function did so within the first five months postburn.

Although initial edema formation is inherent in thermal injuries, it should not be allowed to persist. At present there is some controversy regarding the best therapy for the reduction of edema.

Elevation of the upper extremity is mandatory to reduce edema. The patient must maintain elevation of the arm above the level of the heart continuously until the phase of reactive edema is past; this period may be several days or longer (Moulton 1973). Salisbury (1973) advocated elevation and immediate mobilization by elevating the arm on pillows and, if necessary, suspended from an IV pole.

A few mechanical elements are worth consideration. Grant and his colleagues (1974) were opposed to the use of a sling where the elbow is flexed past the right angle adding blockage to the already impaired lymphaticovenous return. Heavy compression dressings can only increase the lethal internal pressure--especially if one tight turn is applied at the wrist. According to Grant, elevation of the burned extremity is mandatory, but elevation should be applied through a loose padded stirrup at the elbow, with the forearm extended well above and lightly secured to the elevation post.

Some authors advocated elevation and immobilization of the arm. Robertson (1958) felt that immobilization is desirable during the period of greatest swelling and reaction. He considered early movement harmful since swelling and reaction can increase and may result in increased disability.

Boswick's (1970) idea is in contradiction with Robertson's. He stated that motion prevents the sticking of tendons in the protein edema fluid of a burned hand. If motion is started early in the postburn period, the fluid will probably not accumulate to the degree that it would if the hand were not moved.

Peacock (1970) advocated that if the general condition of the patient is such that four or five days are required to treat more serious complications, edema of the hand can be reduced by applying an occlusive dressing and elevating the entire extremity continuously.

Controlled studies performed by Salisbury (1973) compared exposure with active exercise of the burned hand to closed treatment with a compression dressing for forty-eight hours postburn. The study failed to show any statistical difference in the decrease of edema.

A simple readily available item that can be used to help reduce edema is a surgical glove. Patients at the Hand Rehabilitation Center, University of North Carolina, used this without complication as an effective adjunct to other treatments such as massage, active exercise, or an intermittent compression unit (Perry 1974). A glove one or two sizes smaller than the patient would usually wear should be chosen. After the glove is on, the patient can be given exercises or activities in an elevated position. The surgical glove has proven to be an effective device to help decrease edema in the hand.

Treatment of edema has been approached by Grant (1974) with administration of 10 milligrams of prenisolone orally daily for ten days with no gross side effects. However, the Royal Orthopedic Hospital in Copenhagen regards even this limited use as dangerous. Arturson, Ponten, and Ashley (1973) found that dimethyl sulfoxide (DSMO) was ineffective in controlling edema after acid of an extremity.

Positioning and Splinting

Depending on the position in which the hand is maintained after injury, the effects of edema are horrendous. The acute hand deformities after thermal injury are due to the patient's adopting a posture that affords maximal relief of pain. If the patient is unwilling or unable to maintain his hand in a functional position because of edema and pain, it is placed in a splint to maintain the hand in a specific position. All burned upper extremities are routinely placed in splints at night to keep the wrist in dorsiflexion, fingers in moderate flexion, and thumb in opposition while the patient sleeps (Salisbury 1973).

Poor positioning and persistent edema are two important factors determining the severity of hand deformities. The deformities are hyperextension of the metacarpal phalangeal joints, flexion of the proximal interphalangeal joints, loss of the transverse metacarpal arch, adduction of the thumb, and volar flexion of the wrist. All of these deformities are present shortly after injury (Whitson 1971). These acute deformities represent postural changes. At this time the deformities are transient, for they yield rapidly to corrective measures. However, if left untreated, tested acute deformities will pass into permanent fixed deformities. The permanent deformities involve skin, fascia, ligaments, joint, tendons, and the extensor and lumbrico-interosseous muscle complex (Whitson 1971). The initial transient deformities become permanent. The deformities are preventable. In order to minimize deformity in the burned hand one must avoid the devastating effects of prolonged edema, and poor positioning. Other factors determining the severity of hand deformities are infection and inadequate or delayed skin coverage.

Summary

Thermal burns of the upper extremity, especially at the level of the hand,are very common. They are likely to occur because of their exposed position and as a result of utilizing them as a protective mechanism. Prompt and adequate management of the hand is imperative due to the fact that a normally functioning hand is needed whether in earning a living, practicing a hobby, or allowing independence in daily activities

Management of the burned extremity is affected by different factors. These are (1) depth of burn, (2) extent of burn, (3) location of the injury, (4) associated injuries, and (5) cooperation of the patient. Proper therapeutic methods prevent the development of serious anatomic and functional improvements.

One of the most damaging complications of the burn upper extremity resulting in severe functional and rehabilitation problems is postburn edema. Edema which remains in an injured hand compromises motion by the internal splinting effect of the excess fluid in the fingers. Because function of the hand is dependent on good motion and edema is incompatible with good motion, reduction of edema must be a primary goal of treatment. To control edema and minimize swelling, the arm is kept in an elevated position above the level of the heart with the hand and fingers in a functional position.

In addition to control of edema and position of hands and fingers in functional position, other therapeutic measures are established in order to minimize deformity in the burned hand. These therapeutic measures are early accurate debridement with immediate wound closure and prevention of infection. Although all treatment is directed toward decreasing disability, the methods used to achieve success may differ widely.

Thermal injuries of the hand constitute one of the most difficult problems in management. Caring for the burn hand requires the combined efforts of the surgeon responsible for the total care, the physiatrists, whose early involvement can reduce complications and morbidity, the nurse and therapist whose skills and judgment are essential and who bear the brunt of day-to-day care along with other paramedical personnel.

CHAPTER III

PROCEDURE FOR COLLECTION AND TREATMENT OF DATA

This comparative study (Abdellah 1965) was designed to determine the effects of two mechanical methods for facilitating upper extremity elevation on reduction of edema. For this study two devices were utilized, a metal splint and an expanded flexible material suspended to an I.V. pole.

The study focused on the following purposes:

1. To determine the effects of elevation with an expandable flexible material on reduction of edema
2. To determine the effects of elevation with a metal splint on reduction of edema
3. To compare both methods of elevation in relation to reduction of edema

Included in this chapter is the setting of the study, the sample, and a description of the tool developed. Methods of data collection and the procedure for analysis of the data obtained are also described.

Setting

Data necessary for the purpose of this comparative study were collected in the burn unit of Parkland Memorial Hospital, a county-teaching hospital which serves a major metropolitan area of the Southwest. This institution has a total bed capacity of one thousand beds. The adult burn center has eighteen beds with four of these beds designated for intensive care. Both male and female patients are admitted to this unit.

Prior to introducing the study to the participating thermally-injured patients, permission was obtained from Parkland Memorial Hospital to conduct the study in that institution (appendix A). Permission was also obtained from the University of Texas Health Science Center at Dallas and Texas Woman's University Human Research Committee (appendix B).

Population and Sample

The population selected for this study consisted of burn patients above eighteen years of age who had sustained second- and third-degree injury covering 60 percent or more of the total arm surface area. Patients were limited to those sustaining thermal and chemical burns. Patients with extremity burns who did not require escharotomy and whose management required elevation of upper extremities for a time of forty to seventy-two hours were included in the study.

Fifteen patients met the criteria for the study. Three patients could not be included in the data analysis because sequential measurements were incomplete. The sample consisted of twelve male thermally-injured patients between twenty-five and fifty years of age who had sustained second- and third-degree bilaterally symmetrical burns on the upper extremities. The area burned included hands, forearm, and elbow on 60 percent or more of the total arm surface area. The patients had sustained thermal and chemical injury, the majority of which were burns sustained by gasoline. The patients were in good health prior to admission with no circulatory abnormalities and had received the established admission cleansing and debridement procedures. The average time between burn and admission to the burn unit was eight hours with a range of four to ten hours.

Initially the rationale and the expectations of the project were explained to the patient. In addition, the patient was assured that his name and any identifying information would be confidential. The patient was told that his care would not be influenced by his participation and that he had the right to withdraw from the study at any time. All patients agreed to participate and signed a consent form (appendix C).

Collection of Data

The data were collected over a period of approximately eight months from May, 1977, to December, 1977. Demographic information such as sex, age, diagnosis, and present circumstances were included in the collection. The patient was approached at the time of admission and followed for a period of seventy-two hours.

All burned extremities were cleansed and debrided on admission. Provisional diagnosis was made of second- or third-degree burn; correct depth of the burn was determined later by the patient's hospital course. Initial evaluation of the burned limb included surface temperature, color, capillary flush time, sensation, motor function, and presence of palpable pulses.

A clinical decision concerning the need for escharotomy was made on patients with circumferential extremity burns. In cases of absent palpable pulses, the ultrasonic flowmeter was used to assess circulation in the individual limb. Following evaluation with the flow meter, the burned extremity was subjected to escharotomy or treated with elevation and active exercises performed twice a day and with every dressing change for the first seventy-two hours postburn. Patients with bilaterally symmetrical upper extremity burns who did not require escharotomy were included in the sample for this study.

Description of the Tool

In this study two mechanical methods were utilized and compared. In one method the elevation was implemented through the use of a metal splint designed by the researcher. Foam padding was used to line the entire surface of the splint. This padding facilitated comfort and prevented tissue pressure over bony prominences. The forearm and elbow were extended well above the level of the heart. The level of elevation was controlled by pulling or releasing the string tied to the splint. A drawing of the metal splint is included in appendix D.

The alternative method was the elevation of the arm by a flexible expandable material secured to the I.V. pole, the usual procedure utilized in the burn unit. This material looked like a fish net and adjusted to the size of the extremity. The expandable material was wrapped over the dressing of the burn injury and lightly secured to the extremity with tape. Prior to utilizing any of these methods, evaluation of the burned extremity was performed.

Methods of Data Collection

Following the initial cleansing and evaluation, a series of baseline measurements consisting of the circumferences of the elbow, wrist, palmar crease, and thumb were made. Sterilized unmarked aluminum tapes were used for measurement. From this baseline of admission measurements (range five to ten hours posburn), serial measurements determining the amount of swelling were taken at the same site every twelve hours for the first seventy-two hours. Subjective data were collected regarding position, comfort, and presence of pressure points. While the measurements were taken, the patients were asked about the methods being utilized. This offered a more complete understanding of the functions and advantages and disadvantages of the two methods of elevation.

An attempt was made to collect data on range of motion and function of joints in the hand and arm during the early postburn period. However, due to excessive pain and swelling the measurements could not be performed.

Both methods of mechanical elevation were used in each patient; one limb was elevated on the metal splint and the other elevated with an expandable flexible material suspended to an I.V. pole, the standard method used in the unit. The limbs were chosen by convenience or depending on the situational circumstances. The position of the bed in relation to the mechanical devices around the bed was a factor determining which side was more convenient for the placement of the splint. Each extremity was elevated above the level of the head and dressed in a position for function. The extremities were covered with silver sulfadiazine and wrapped in a soft dressing of fine mesh gauze and Kling. Every twelve hours the dressings were removed and measurements of the circumference of the elbow, wrist, and palmar crease, and phalangeal joints were taken. For a gross overview of changes in joint function as related to edema formation, the patient was asked to perform the following different motions: (1) making a fist, (2) flexion and extension of the elbow, and (3) flexion and extension of the wrist. Range of motion measurements with the goniometer were discontinued after the fourth patient because the presence of extreme edema, pain, and lack of patient cooperation interfered with the procedure.

Throughout the study, clinical signs were determined since these are helpful in evaluation even though it is difficult to determine the circulatory status of an extremity by clinical signs. As stated by Moylan (1971) a hand may be cool and pale due to extreme edema secondary to the burn or inadequate perfusion. To tabulate this clinical information, the following criteria were used: (1) the color of the hands determined as pale, cyanotic, or red; (2) the capillary refill time measured in seconds; (3) the temperature evaluated as warm or cool; (4) palpation of pulses measured as present or absent; and (5) sensation to touch indicated as present or absent.

Treatment of Data

According to the tool developed and kind of data obtained from the study, the Sign Test was the most appropriate method of utilizing the data. It was used to determine if there was a significant difference in amount of edema present between the two methods of elevation.

The Sign Test is the simplest of all nonparametric methods which can be used to test the significance of the difference between two measurements in a paired sample. In this test as is implied by its name, only the sign of the difference between the paired varieties is used (Allder 1972).

Summary

The data for this comparative study were collected from twelve adults with burned upper extremities who were patients in the Adult Burn Unit at Parkland Memorial

Hospital. All the participants gave written consent for their inclusion in the study after verbal explanation of the study was given by the researcher. The method of convenience sampling was utilized in obtaining the population for this study.

In this study two mechanical methods of elevation were utilized and compared, the metal splint and the flexible expandable material. Prior to utilizing any of these methods, evaluation of the burned extremity was performed.

After meeting the criteria for the study, sterilized aluminum tapes were used to measure the circumference of the thumb, palmar crease, wrist, and elbow. Measurements at twelve, twenty-four, thirty-six, forty-eight, and seventy-two hours postburn were taken to determine the formation of edema. Clinical signs including color, temperature, pulse sensation, and hand function were utilized for a gross general evaluation of the extremity. The data were then analyzed utilizing the Sign Test to determine if there was a significant difference in reduction of edema between the two methods of elevation.

CHAPTER IV

ANALYSIS OF DATA

This study was concerned with determining the amount of edema reduction in upper extremities in the early postburn period with two different mechanical methods of elevation, a metal splint and an expandable flexible material suspended from an I.V. pole. Circumferential measurements were made of the fingers, palmar crease, wrist, and elbow. This chapter will be devoted to the analysis and interpretation of the data.

Presentation of Sample

The twelve patients comprising the sample population sustained second- and third-degree thermal or chemical burns on 60 percent or more of both upper extremities. The age distribution of the patients ranged between eighteen and fifty-five years of age. All of the patients had a history of good health prior to the accident and followed a normal course of hospitalization. Wound healing progressed without abnormal significant change.

Patients with bilaterally symmetrical burned upper extremities were selected. All surfaces of the burned extremities were cleansed and loose tissue was removed on admission. Initial evaluation of the burned limb was performed and the injury was provisionally assessed as second- or third-degree burn. Six patients had second-degree burns and six patients had mixed second- and third-degree burns.

The sample for this study was selected using the convenience sampling technique (Abdellah 1965). Upper extremity elevation was accomplished in one arm, the splint, and in the second arm by the alternate method, the flexible material. The position of the bed in relation to the mechanical devices around the bed was a factor determining which side was more convenient for the placement of the splint.

The twelve patients studied were all male between eighteen and fifty-five years of age. The greatest percentage of patients sustained the injury in an accident involving gasoline. Provisional diagnosis was made for second- or third-degree burn. Correct depth of the burn was determined later in the patient's hospital course. In these patients with upper extremity burns, an average of 60 percent of the arm surface was burned. Twenty-four burned upper extremities were studied in twelve patients. Table 1 presents demographic information concerning the burn injury.

TABLE 1

INITIAL EVALUATION OF THE PATIENT'S BURN INJURY

Patient	Age	Type of Burn	Percent TBSA Burn	Depth Second	Depth Third
1	45	Car explosion	44	x	x
2	38	House fire	37	x	x
3	27	Carburetor	30	x	
4	40	Cleaning with gasoline	25	x	x
5	53	House fire	51	x	x
6	42	Car explosion	32	x	x
7	46	Kerosene	28	x	
9	55	Carburetor	26	x	
10	18	Gasoline	45	x	x
11	24	Explosion--paints	33	x	
12	35	Acid	22	x	

The burned patient was initially assessed at the time of admission to the burn unit and before either method of elevation was employed. The average time between burn and admission to the hospital was eight hours with a range of six to ten hours. Initial evaluation of the burned limb included surface temperature, color, capillary flush, time, sensation, motor function, and presence of palpable radial pulses. After assessing these parameters, a decision concerning the need for elevation or escharotomy was made.

The color of the hands was determined as pale, cyanotic, or red. In eleven patients the skin appeared mottled red or pink with painful skin surfaces. Temperature to touch in all instances was subnormal. Each patient's hands and arms felt cool to touch. The capillary flush time was greater than five seconds in all but four extremities. Motor function was evaluated by the patient's ability to make a fist and to flex and extend fingers and elbows. These capabilities were present in eight patients. In four patients motor function was limited due to swelling and pain. Sensation to touch utilizing light touch was absent in three limbs.

Palpation of pulses was variable. The ultrasonic flowmeter was used to verify adequate flow. Table 2 presents the criteria utilized in the initial assessment of the burned limb.

Analysis of Clinical Data

The hypothesis formulated for the purposes of this study was that there would be no difference in reduction of edema between the elevation of burned upper extremities with a metal splint and an expandable flexible material. Statistical analysis was utilized in the following four

TABLE 2

INITIAL CLINICAL ASSESSMENT OF BURNED UPPER EXTREMITIES

Patient	Color			Temperature	Capillary Flush Time	Motor Function		Sensation	Pain
	Pale	Cyanotic	Red	Cool	>5 seconds	Make Fist	Flexion Extension		
1			X	X	X	0	0	X	X
2		X		X	X	X	X	O	X
3			X	X		X	X	X	X
4			X	X	X	O	O	X	O
5			X	X	X	X	X	O	X
6			X	X	X	X	X	O	X
7			X	X		X	X	X	X
8			X	X		X	X	X	X
9			X	X	X	X	X	X	X
10			X	X	X	O	O	X	X
11			X	X		O	O	X	X
12			X	X	X	X	X	X	X

Key: X = Present

O = Absent

parameters: (1) the thumb, (2) palmar crease, (3) wrist, and (4) elbow.

The Sign Test was used to determine if there was a significant difference in amount of edema present between the two methods of elevation. In this test as is implied by its name, only the sign of the difference between the paired variates is used (Allder 1972).

In the paired samples the measurements of the designated areas were expressed in centimeters. Measurements at twelve, twenty-four, thirty-six, forty-eight, and seventy-two hours utilizing the net and the splint are given in table forms. To determine the change of edema formation the measurements at twelve-hour intervals are subtracted.

A difference is obtained for the splint (x) and the net (y). The actual difference between the measurements is not utilized in the Sign Test; only the direction or sign of each difference is tabulated. The direction is recorded utilizing plus, zero, or minus. The number of minus signs are counted. A difference of zero is disregarded from the analysis, so N is defined as the number of differences having a sign. The probability is calculated by means of a table corresponding to the Sign Test.

Thumb

Utilizing the Sign Test for measurements of the thumb, no significant difference is seen in circumferential measurements between the two methods. The period of time from twelve hours to twenty-four hours postburn shows a consistency in sign direction. Ten differences are negative and one positive and the zero is disregarded. With N = 11 the P-value for the Sign Test is .001 (table 3). Although the period of time from baseline, twelve hours postburn to twenty-four hours postburn shows a consistency in sign direction with a level of probability of .001, further calculations of changes in circumferential measurements at twenty-four to thirty-six hours and forty-eight to seventy-two hours reveal P-values of .984 and .773, respectively, for the significance of the difference.

At thirty-six to forty-eight hours, the Sign Test was noninformative since the differences in measurement between the two methods was too small to be well within the margin of clinical measurement (differences of zero in the Sign Test are noninformative).

In the period of time from forty-eight to seventy-two hours postburn, there is no consistency in sign direction. There are four plus signs and seven negative signs, and the zero is disregarded. With N = 11 the

TABLE 3

GAIN IN CIRCUMFERENCE OF THE THUMB FROM TWELVE TO TWENTY-FOUR HOURS

Patient	12 Hours		24 Hours		x	y	Sign of x - y
	Splint	Net	Splint	Net	Splint	Net	
1	7.6	7.2	7.6	8.0	0	0.8	-
2	8.2	7.9	7.9	8.0	-0.3	0.1	-
3	7.7	7.8	7.7	7.8	0	0	0
4	8.0	7.8	8.4	9.7	0.4	1.9	-
5	6.6	6.2	6.6	7.0	0	0.8	-
6	7.2	6.8	6.9	6.8	-0.3	0	+
7	6.7	6.7	6.7	6.8	0	0.1	-
8	7.0	6.8	7.4	8.7	0.4	1.9	-
9	7.6	7.2	7.6	8.0	0	0.8	-
10	8.0	7.8	8.4	9.7	0.4	1.9	-
11	7.0	6.8	7.4	8.7	0.4	1.9	-
12	6.6	6.2	6.6	7.0	0	0.8	-

P-value .001.

P-Value for the Sign Test is .773. No significant difference is seen in this value (table 4).

Palmar Crease

Utilizing the Sign Test for measurements of the palmar crease, no significant difference is seen in

TABLE 4

GAIN IN CIRCUMFERENCE OF THE THUMB FROM FORTY-EIGHT TO SEVENTY-TWO HOURS

Patient	48 Hours		72 Hours		x	y	Sign of
	Splint	Net	Splint	Net	Splint	Net	x - y
1	7.4	8.0	7.6	8.3	0.2	0.3	-
2	8.3	8.2	8.0	7.8	-0.3	-0.4	+
3	7.6	7.7	7.1	7.5	-0.5	-0.2	-
4	8.3	8.1	8.0	7.7	-0.3	-0.4	+
5	6.4	7.9	6.6	7.3	-0.2	0.3	-
6	7.3	7.2	7.0	6.8	-0.3	-0.4	+
7	6.6	6.7	6.1	6.2	-0.5	-0.5	0
8	7.3	8.0	7.3	7.9	0	-0.1	+
9	7.6	8.0	7.6	8.3	0.2	0.3	-
10	8.3	8.1	8.0	7.7	0.3	0.4	+
11	7.3	8.0	7.3	7.9	-	-0.1	+
12	6.4	7.0	6.6	7.1	0.2	-0.1	+

P-value .773.

circumferential measurements between the two methods. No consistency in sign is seen and the levels of probability for twenty-four, thirty-six, forty-eight, and seventy-two hours are .637, .363, .001, and .254. It should be noted that at forty-eight hours, the value .001 is statistically significant.

The circumferential measurements of the palmar crease at twelve hours interval for the first seventy-two hours of the initial postburn period are presented in tables. In the period of time from twelve to twenty-four hours postburn, a sample of twelve differences is found (N = 12), where four are positive and eight are negative. There is no consistency in sign direction. The P-value for the Sign Test is .637, thus there is no significant difference between the two methods (table 5).

In the time interval from twenty-four to thirty-six hours postburn a sample of eleven differences (N = 11) is found. Three are positive and eight are negative. The case where the sign equals zero is disregarded from the analysis. The P-value is tabulated with a result of .363, which shows no significant difference between the two methods of evaluation (table 6).

In the period of time from thirty-six to forty-eight hours postburn a sample of differences (N = 12) is found, where all are negative. A consistency in sign direction is observed. The P-value for the Sign Test is .001. These forty-eight hour measurements are statistically significant but when compared to the individual measurements of the specific areas of the thumb, wrist, and elbow, it is not statistically significant. Clinical significance cannot

TABLE 5

GAIN IN CIRCUMFERENCE OF THE PALMAR CREASE FROM TWELVE TO TWENTY-FOUR HOURS

Patient	12 Hours		24 Hours		x	y	Sign of x - y
	Splint	Net	Splint	Net	Splint	Net	
1	23.2	24.5	24.3	24.8	1.1	0.3	+
2	24.6	24.5	24.6	25.5	0	1.0	-
3	20.5	21.4	25.0	26.4	4.5	5.0	-
4	23.5	22.5	23	23.7	-0.5	1.2	-
5	23.5	23.4	23	23.8	-0.5	0.4	-
6	21.4	23.6	24.5	0.1	0.1	3.1	-
7	22.5	21.5	24.0	24.3	1.5	2.8	-
8	23.5	22.5	22	21.7	-1.5	-0.8	-
9	24.3	25.5	24.3	24.8	0	-0.7	+
10	25.6	26	24	24	-1.6	-2.3	+
11	23.5	23.4	23	21.7	-0.5	-1.7	+
12	22.5	21.5	23.3	23.8	0.8	2.3	-

P-value .637.

be determined and it can only be suggested that some potential patient benefit might occur (table 7).

Wrist

In measurements of the wrist, no significant difference is seen in circumferential measurements between

TABLE 6

GAIN IN CIRCUMFERENCE OF THE PALMAR CREASE FROM TWENTY-FOUR TO THIRTY-SIX HOURS

Patient	24 Hours		36 Hours		x	y	Sign of x - y
	Splint	Net	Splint	Net	Splint	Net	
1	24.3	24.8	24.1	26.3	-0.2	1.5	-
2	24.6	25.8	26.5	26	1.9	0.2	+
3	25	26.4	24.7	26	-0.3	-0.4	+
4	23.8	23	23.6	24.2	-0.2	1.2	-
5	23.3	23.8	23.1	25.3	-0.2	2.5	-
6	23.6	24.5	25.5	25	-1.9	0.5	-
7	24	24.3	24.3	24	0.3	0.3	0
8	22	21.7	22.9	22.2	0.9	0.5	+
9	24.3	24.8	24.1	26.3	-0.2	1.5	-
10	24	23.7	23.6	24.2	-0.4	0.5	-
11	23	21.7	23.3	22.2	0.3	0.5	-
12	23.3	23.8	23.1	25.3	0.2	1.5	-

P-value .363.

the two methods. Calculations of change in circumferential measurements at twenty-four, thirty-six, forty-eight, and seventy-two hours reveal levels of probability of .227, .656, .938, and .637, respectively.

TABLE 7

GAIN IN CIRCUMFERENCE OF THE PALMAR CREASE FROM THIRTY-SIX TO FORTY-EIGHT HOURS

Patient	36 Hours		48 Hours		x	y	Sign of x - y
	Splint	Net	Splint	Net	Splint	Net	
1	24.1	26.3	23	25.7	-1.1	-0.6	-
2	26.5	26	25.2	25.1	-1.3	-0.9	-
3	24.7	26	25.3	26.7	0.4	0.7	-
4	23.6	24.2	23.2	24	-1.1	-0.2	-
5	23.1	25.3	22.0	24.7	-1.3	-0.6	-
6	25.5	25	24.2	24.1	-0.3	-0.9	-
7	24.3	24	24	24.2	0.1	0.2	-
8	22.9	22.2	23	23.1	-1.1	0.9	-
9	24.1	26.3	23	25.7	-0.4	-0.6	-
10	23.6	24.2	23.2	24	-0.1	-0.2	-
11	23.3	22.2	23.2	23.1	-1.1	0.9	-
12	23.1	25.3	22	24.7	-	0.6	-

P-value .001.

In the period of time from twelve to twenty-four hours postburn, a sample of ten differences (N = 10) is found. Seven differences are negative and three are positive. The two cases where the sign equals zero are disregarded. The P-value for the Sign Test is .227, thus there is no significant difference between the two methods (table 8).

TABLE 8

GAIN IN CIRCUMFERENCE IN THE WRIST FROM TWELVE TO TWENTY-FOUR HOURS

Patient	12 Hours		24 Hours		x	y	Sign of x - y
	Splint	Net	Splint	Net	Splint	Net	
1	18.7	18	18.7	19.3	0	1.3	-
2	19.8	23.9	19.1	20.2	-0.7	-3.7	+
3	20	20	21	21	1	1	0
4	19.4	18.7	19.2	19.4	0.2	0.7	-
5	17.7	17.0	17.7	18.3	0	1.3	-
6	18.8	22.9	18.1	19.2	-0.7	-3.7	+
7	19	19	20	20	1	1	0
8	17	17.7	18	18.4	1	0.7	+
9	18.8	18	18.7	19.3	0	1.3	-
10	19.4	18.7	19.2	19.4	-0.2	0.7	-
11	18.4	17.7	18.2	19.4	-0.2	0.7	-
12	17.7	17	17.7	18.3	0	1.3	-

P-value .227.

In the period of time from twenty-four to thirty-six hours postburn there is a sample of nine differences (N = 9). Three differences are positive and six are negative. A difference of zero is disregarded from the analysis. A probability of .656 was obtained as the P-value for the Sign Test, showing no significance between the two methods of elevation (table 9).

TABLE 9

GAIN IN CIRCUMFERENCE OF THE WRIST FROM TWENTY-FOUR TO THIRTY-SIX HOURS

Patient	24 Hours		36 Hours		x	y	Sign of x - y
	Splint	Net	Splint	Net	Splint	Net	
1	18.7	19.3	19	20.6	0.3	1.3	-
2	19.1	20.2	19.2	19.9	0.1	-0.3	+
3	21	21	21	21.1	0	0.1	-
4	19.2	19.4	19.5	19.7	0.3	0.3	0
5	17.7	18.3	18	19.6	0.3	1.3	-
6	19.2	19.4	19.5	19.7	0.3	-0.3	0
7	18.2	18.4	18.5	18.7	0.3	-0.3	0
8	17.7	18.3	18	19.6	0.3	1.3	-
9	18.0	19.2	18.2	18.9	0.1	0.3	-
10	20	20	20	21	0	-1	+
11	18.0	18.4	18.5	18.7	0.5	-0.3	+
12	18.7	19.3	19	20.6	0.3	-1.3	-

P-value .656.

In the period of time from thirty-six to forty-eight hours postburn a sample of twelve differences (N = 12) is found. Seven differences are positive and five are negative. No consistency of sign direction is seen. The P-value for the Sign Test is .938. There is no significant difference in reduction of edema, between the two methods of elevation at this time (table 10).

TABLE 10

GAIN IN CIRCUMFERENCE OF THE WRIST FROM THIRTY-SIX TO FORTY-EIGHT HOURS

Patient	36 Hours		48 Hours		x	y	Sign of x - y
	Splint	Net	Splint	Net	Splint	Net	
1	18.2	18.9	18.2	19.2	0	0.3	-
2	10	21	19.8	21.3	-0.2	0.3	-
3	18.5	18.7	18.3	18.8	-0.2	0.1	-
4	19	20.6	18.8	19.5	-0.2	-1.1	+
5	19.5	19.7	19.7	19.8	0.2	0.1	+
6	18.5	18.7	18.7	18.8	0.2	0.1	+
7	18	19.6	17.8	18.6	-0.2	-1.0	+
8	19	20.6	18.8	19.5	-0.2	-1.1	+
9	19.2	19.9	19.2	20.2	0	0.3	-
10	21	21.1	20.8	20.8	-0.2	-0.3	+
11	19.5	19.7	19.2	19.8	-0.2	0.1	-
12	18	19.6	17.8	18.5	-0.2	-1.1	+

P-value .938.

In the period of time from forty-eight to seventy-two hours postburn a sample of twelve differences (N = 12) is found. Eight differences are positive and four are negative. There is no consistency in sign direction. The P-value for the Sign Test is .637, which shows no significant difference between the two methods (table 11).

TABLE 11

GAIN IN CIRCUMFERENCE OF THE WRIST FROM FORTY-EIGHT TO SEVENTY-TWO HOURS

Patient	48 Hours		72 Hours		x	y	Sign of x - y
	Splint	Net	Splint	Net	Splint	Net	
1	18.8	19.5	19	19.2	0.2	-0.3	-
2	19.2	20.2	18.3	17	-0.9	-3.2	-
3	20.8	20.8	20.6	20.7	0.2	-0.1	-
4	19.2	19.8	19.0	19.0	-0.2	-0.8	+
5	17.8	18.5	18	18.2	0.2	-0.3	0
6	18.2	19.2	17.3	18.9	-0.9	-0.3	-
7	19.8	21.3	19.6	21	-0.2	-0.3	0
8	18.3	18.8	18	18	-0.3	-0.8	+
9	18.8	19.5	19	19.2	0.2	-0.3	+
10	19.7	19.8	19.2	19	-0.5	-0.8	-
11	18.7	18.8	18.2	18	-0.5	-0.8	+
12	17.8	18.6	18	18.2	-0.2	-0.4	+

P-value .637.

Elbow

In measurements of the elbow, no significant difference is seen in circumferential measurements between the two methods. No consistency in sign is seen and the levels of probability for twenty-four, thirty-six, forty-eight, and seventy-two hours are .637, .984, .773, and 1.0, respectively.

In the period of time from twelve to twenty-four hours postburn, a sample of twelve differences (N = 12) is found. Eight differences are positive and four are negative. The P-value for the Sign Test is .637. This is a nonsignificant difference between the two methods (table 12).

In the time period from twenty-four to thirty-six hours postburn a sample of eleven differences (N = 11) is found. Seven differences are positive and four are negative. The zero is disregarded from the analysis. With N = 11 the P-value for the Sign Test is .984, which shows a nonsignificant difference between the two methods (table 13).

In the time period from thirty-six to forty-eight hours a sample of nine differences (N = 9) is found after disregarding the three cases where the sign equals zero. There are six positive and three negative differences. There is no consistency in sign direction. The probability

TABLE 12

GAIN IN CIRCUMFERENCE OF THE ELBOW FROM TWELVE TO TWENTY-FOUR HOURS

Patient	12 Hours		24 Hours		x	y	Sign of x - y
	Splint	Net	Splint	Net	Splint	Net	
1	32	30.8	32	34.3	0	-3.5	+
2	30.7	29.7	31.7	30	1.0	-0.3	+
3	32.5	33	36.5	33	4.0	0	+
4	29	30.2	32	30.4	3	0.2	+
5	30	29.8	30	33.3	0	3.5	-
6	28.7	28.9	28.9	29.3	0.2	0.4	-
7	31.5	31.5	33.3	34.5	1.8	3.0	-
8	27.9	28.5	28.5	27.4	0.6	-1.1	+
9	32	30.8	32	34.3	0	3.5	-
10	31.5	30.2	32.5	32.4	1.0	0.2	+
11	31	38.5	31.5	27.4	0.5	-1.1	+
12	30	39.8	30	33.3	-3.3	-3.5	+

P-value .637.

is tabulated and the P-value for the Sign Test is .773. No significant difference in reduction of edema between the two methods is seen (table 14).

The measurement for the elbow at forty-eight to seventy-two hours postburn presents a sample of twelve

TABLE 13

GAIN IN CIRCUMFERENCE OF THE ELBOW FROM TWENTY-FOUR TO THIRTY-SIX HOURS

Patient	24 Hours		36 Hours		x	y	Sign of x - y
	Splint	Net	Splint	Net	Splint	Net	
1	32	34.3	34.1	36	2.1	1.7	+
2	31.7	30.0	31.0	30.3	-0.7	0.3	-
3	36.5	33	36	35	-0.5	2	-
4	32	30.4	32.5	32.5	0.5	2.1	-
5	30	33.3	32.1	35	2.1	1.7	+
6	28.9	29.3	29	29	0.1	-0.3	+
7	33.3	34.5	35.5	34.3	0.2	-0.2	0
8	28.5	27.4	30	30.5	2.5	3.1	-
9	32	34.3	34.1	36	2.1	1.7	+
10	32.5	30.4	35.5	32.5	3.0	2.1	+
11	31.5	34.5	34.5	30.5	3.0	3.1	-
12	30	32.1	32.1	35	2.1	1.7	+

P-value .984.

differences (N = 12). Six differences are positive and six are negative. There is no consistency in sign direction. The P-value for the Sign Test is 1.0. No significant difference is shown (table 15).

TABLE 14

GAIN IN CIRCUMFERENCE OF THE ELBOW FROM THIRTY-SIX TO FORTY-EIGHT HOURS

Patient	36 Hours		48 Hours		x	y	Sign of
	Splint	Net	Splint	Net	Splint	Net	x - y
1	34.1	36	33.9	34	-0.2	-0.2	0
2	31	30.3	30.5	30.5	-0.5	0.2	-
3	36	35	36.6	35.3	0.6	0.3	+
4	32.5	32.5	32.2	33	-0.3	0.5	-
5	32.1	35	30.9	33	-1.2	-2	+
6	35.5	32.5	33.6	33	-1.9	0.5	-
7	34.5	30.5	33.6	30.5	-0.9	0	+
8	32.1	35	30.9	33	-1.2	2	+
9	29	29	28.5	29.5	-0.5	0.5	0
10	35.5	34.3	34.6	34.3	-0.9	0	+
11	30	30.5	30.6	30.5	0.6	0	+
12	34.1	36	33.9	34	-0.2	-2	0

P-value .773.

Additional Findings

Subjective data were collected regarding comfort, pressure points, and hand function. While the measurements were taken, the patients were asked about the methods being utilized. Seven patients preferred the splint. The

TABLE 15

GAIN IN CIRCUMFERENCE OF THE ELBOW FROM FORTY-EIGHT TO SEVENTY-TWO HOURS

Patient	48 Hours		72 Hours		x	y	Sign of x - y
	Splint	Net	Splint	Net	Splint	Net	
1	28.5	29.5	29	28.5	0.5	-1	+
2	34.6	34.3	32.6	33	-2.0	-1.3	+
3	30.6	30.5	29.3	31	-1.3	1.5	-
4	33.6	33	34.5	33	0.9	0	+
5	33.9	34	33	34.5	-0.9	0.5	+
6	30.5	30.5	32	29.5	2.5	-1.0	+
7	36.3	35.3	33.6	34.1	=0.3	-1.2	+
8	32.3	33	32	33	-0.2	0	=
9	30.9	33	30	33.5	-0.9	0.5	-
10	33.6	30.5	33.5	31	-0.1	1.5	-
11	30.9	33	30	33.5	-0.9	0.5	-
12	30.6	30.5	29.3	31	-1.3	1.5	-

P-value 1.0.

extremity could be maintained in a definite position for a prolonged period of time. No pressure points were observed due to a foam padding covering the length of the splint.

Five patients did not accept the splint as a better method. Their problems included:

1. The arm slides down making it difficult to keep the entire extremity within the splint

2. The splint was a big device occupying too much space at the bedside

No difference in hand function (flexion and extension of elbow, wrist, and fingers) between the two methods could be ascertained by gross clinical examination. Edema and pain were the primary factors involved.

Comparing the individual measurements at twelve, twenty-four, thirty-six, forty-eight, and seventy-two hours postburn of the fingers, palmar crease, wrist, and elbow a maximum of edema formation was observed during the period of twenty-four to thirty-six hours postburn in all areas. In most instances the measurements at twelve hours postburn were similar to the seventy-hours postburn.

The mean of the circumferential measurements of the thumb, palmar crease, wrist, and elbow was computed for the twelve, twenty-four, thirty-six, and forty-eight hours postburn and then plotted in a graph. The visual interpretation of these data showed a maximum of edema formation during the period of twenty-four to thirty-six hours postburn in all areas. In most instances, the measurements at twelve hours postburn were similar to the seventy-two hour measurements.

The palmar crease graph was representative of the similar patterns demonstrated by the graphs of the elbow, thumb, and wrist. For each twelve-hour interval, the mean of the circumferential measurements of the palmar crease was determined and plotted. Circumferential measurements are plotted against time. Circumferential measurements are in the y axis and time in x axis (figure 1)

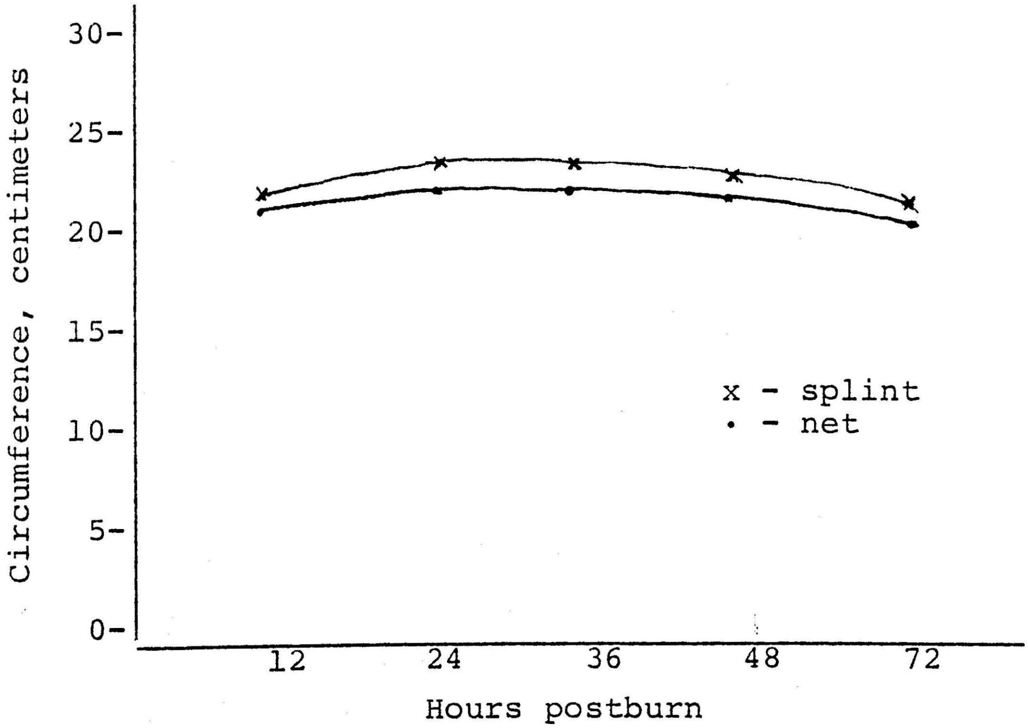


Fig. 1--Edema formation of the palmar crease in the initial postburn period.

Summary

This chapter presented the analysis and interpretation of the data collected from the sample population of twelve male patients between eighteen and fifty-five years of age. These patients sustained thermal or chemical burns on 60 percent or more of both upper extremities.

Circumferential measurements of the thumb, wrist, palmar crease, and elbow were performed to determine change in edema formation. Each circumferential measurement at twelve, twenty-four, thirty-six, forty-eight, and seventy-two hours postburn was analyzed separately.

The Sign Test showed a significant difference of .001 in individual measurements of the thumb and palmar crease. Overall, the Sign Test showed no significant difference in reduction of edema with the use of an expandable flexible material and the metal splint. The null hypothesis formulated for the purpose of this study was not rejected.

CHAPTER V

SUMMARY, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

Burns of the upper extremities are very common in patients with severe burns, and may result in incapacitating injury. In order to minimize deformity in the burned arm, particularly in the hand, prolonged edema formation must be avoided. Persistent edema which remains over a long period of time in an injured hand compromises motion.

Detrimental effects caused by persistent edema in the upper extremities present a problem of significant magnitude, therefore, high priority should be given to early treatment for burns of the arms and hands. The elevation of upper extremities is advocated to maintain adequate flow and retard edema formation.

This comparative study was conducted to determine the effects of two different methods of elevation in relation to reduction of edema. The methods utilized were the metal splint and an expandable flexible material suspended from an I.V. pole. This chapter includes a summary and discussion of the findings, conclusions, implications, and recommendations.

Summary

Most authors believe that elevation of the burned upper extremity is mandatory to reduce edema. A review of the literature revealed that members of the burn team agree that to control edema and minimize swelling, the arm is kept in an elevated position above the level of the heart with the hand and fingers in a functional position. Because function of the hand is dependent on good motion and edema is incompatible with good motion, reduction of edema must be a primary goal of treatment.

The problem of this study was to determine the effects of two mechanical methods for facilitating upper extremity elevation. In addition, information was obtained regarding comfort, positioning, and presence of pressure points.

The setting for this study was the burn unit of Parkland Memorial Hospital, a county-teaching hospital in Dallas, Texas. The patients were seen initially in the burn unit and evaluated for seventy-two hours postburn.

The sample for this study consisted of twelve patients above eighteen years of age who had sustained second- and third-degree injury covering 60 percent or more of the total arm surface area. The patients had received a thermal or chemical injury, the majority of which were burns sustained by gasoline.

The average time between burn and admission to the burn unit was eight hours with a range of four to ten hours. All burned extremities were cleansed and debrided on admission. Initial evaluation of the burned limb included surface temperature, color, capillary flush time, sensation, motor function, and presence of palpable pulses.

Following the initial cleansing and evaluation, a series of baseline measurements consisting of the circumference of the elbow, wrist, palmar crease, and thumb were made. Sterilized unmarked aluminum tapes were used to measure the circumference at the thumb, palmar crease, wrist, and elbow. From this baseline of admission measurements, serial measurements determining the amount of swelling were taken at the site every twelve hours for the first seventy-two hours postburn. Observations were made regarding position, comfort, and presence of pressure points.

In this study two mechanical methods of elevation were compared: the metal splint and a flexible expandable material secured from an I.V. pole. The flexible expandable material was the usual procedure utilized in the burn unit. According to the tool developed and type of data obtained from the study, the Sign Test was the most appropriate method to determine if there was a significant difference in amount of edema present between the two methods of elevation.

The hypothesis formulated for this study was that there would be no difference in reduction of edema between the elevation of burned upper extremities with a metal splint and an expandable flexible material. It was found that there was no significant difference in reduction of edema between the elevation of burned upper extremities with a metal splint and an expandable flexible material. However, at twenty-four and forty-eight hours postburn, measurements of the thumb and palmar crease showed a significant difference of .001.

Subjective data were collected regarding comfort, presence of pressure points, and hand function. Seven patients preferred the splint. No pressure points were observed with this method of elevation. No difference in hand function between the two methods could be ascertained by gross clinical examination.

Plotting of the mean of the circumferential measurements of the wrist, palmar crease, and elbow at twelve-hour intervals for the first seventy-two hours postburn allowed a visual interpretation of the formation of edema during the initial postburn period. A maximum of edema formation during the period of twenty-four to thirty-six hours postburn was observed in all areas.

Conclusions

Based on the findings of this study, the following conclusions were made:

1. The metal splint was not an appropriate device to use as an alternate to the flexible net
2. An increase in edema formation and gradual decline occurred with both methods
3. Close assessment of the circulatory system should be performed at twenty-four hours postburn due to the fact that edema formation is at its maximum
4. The need for elevation of upper extremities after seventy-two hours is decreased

Implications

Much of the nursing responsibility in the care of the thermally-injured patient focuses on the prevention of contractures and deformity. Maintaining the patient in good body alignment is a measure that should be initiated early by the nursing staff. Positioning of all burned and unburned areas of the body must be considered an independent nursing management. For the first two to three days following injury, the burned extremities are elevated above the level of the heart. An adequate and effective method to facilitate upper extremity elevation is necessary. The use of the metal splint may facilitate and enhance reduction of edema. The entire extremity maintains a consistent elevation in a straight angle above the level of the heart for a prolonged period of time. This method of elevation may be of value and have implications for basic nursing care.

The implications for nursing education are great. The problem of the thermally-injured must be a part of the curriculum of nursing education programs. Broad knowledge and in-depth understanding are essential for adequate intervention of the burn patient.

A nurse working with burn patients requires knowledge regarding rehabilitation, which starts the first day of admission. The positioning of the burned extremities is essential in the care of the thermally-injured patient. Effective methods of elevation should be demonstrated in order to prevent future complications related to prolonged edema formation.

Continuing education programs may be necessary to provide up-to-date information from research studies. The burn nurse should be alert of the changes and improvements regarding the different modalities of therapy for successful treatment of the thermally-injured.

Research and evaluative studies of different techniques are necessary to enhance the nurse's role in planning and implementing care of the burned patient. At this point in time, there is no established method considered to be superior for the management of edema in the upper extremities. Nurses responsible for the care of the thermally-injured patient should consider the evaluation of different methods of elevation. The use of an effective method of elevation should result in better management of patients' burned upper extremities.

Nurses involved in research should be familiar with studies already completed in order to improve their methodology and add to the body of nursing knowledge. It is expected that the recommendations of this study will be considered by nurse researchers in order to provide continuity of findings.

Recommendations

Based on the findings of this study, the following recommendations are offered:

1. A similar study be conducted utilizing a larger sample size for a more precise determination of the effects of both methods of elevation

2. A similar study be conducted in which formation of edema is evaluated utilizing measurements of inter-compartmental pressure

3. A similar study be conducted utilizing the doppler to evaluate formation of edema and its effects on circulatory flow

4. A similar study be conducted where circumferential measurements are taken between the third- and seventh-day postburn to determine presence of edema and hand function

APPENDIX A

TEXAS WOMAN'S UNIVERSITY
COLLEGE OF NURSING
DENTON, TEXAS

DALLAS CENTER
1810 Inwood Road
Dallas, Texas 75235

HOUSTON CENTER
1130 M.D. Anderson Blvd.
Houston, Texas 77025

AGENCY PERMISSION FOR CONDUCTING STUDY*

THE Parkland Memorial Hospital

GRANTS TO Adelaida Boothby

a student enrolled in a program of nursing leading to a Master's Degree at Texas Woman's University, the privilege of its facilities in order to study the following problem:

The problem of this study will be to determine the effects of two mechanical methods for upper extremity elevation on edema.

The conditions mutually agreed upon are as follows:

1. The agency (may) ~~(may not)~~ be identified in the final report.
2. The names of consultative or administrative personnel in the agency (may) ~~(may not)~~ be identified in the final report.
3. The agency ~~(wants)~~ (does not want) a conference with the student when the report is completed.
4. The agency is (willing) ~~(unwilling)~~ to allow the completed report to be circulated through interlibrary loan.
5. Other: [illegible]

Date July 22, 1976

[illegible signature]
Signature of Agency Personnel

Adelaida Boothby
Signature of student

Geraldine M. Goosen
Signature of Faculty Advisor

*Fill out and sign three copies to be distributed as follows: Original -- Student; first copy -- agency; second copy -- T.W.U. College of Nursing.

APPENDIX B

THE UNIVERSITY OF TEXAS
HEALTH SCIENCE CENTER AT DALLAS
Southwestern Medical School

DEPARTMENT OF INTERNAL MEDICINE

5323 HARRY HINES BOULEVARD
DALLAS, TEXAS 75235
TELEPHONE (214) 688-3466

August 5, 1976

Dr. Charles R. Baxter
Department of Surgery

Dear Dr. Baxter:

A subcommittee of the Human Research Review Committee has made a preliminary review of your study entitled "Elevation of Upper Extrmities During the Early Postburn Period" and it appears to meet our requirements in regard to protection of the individual's rights, experimental design, informed consent, etc. The full committee will meet on August 23, 1976 to review your request, at which time approval by the Committee is anticipated. Following that review, you will receive written notification of our action.

Sincerely,

J. Frederick Gotth M.D.

J. Donald Smiley, M.D.
chairman
Human Research Review Committee

cf

TEXAS WOMAN'S UNIVERSITY
RESEARCH INSTITUTE
DENTON, TEXAS 76204

BONE METABOLISM LABORATORY
BOX 23546, TWU STATION
PHONE (817) 387-5305

September 14, 1976

Ms. Adelaida Boothby
Texas Woman's University
Dallas Campus
Dallas, Texas

Dear Ms. Boothby:

The Human Research Review Committee has reviewed and approved your program plan, "Elevation of the upper extremities during the early postburn period".

Sincerely yours,

George P. Vose, Chairman
Human Research Review Committee

cc Dr. Bridges

APPENDIX C

APPENDIX

CONSENT TO INVESTIGATIONAL PROCEDURE OR TREATMENT

SUBJECT______________________________UNIT NO.______________

1. I hereby give my consent to Dr. ______________ to perform or supervise the following investigational procedure or treatment:

Elevation of burned upper extremities in a metal splint and an expandable flexible material

______________________ on ______________________
NAME OF SUBJECT

The nature and purpose of the procedure or treatment, possible alternative methods of treatment, the risks involved, and the possibility of complications have been explained to me by Dr.______________. I understand that the procedure or treatment to be performed is investigational and that I may withdraw my consent for my (his,her) further participation as a subject at any time without affecting my (his,her) status as a patient. With my understanding of this, having received this information and satisfactory answers to the questions I have asked, I voluntarily consent to the procedure or treatment designated in Paragraph 1 above upon

______________________ ______________________
NAME OF SUBJECT TIME

____
DATE

WITNESS:______________ SIGNED:______________
SUBJECT OR PERSON RESPONSIBLE

WITNESS:______________ ______________________
RELATIONSHIP

Instructions as to persons authorized to sign:

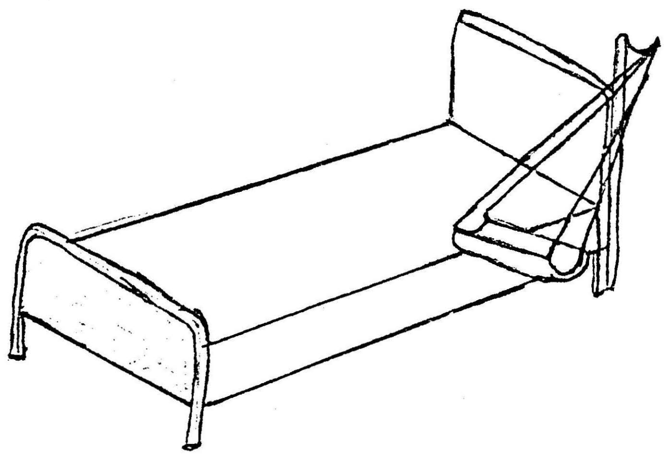
If the subject is not competent, the person responsible shall be the legal appointed guardian or the nearest of kin.

If the subject is a minor under 21 years of age, the person responsible is the mother or father or legally appointed guardian.

If the subject is unable to write his name, the following is legally acceptable:

John H. (His X Mark) Doe and two (2) Witnesses

APPENDIX D



THE METAL SPLINT

APPENDIX E

TEXAS WOMAN'S UNIVERSITY

DENTON, TEXAS 76204

TWU 75 DIAMOND JUBILEE

THE GRADUATE SCHOOL
P.O. Box 22479, TWU STATION

November 8, 1977

Miss Adelaida Yolma Boothby
Urb. San Jorge calle 5
#31
Ponce, Puerto Rico 00731

Dear Miss Boothby:

I have received and approved the Prospectus for your research project. Best wishes to you in the research and writing of your project.

Sincerely yours,

Phyllis Bridges

Phyllis Bridges
Dean of the Graduate School

PB:jp

cc: Mrs. Geraldine Goosen
Dr. Anne Gudmundsen
Nursing Center
Graduate Office

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