1999

Principles of Pediatric Burn Care: A Literature Review

J. Chris Leonard
University of North Dakota

Follow this and additional works at: https://commons.und.edu/pt-grad

Part of the Physical Therapy Commons

Recommended Citation

This Scholarly Project is brought to you for free and open access by the Department of Physical Therapy at UND Scholarly Commons. It has been accepted for inclusion in Physical Therapy Scholarly Projects by an authorized administrator of UND Scholarly Commons. For more information, please contact zeinebyousif@library.und.edu.
PRINCIPLES OF PEDIATRIC BURN CARE: A LITERATURE REVIEW

By

J. Chris Leonard
Bachelor of Science in Physical Therapy
University of North Dakota, 1998

An Independent Study
Submitted to the Graduate Faculty of the
Department of Physical Therapy
School of Medicine
University of North Dakota
in partial fulfillment of the requirements
for the degree of
Master of Physical Therapy

Grand Forks, North Dakota
May
1999
This Independent Study, submitted by James C. Leonard in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

(Faculty Preceptor)

(Graduate-School Advisor)

(Chairperson, Physical Therapy)
PERMISSION

Title Principles of Pediatric Burn Care: A Literature Review

Department Physical Therapy

Degree Master of Physical Therapy

In presenting this Independent Study Report in partial fulfillment of the requirements for a graduate degree from the University of North Dakota, I agree that the Department of Physical Therapy shall make it freely available for inspection. I further agree that permission for extensive copying for scholarly purposes may be granted by the professor who supervised my work or, in her absence, by the chairperson of the department. It is understood that any copying or publication or other use of this Independent Study Report or part thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and the University of North Dakota in any scholarly use which may be made of any material in my Independent Study Report.

Signature  

Date 12-10-98
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>ACKNOWLEDGMENTS</th>
<th>vi</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td>vii</td>
</tr>
<tr>
<td><strong>CHAPTER</strong></td>
<td></td>
</tr>
<tr>
<td>I  INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>II PREVENTION OF CHILDHOOD BURNS</td>
<td>3</td>
</tr>
<tr>
<td>III ANATOMY, SYSTEMIC PATHOPHYSIOLOGY, AND CLASSIFICATION OF PEDIATRIC BURNS</td>
<td>11</td>
</tr>
<tr>
<td>Anatomy of the Skin</td>
<td>11</td>
</tr>
<tr>
<td>Classification of Pediatric Burns</td>
<td>12</td>
</tr>
<tr>
<td>IV THE BURN WOUND</td>
<td>17</td>
</tr>
<tr>
<td>The Threat of Sepsis in the Burn Wound</td>
<td>19</td>
</tr>
<tr>
<td>The Physiology of Burn Wound Healing</td>
<td>21</td>
</tr>
<tr>
<td>Topical Antimicrobials</td>
<td>22</td>
</tr>
<tr>
<td>Decisions Related to the Burn Wound</td>
<td>23</td>
</tr>
<tr>
<td>Pain Considerations in the Care of Pediatric Burn Wounds</td>
<td>28</td>
</tr>
<tr>
<td>V  PSYCHOLOGICAL ASPECTS</td>
<td>32</td>
</tr>
<tr>
<td>VI PATHOPHYSIOLOGY AND TREATMENT OF BURN SCARS</td>
<td>36</td>
</tr>
<tr>
<td>Positioning</td>
<td>39</td>
</tr>
<tr>
<td>Splinting</td>
<td>40</td>
</tr>
<tr>
<td>Serial Casting</td>
<td>41</td>
</tr>
<tr>
<td>Compression Therapy</td>
<td>42</td>
</tr>
<tr>
<td>Stretching</td>
<td>45</td>
</tr>
<tr>
<td>Continuous Passive Motion</td>
<td>48</td>
</tr>
<tr>
<td>PROM Under Anesthesia</td>
<td>48</td>
</tr>
</tbody>
</table>
VII EXERCISE AND THE PEDIATRIC BURN PATIENT .......... 50
  Exercise During the Acute Stage ....................... 51
  Exercise and Ambulation after Skin Graft Surgery ..... 52
  Exercise During the Rehabilitation Phase ............... 54
  Home Exercise and Post Discharge Patient Education ... 56

VIII CONCLUSION ............................................. 57

APPENDIX .......................................................... 59

REFERENCES ....................................................... 61
ACKNOWLEDGMENTS

I would like to thank my family for their unconditional support and encouragement over the years. I would like to thank those teachers who have gone the extra mile for me, including Dr. Tom Petros, Dr. Thomas Ballentine, Dr. Vicki McCleary, and the entire faculty of the University of North Dakota PT Department. I would like to thank students who helped me along the way, including Leah Hermanson, Scotty Hagar, Mike Rexin, Heather Phillips, and Schawn Dockter. I could not have gotten through school without them. Finally, I want to thank Peg for all of her help, guidance, and patience in preparing this project.
ABSTRACT

Principles of Pediatric Burn Care: A Literature Review is meant to provide a compact and comprehensive source of information on the therapy related care of young burn victims. This literature review will be most useful for students and clinicians of physical and occupational therapy.

Recent medical advances have improved the survival rates of children who have sustained burns; this situation demands an increased knowledge and awareness of pediatric burn therapy. The information in this literature review includes a comparison and contrast of the findings of research related to the prevention, classification, pathophysiology, and treatment options of pediatric burn care from the acute stage until scar maturity. This includes a brief review of the anatomy and physiology of healthy skin and the pathophysiology of burn wounds and burn scars. Information regarding the psychological aspects of burn care and pain related issues is also included, with a focus on the issues unique to children who have burns.
CHAPTER I

INTRODUCTION

Advances in the treatment of burn injuries have greatly increased the survival rates of burn victims. In 1949, patients who sustained 49% total body surface area (TBSA) burns had a 50% mortality rate; while in 1997, a 50% mortality rate was associated with persons sustaining burns of 98% TBSA. Reasons for increased survival include improved resuscitation procedures, prevention of hypovolemic shock, support of hypermetabolic response to burn trauma, improved control of infection, better wound care, improved treatment of inhalation injury, and early excision of burn wounds. The trend of increased survival has increased the demand for physical therapists to be knowledgeable about burn care and capable of assisting in the rehabilitation of people with burn injuries. This is exemplified by the fact that, between 1973 and 1992, the number of burn centers in the United States rose from 12 to 138. The physical therapist will spend a great deal of time with the burn patient and will be involved throughout his/her treatment. More than half of all victims of burns are children, and more than half (52%) of children burned are under the age of four. Harmel et al estimate that one million children are burned each year, while Stap et al estimate 610 000. Of these, approximately 100 000 per year require hospitalization. Noting the increased need for knowledgeable burn
therapists, this review is meant to provide medical professionals with background knowledge and research findings on the causes, pathology, and treatment options for young burn victims throughout the course of their medical care. It is important for therapists to be competent in the pathophysiology and treatment of burns and for therapists to be aware of the differences between burns in children and adults.
CHAPTER II
PREVENTION OF CHILDHOOD BURNS

Prevention is an essential aspect of fighting the problem of pediatric burns. It is very cost effective, relatively easy, and, best of all, a painless solution. Prevention has played an important role in the decline in burn injuries, yet thousands of children are burned each year and most childhood burn injuries are preventable. This chapter will point out burn related facts which are important for all people who work with children and will review a few successful prevention methods from the literature.

The majority of pediatric burn victims are under five years old and nearly three out of four burn injuries occur in the home. Thus, the discussion will begin with facts and suggestions related to the common causes of burn injury found within the home.

Both Fisher and Helm's Comprehensive Rehabilitation of Burns and Carvajal and Parks' Burns in Children: Pediatric Burn Management present a list of nearly identical suggestions for prevention of burns in the home. This writer feels it is appropriate to include these suggestions. They are based on the National Institute for Burn Medicine's Measures to Prevent Burns.
IN THE KITCHEN

Cooking:

Keep an eye on youngsters when you are cooking!

Keep handles of pots and pans turned in so children cannot "pull" them off the edge of the stove or countertop; better yet, cook on back burners.

Supervise children when they are ready to learn to cook.

Do not squirt barbecue lighter fluid on fires.

Do not reach across a lit gas or electric burner. Do not store foods, especially cereal, over the stove—children could climb onto the stove to reach it.

Use only proper lighter fluid to light a barbecue, not gasoline or any other flammable fluid.

Keep children away from barbecue fires.

Electrical Appliances:

Use only UL approved electrical appliances.

Coil electrical appliance cords so children cannot pull on dangling cords!

Unplug electrical appliances when not in use.

Keep electrical appliances away from water.

Do not misuse or overload extension cords; if a toddler is in the home, do not use extension cords.
IN THE BATHROOM

Set the temperature of hot water heater at 124° (F); a water temperature of 140° can scald.

Test the temperature of baby’s bath water. Never bathe a baby or youngster in hot water—their skin is too tender.

Supervise toddlers and youngsters in the bathtub.

IN THE BEDROOM

Use fire-retardant sleepwear for infants, toddlers, and young children.

Be careful when using heating pads—follow directions provided.

Do not let cords from vaporizers dangle!

Keep the baby’s or toddler’s crib a safe distance from radiators.

No smoking in bed.

Keep space heaters and vaporizers away from cribs, beds, and curtains.

IN GENERAL

If you smell gas or suspect a gas leak, call the gas company or fire department for help. Do not light a match or turn on the electric lights.

Install heat and smoke detectors and keep them operating properly.

HAVE A FIRE ESCAPE PLAN for all family members with a place to meet outside the home. PRACTICE IT. Instruct babysitters of the plan.

Keep fire and police numbers by the phone.
Do not allow candles to burn unattended.
Keep the fireplace screened.

Matches:
Keep matches and lighters out of reach of toddlers and youngsters.
Teach children (when they are ready to learn) that MATCHES ARE A TOOL and teach them proper use.

Gasoline and Other Chemicals:
Do not misuse gasoline! Gasoline should only be used in proper engines.

Store gasoline, other combustibles, and cleaning or toxic chemicals in special closed containers, out of reach of children. Better yet, do not store them. Buy a one-time-use quantity and replenish as needed. Never store in the home.

Use combustible liquids ONLY WITH PROPER VENTILATION. Do not pour from any container when inside of any building.

Do not refill a hot lawn mower or snow blower. Let it cool.

When discussing the prevention of burns in very young children, the importance of supervision cannot be overstated. It is interesting to note that 76% of young victims are burned as a result of their own actions and these burns show a peak incidence during times of possible decreased supervision, including the early morning and late afternoon hours. These findings support Green et al who point to “a sad lack of respect for hot water in the home” as
the cause of many burns. All supervisors of young children must be aware of both the location of possible dangers and the location of the child at all times.

As children reach school-age, scald injuries become less common while the incidence of flame injuries increases. Prevention methods can now turn toward flame prevention and escape. But how should we go about educating these children? Should we simply show slides of burn victims in hopes of scaring the children out of playing with fire? Hammond and Varas point out that fear is only effective if an alternative suggestion is given. They also state that it is more effective to reinforce positive behavior and that a message is more clearly absorbed if the recipient is called into specific action. They stress the importance of an active program with a sharp focus.

Wade et al present a case study of that sort of program. The “Learn Not to Burn” program, produced by the National Fire Protection Association uses four 45-minute sessions which inform and involve the children with videos, technique practice, creation and experience of vapors, smoke detector use, crawling “like GI Joe” to escape, and a question/answer session in the dark with a fully equipped firefighter. At the end of the program, the children are shown slides of burned children to point out the seriousness of the subject. The program is prewritten (minimal preparation time) for schoolteachers to use, yet less than 5% of US public schools use the program. Wade et al cite teacher overload as the reason for lack of use. This program as a valuable service which proactive school therapists could undertake. “Learn Not to Burn” is available in four levels
which correspond to age and is designed for children in kindergarten through high school.¹⁰

Another noteworthy prevention measure related to pediatric burns is an antiscald device which stops the flow of water through a source if the water temperature exceeds a certain temperature (usually 110°F).¹³ These devices would be especially important in homes where the water heater was set at a high temperature (above 125°F). Keep in mind, the device could be used selectively on only the water sources within the child’s reach.

Also, since cigarettes are the ignition source of 35% of all fatal fires,¹³ it is important to consider them in prevention discussions. McLoughlin and McGuire¹³ point out the findings of the Technical Study Group on Cigarettes and Little Cigar Fire Safety, which show that cigarettes can be made significantly less likely to cause a fire through simple changes such as reduced circumference, less dense tobacco, less porous paper, and lower levels of citrate in the paper.¹³ Most importantly, the public must be aware of the high incidence of fires caused by cigarettes and should learn to be sure that they are extinguished and disposed of properly.

Finally, the importance of smoke detectors is undeniable. McLoughlin and McGuire¹³ report that the risk of death due to fire is cut in half when a home is equipped with an effective smoke detector. They also point out the importance of checking the smoke detector and its batteries periodically. They cite a 1988 survey which showed that 82% of American homes and apartments were equipped with smoke detectors, but that one-third of these detectors did not
contain functional batteries. They follow with the suggestion of checking smoke
detector batteries when a family sets its clocks back on hour in the fall.

As stated earlier, prevention is a very cost effective and pain saving
method of fighting the problem of pediatric burns. It is an area that can always
be improved and which physical therapists, especially those in the school setting,
can influence.

It is appropriate to address the problem of burn-related child abuse as it is
pertinent to prevention in two ways. First, a child who has been the victim of an
abuse burn has a 70% risk of sustaining another abuse injury in the future.
Second, children who have been abused are more likely to abuse other children
or to grow up to become child abusers. Burns are a common method of child
abuse, as 10% of physical abuse produces burn injury. It is important that all
professionals who work with these children are aware of the unique signs of an
abuse burn so that future abuse can be prevented.

Though it is difficult to spot a child abuser, as 90% of these adults do not
show outward signs of psychotic, criminal, or antisocial behavior, one can look
for certain indicators in cases where abuse is suspected. The signs include the
following: 1) delayed treatment seeking, 2) injuries with questionable
explanations which are not commensurate with the child’s physical abilities or
the pattern of the burn, 3) previous accidental injury, 4) a burn occurring
when the child was alone, 5) burns blamed on a sibling, and 6) when the child
arrives at a treatment center with someone other than a parent or primary caretaker.\textsuperscript{5}

The pattern of an abuse related burn can be especially indicative of its non-accidental nature. An immersion burn marked by straight parallel lines around the abdomen and legs, but sparing the popliteal and groin crease areas may indicate that the victim was placed in a scalding tub.\textsuperscript{5,14} Any bilaterally symmetric, circumferential, and glove or stocking injuries should be checked. Finally, burns in the pattern of objects such as kitchen utensils, irons, or oven or grill racks should be investigated, especially if they occur on a non-exploratory part of the child's body, such as the trunk or back.\textsuperscript{5}

Medical professionals must take steps to recognize and prevent abuse. It is imperative that the history of burn injury is recorded word for word, so that inconsistencies can be detected and investigated in the future.\textsuperscript{5} Also, photographs should be taken upon the child's arrival, so that they are available for potential future litigation.\textsuperscript{5,14}
CHAPTER III
ANATOMY, SYSTEMIC PATHOPHYSIOLOGY AND
CLASSIFICATION OF PEDIATRIC BURNS

The anatomy and classification of pediatric burns are similar to that of adult burns. In this chapter, the author will explain both information pertaining to all burn patients and the unique characteristics of pediatric burn anatomy and classification.

Anatomy of the Skin

The skin is made up of two main layers, the epidermis and the dermis. The epidermis has four main layers including, from superficial to deep, the stratum corneum, stratum granulosum, stratum spinosum, and the basil layer. The stratum corneum is the layer which waterproofs the skin and acts as a barrier to infection. The stratum granulosum functions in water retention and heat regulation. The stratum spinosum serves to protect the underlying basal layer, which holds the cells responsible for the regeneration of the epidermis and contains melanocytes which are the cells responsible for color. The dermis is immediately deep to the epidermis and is 20 to 30 times thicker. The dermis contains blood vessels, lymphatics, nerve endings, collagen, and elastic fibers. It also contains sweat glands, sebaceous glands, and hair follicles which are referred to as epidermal appendages.
The undersurface of the epidermis has ridges which serve to increase the surface area between the epidermis and dermis.\textsuperscript{1} This configuration helps to combat friction and helps to explain why post-burn skin, which lacks these ridges, partially or completely, is threatened by even small amounts of friction. The dermis is connected to the subcutaneous fat cell layer by fibrous connective tissue.\textsuperscript{1}

The skin is a vital part of our life, as it is directly involved in temperature regulation,\textsuperscript{15} fluid balance,\textsuperscript{2} protection from infection and trauma,\textsuperscript{2} and is central to cosmetic appearance.\textsuperscript{16} Burn injuries which damage the skin threaten the patient’s looks, health status, and survival.

Classification of Pediatric Burns

When classifying burns, one must first take into consideration the amount of body surface area involved. Then the depth of the burn is examined.

For adults, the “Rule of Nines” is an accurate and easy way to estimate the amount of body surface area (BSA) involved.\textsuperscript{1,2,4,14,17} In this system, the head and each upper extremity are assigned 9% BSA, while the front of the trunk, back of the trunk, and each lower extremity are assigned 18%.\textsuperscript{1,2,4,14,17} However, the Rule of Nines is not accurate for children less than 15 years of age.\textsuperscript{2,4,14,17} Helvig\textsuperscript{14} suggested the following modification for the Rule of Nines. An infant’s head and neck are assigned 18% BSA, and each lower extremity is assigned 14%. Each year after the age of two, 1% should be subtracted from the original 18% assigned to the head, while .5% should be added to the 14% assigned to
each lower extremity. The Lund-Browder chart is another method of determining the BSA involved in a pediatric burn.4

Burns are classified regarding which tissue layers are involved. A burn injury can affect just the epidermis, or in the most severe cases, all layers, including the epidermis, dermis, fat layer, fascia, muscle, and bone, are injured.1,2,6,7

In the past, burns were classified as first-, second-, or third-degree. First-degree burns affect the epidermis only, second-degree burns affect all of the epidermis and part of the dermis, and third-degree burns affect all of the epidermis and dermis. Some sources also mention fourth-degree burns which affect subcutaneous tissue.2,6,7

More recently, the terms superficial, superficial-partial thickness, deep partial thickness, full-thickness, and subdermal have been used to classify and describe the depth of burns.1 Often the two methods of describing burn depth are combined. First-degree burns and superficial burns are synonymous and describe a burn which damages only the epidermis.1,2,7,17 Second-degree burns are referred to as partial thickness burns and are classified as either superficial partial thickness or deep partial thickness; the difference, of course, is related to the amount of dermis involved.1,2,7,17 Third-degree burns are called full-thickness burns which are deep enough to affect the entire dermis.1,2,7,17 Fourth-degree burns are synonymous with subdermal burns; these affect the skin layers as well as underlying fat, fascia, muscle, or bone.2,6,7
The first 24 hours after serious burn injury are a time of physiological chaos. The early period is marked by a serious hypermetabolic state;\textsuperscript{1,14,15,19} this leads to increased breakdown of the body's protein and fat stores and total body wasting.\textsuperscript{1,3} The kidneys and liver are both threatened by the byproducts of this wasting as well as the decrease in vascular fluid.\textsuperscript{1,15} The patient experiences a dramatic increase in resting oxygen consumption\textsuperscript{15} and an increase in body temperature to over 100° F.\textsuperscript{1,3} Catabolic hormones such as catecholamines, glucocorticoids, and glucagon are released and are partly responsible for these problems.\textsuperscript{3} Nearly all organs are affected by this state of catabolism and hypermetabolism.\textsuperscript{15}

Histamine is immediately released from mast cells and causes a decrease in capillary permeability.\textsuperscript{3} As protein rich fluid leaves the vessels, an osmotic pull is created which leads to edema.\textsuperscript{1,2,4,14} The burn has compromised the ability of the skin to conserve body fluids\textsuperscript{15} and evaporative loss of fluid from the burn wound occurs.\textsuperscript{3,15,20} Large fluid shifts soon follow.\textsuperscript{14} This decrease in vascular fluid and the edema which follows can cause kidney failure,\textsuperscript{15} multi-organ failure, and cardiovascular complications, such as decreases in blood volume and cardiac output.\textsuperscript{15}

Burn injury may also lead to pulmonary and gastrointestinal complications. Serotonin, a potent vasoconstrictor, is also released and leads to increased resistance in the pulmonary vascular system,\textsuperscript{3} thus threatening a pulmonary system which may have sustained substantial damage due to smoke inhalation.\textsuperscript{3,15} Pulmonary edema may dictate that intubation be used just to
make breathing possible.\textsuperscript{3,15} Pulmonary complications and inhalation injuries, common causes of death in burn victims, may be accompanied by facial burns, singed nasal hairs, harsh cough, hoarseness, abnormal breathing, respiratory distress, carbonaceous sputum, hypoxemia, and pneumonia.\textsuperscript{1} Burn victims are also prone to paralytic ileus,\textsuperscript{4} which is a paralysis of the intestines, and Curling's ulcer,\textsuperscript{4} which is a stress ulcer.

Finally, even the brain and joints are directly influenced by the physiology of burn injury.\textsuperscript{1} Hypoxemia and hypovolemia can lead to seizures, delirium, and hallucinations.\textsuperscript{15} Seizures can also be caused if fluid resuscitation is accomplished too quickly.\textsuperscript{15} Joints become involved when protein rich edema fluid surrounds the joint and its tendons and ligaments; new collagen is formed which adheres to the proteins, thus leading to adhesions and decreased ROM.\textsuperscript{1,2}

As mentioned previously, the insult to the patient's skin causes an ongoing problem with temperature regulation.\textsuperscript{3,14,15,19} Furthermore, pediatric patients demand closer attention to body temperature because of their thin skin\textsuperscript{15} and increased body surface to weight ratio.\textsuperscript{14} The pediatric burn patient will keep a body temperature around 38.5\textdegree C (101.3\textdegree F).\textsuperscript{3} It is important that their room\textsuperscript{3,19} and all equipment that they use\textsuperscript{19} are warm, because this will minimize the hemodynamic and metabolic stress\textsuperscript{15} and will decrease the threat of hypothermia.\textsuperscript{3,19} A room temperature of at least 37\textdegree C (98.6\textdegree F) is recommended.\textsuperscript{15}

Burn injuries affect the entire body.\textsuperscript{15} A greater understanding of the changes in metabolism and advances in fluid resuscitation have led to
decreased mortality among burn victims.\textsuperscript{1,3,9,28} This increase in the survival of patients with serious burns demands that the health care professionals who care for them are more aware of the needs of this group.\textsuperscript{1,2}
CHAPTER IV
THE BURN WOUND

The amount of tissue damage, and thus the extent of a burn wound, is determined by the intensity of the heat source, duration of exposure, and individual characteristics of the exposed body part. \(^1\) \(^7\) \(^20\) Age of the victim is also a factor. \(^1\) \(^14\) Specific pediatric considerations include the vulnerability of thinner skin \(^2\) \(^14\) (less time of exposure and less heat intensity are needed to produce a comparable burn) and the fact that the child’s immature motor skills make escape from the burning agent more difficult. \(^14\) Areas of thin skin, such as the inner arm, require less exposure time and heat intensity to sustain a burn than do areas of thicker skin, such as the back and palms of the hands. \(^2\)

Tissue damage is possible at temperatures as low as 40°C (104°F). \(^2\) \(^7\) At temperatures of 45°C (113°F), proteins in skin cells start to denature at a rate that is too rapid for their normal replacement by the cell. \(^2\) \(^7\) At temperatures above 113°F, the rate of cell destruction doubles with each one degree rise in temperature. \(^1\) \(^4\) Enzyme function that is also essential to the survival of cells is disrupted at similar temperatures, \(^7\) and 50% decrease in enzyme activity causes cell death. \(^7\)

It is important to point out that cells can be injured or destroyed by the immediate effects of exposure to heat, as stated above, or they can be damaged
during the early post-burn period due to the progressive effects of inflammation and decreased local microcirculation.\textsuperscript{7,21} This fact can be clearly described using Jackson's zones of thermal injury.\textsuperscript{1,6,7,20} The three zones are concentric, three dimensional, and include the zone of coagulation, zone of stasis, and the zone of hyperemia.\textsuperscript{1,6,7,20}

The zone of coagulation is the area which has been in direct contact with the heat source and is influenced immediately. This zone is characterized by coagulation necrosis, and the cells here are damaged beyond repair.\textsuperscript{1,6,7,20}

Just concentric and deep to the zone of coagulation is the zone of stasis.\textsuperscript{1,6,7,20} This is the critical zone as far as wound care is concerned. The cells here are not damaged beyond repair, although these cells will die within 48 hours if they do not receive proper treatment.\textsuperscript{1,7} Decreased local microcirculation and local inflammation threaten the zone of stasis, and it is critical that infection and dessication are avoided.\textsuperscript{1}

Deeper still and on the outside of the wound lies the slightly damaged zone of hyperemia.\textsuperscript{1,6,7,20} The cells here will recover within seven to ten days.\textsuperscript{1,7,20}

What causes the burn wound to become essentially avascular in the first 24 hours post burn; i.e. what causes local microcirculation to stop? When one searches for this answer, one finds many contributors to this pathologic situation. Swelling of the vascular endothelium decreases the lumen size of local vessels and arterio-venous shunts decrease blood flow to the injured tissue.\textsuperscript{21} Erythrocytes,\textsuperscript{21} granulocytes,\textsuperscript{21} leukocytes,\textsuperscript{7} and platelets\textsuperscript{21} adhere to the vessel
walls; this is called margination.\textsuperscript{21} Vessels are damaged by platelet and fibrin microthrombi.\textsuperscript{7,21}

Histamine, serotonin, prostaglandins\textsuperscript{7,21} and other inflammatory substances increase capillary permeability, decrease local perfusion, and further damage vessel endothelium.\textsuperscript{21} Venular resistance can become 300 times greater than normal due to aggregation of red blood cells, white blood cells, platelets, and fibrin, all caused by the inflammatory response.\textsuperscript{21}

Another inflammatory mediator mentioned in the literature is thromboxane. It is thought that this substance causes platelet aggregation and vasoconstriction and it is found at greatly elevated levels in the fluid of burn wounds.\textsuperscript{7,3}

Drug treatments which fight the inflammatory process and thus improve local perfusion are being used with positive findings.\textsuperscript{7,21} Thromboxane synthetase inhibitors have been shown to improve dermal microcirculation by causing vasodilatation and decreased platelet, red blood cell, and white blood cell adherence, thus improving healing.\textsuperscript{7} Heparin has antithrombic, antihistamine, antiserotonin, antiinflammatory, and antiproteolytic enzyme capabilities. It has been shown to decrease pain and fluid loss and stop burn extension.\textsuperscript{21} Anabolic agents such as growth hormone and insulin have been shown to improve protein balance and accelerate wound healing.

The Threat of Sepsis in the Burn Wound

Until the arrival of penicillin, gram-positive microbes, including Beta-Hemolytic Streptococcus and Staphylococcus Aureus, were the major threats to
the lives of burn patients. Although deaths due to sepsis were cut in half during the time between the mid 1960s and the early 1980s, infection remains the leading cause of death in burn victims. The risk of infection increases with increased depth of burn. Burn patients are threatened by bacterial, viral, and fungal infections. If these infections reach the bloodstream, systemic sepsis results and a life threatening situation follows. A burn wound is considered to be infected if more than 100,000 organisms per gram of tissue are found. When sepsis reaches this level, skin grafts are likely to fail.

The most common bacterial culprits are Staphylococcus Aureus, Pseudomonas Aeruginosa, and gram negative opportunists. Possible viral pathogens include Cytomegalovirus (CMV), Herpes Simplex Virus (HSV), Varicella-zoster virus, Epstein-Barr virus, and adenoviruses. Fungal infections can include Candida Albicans, Candida Tropicalis, and Candida Parapsilosis. It is important to be aware that while prophylactic antibiotics are effective against some bacteria, especially gram positive microbes, they may increase the likelihood of opportunistic gram negative microbes and viral and fungal infections. Burn patients can be considered immunocompromised, which also contributes to their susceptibility to sepsis, and complicates decisions related to prophylaxis.

Therapists should be aware of the early signs of sepsis as it is essential that treatment be instituted immediately or the patient may be threatened with death within hours. Possible signs of infection include lethargy, confusion, and delirium, as well as diarrhea and vomiting. Hyperthermia or hypothermia may
accompany sepsis as may hypotension, tachycardia, breathing irregularities, and hemodynamic impairment. If the wound is healing very slowly or is getting worse, sepsis may be indicated.

The Physiology of Burn Wound Healing

Wound healing is often broken into three stages. These include the inflammatory phase, proliferative phase, and maturation phase.

The inflammatory phase begins immediately and lasts three to five days. During this phase, we see clear fluid seep into the wound as a result of local vasodilatation which leads to leukocytes and proteins leaving the vascular system, and vascular fluid follows. When the leukocytes lyse, pus forms and the fluid becomes more viscous and less clear. During this phase, the wound appears red, warm, painful, and edematous. Also, during the inflammatory phase, the epidermal cells increase their activity and start to migrate across the wound bed, as long as the wound bed is moist. Remember, these epidermal cells are from the basil layer of the epidermis and even in partial thickness burns, where the epidermis is essentially destroyed, the basil layer is present in the epidermal appendages contained in sweat glands and hair follicles. Partial thickness burns should heal in 14 to 21 days as a result of this activity.

The two main components of the proliferative phase are re-epithelialization of the wound surface and contraction. Contraction is the process whereby the edges of a wound are pulled together by the action of myofibroblast cells. Note that contraction does not start in the first 72 hours after the burn injury, so splinting should not be necessary right away, and it may
even be detrimental as it only increases compartmental pressure as edema rises.\textsuperscript{22,23} During this phase, the wound will acquire pink or red granulation tissue, fibroblasts will deposit collagen randomly, the wound edges will display migrating epithelium, and the wound will shrink.\textsuperscript{22}

The maturation phase begins after the wound is closed and involves remodeling of the scar to its mature (flat and pale) form.\textsuperscript{22} In a burn injury, the remodeling phase may take up to two years.\textsuperscript{17,24}

The above mentioned healing process is secondary intention healing.\textsuperscript{22} Due to the size of many burns and or the threat of scarring, many burn wounds are closed with various graft techniques to minimize scarring,\textsuperscript{25,26} dessication,\textsuperscript{20} pain,\textsuperscript{26} infection,\textsuperscript{5,20} and blood loss.\textsuperscript{26} This topic is described in later chapters.

**Topical Antimicrobials**

Topical antimicrobials have been key players in the reduction of sepsis and death due to infection.\textsuperscript{1,4,27} Ideally, each wound would be tested for specific microbes and an agent which has been proven effective against the specific microbes involved could be applied.\textsuperscript{7,27} Unfortunately, the choice of topical agent is often simply based on physician preference and is presumed to work.\textsuperscript{27}

Commonly used topical antimicrobials for pediatric burns include bacitracin, mafenide acetate, mupirocin, nitrofurazone, and silver sulfadiazine.\textsuperscript{27} Rodgers et al\textsuperscript{27} tested five antimicrobials on 177 different strains of bacteria collected from pediatric burn patients; they found that nitrofurazone had the broadest spectrum efficacy and was most active against gram-negative organizims.\textsuperscript{27} Silver sulfadiazine is the most common agent\textsuperscript{17,27} and is effective
against gram-positive and gram-negative bacteria as well as candida.\textsuperscript{27} Mafenide acetate is also commonly used,\textsuperscript{4} as it is effective against a wide spectrum of microbes.\textsuperscript{20} Mafenide can effectively penetrate eschar;\textsuperscript{20,27} however, it is painful, stains black, and may lead to metabolic acidosis.\textsuperscript{20}

A few problems have surfaced regarding the use of topical agents. First, resistant bacteria have developed;\textsuperscript{1,7} this is especially common when only one agent is used.\textsuperscript{7} Second, while these agents are effective against bacteria, they may actually increase the incidence of viral and fungal infections.\textsuperscript{7} Finally, many topical agents may be toxic to healing epithelium,\textsuperscript{3} which is especially problematic if secondary intention healing is being promoted.

To combat the problems of resistance and the limited spectrum of antimicrobials, it is recommended that more than one antimicrobial be used with each patient.\textsuperscript{7} A schedule of rotating antimicrobials every eight hours has been recommended.\textsuperscript{7}

**Decisions Related to the Burn Wound**

When making treatment decisions about a burn wound, it is important to note that burn wounds are different from trauma wounds and venous/arterial ulcers. A burn wound contains more dead tissue and thus has a greater potential for infection than do wounds with other causes. They have more exudate as vascular fluid seeps into the wound. The burn wound stays open and often covers a larger surface area than the other conditions.\textsuperscript{17} Early goals for the burn wound should include closure as soon as possible, promotion of granulation
tissue in preparation for grafting or promotion of re-epithelialization if healing by secondary intention, and patient comfort.\textsuperscript{17}

First-Degree Burns

First-degree burns are much like a sunburn; they are red, dry, and painful. These burns are treated with pain relief medications and fluids and are expected to heal in a short time.\textsuperscript{17}

Second-Degree Burns (Partial Thickness)

When faced with a second-degree burn (superficial partial thickness or deep partial thickness), the burn team has two options. The team can depend on secondary intention healing and let the surviving epithelial cells in the dermal appendages re-epithelialize the wound over 14 to 21 days or they can excise the necrotic tissue and graft the wound.\textsuperscript{20,23}

Until the mid 1970s, second-degree burns were allowed to heal by secondary intention.\textsuperscript{23} This method subjected the patient to many long and painful procedures including hydrotherapy, prophylactic splinting, dressing changes, and exercise.\textsuperscript{23} This method greatly increased the chance of sepsis and limited the patient's movement for a long period of time.\textsuperscript{23}

Advances in the treatment of these burns have been very beneficial. Early excision and grafting, when compared to non-operative or late grafting procedures, has been shown to decrease blood loss,\textsuperscript{26} number of operations,\textsuperscript{3} number of painful procedures,\textsuperscript{26} decrease length of hospitalization,\textsuperscript{3,20,25} mortality,\textsuperscript{3,20,25,26} morbidity, and hypertrophic scarring, and result in an improved functional outcome in hands.\textsuperscript{25} It should be noted that excision and grafting is
used on deep partial thickness and full thickness burns and that superficial partial thickness injuries, which will heal in less than three weeks, are often allowed to do so.³

Another advance in the treatment of second-degree (partial-thickness) burns is the increased use of biologic and synthetic dressings. Ideally, the clean burn wound is covered by an autograph (graft from self).²⁰ However, if the wound is not completely debrided or an autograft is not available, biological or synthetic dressings can be used.¹⁷,²⁰ Biological dressings include homographs (from living humans), allographs (from a cadaver), heterographs (from another animal, usually pig), and amnion (from the human placenta).¹⁷ These adhere to the dermis for three to five days and protect the wound from drying and trauma until autografting is possible.¹⁷ Biological dressings are much more comfortable than methods involving other types of dressings.⁴ They also hasten functional recovery, decrease evaporative fluid loss, protect raw nerve endings, provide a barrier to bacteria, maintain a moist environment for re-epithelialization, and protect new granulation tissue.¹⁷ Biologic dressings aid in debridement after eschar separation. Furthermore, by noting how the biological dressing is adhering and observing the amount of exudate it contains, the burn team can get an idea of the chance of adherence of an autograft.⁴,¹⁷ The problems with biological dressings include limited availability, questionable sterility, and high cost. Synthetic dressings, such as biobrane, Tega-derm, and Op-Site, have shown promise in serving in their place.¹⁷,²⁰
Second-degree burns will often present with blisters.\textsuperscript{1,7,14,17} There is some disagreement as to whether these blisters should be evacuated or not. Some people believe that blister fluid should be evacuated as it contains inflammatory substances and may support bacteria.\textsuperscript{1,7,28} Others believe that blisters should only be broken if they are dirty or if they lie across a joint line.\textsuperscript{17}

Third-Degree Burns (Full Thickness)

Full thickness burn injury damages the entire depth of the skin and reepithelialization cannot occur (unless the wound is very small, in which case the epithelium will migrate from the wound edges).\textsuperscript{2} Full-thickness wounds will need to be grafted.\textsuperscript{2,17}

In cases where the wound is only partly full thickness, it can be debrided instead of completely excised and prepared for autograft; this process may take two to three weeks.\textsuperscript{2} The debridement methods used would include sharp (scalpel, scissors) and blunt (tweezers, gauze) methods and also may include the use of guarded skin graft knives which require local anesthetic.\textsuperscript{2} This method is referred to as sequential tangential excision.\textsuperscript{2,5}

Another way to treat a third-degree burn is to use graft-knives and selective debridement to eliminate eschar, and graft within a few days of the injury. This method can be referred to as early excision and grafting\textsuperscript{3,25,26,29} or early tangential excision.\textsuperscript{20} Excessive blood loss and hypothermia are concerns with this method.\textsuperscript{20}

A third way to treat third-degree burns is by excising to the fascia and grafting immediately.\textsuperscript{5,20} This method decreases blood loss and sepsis and
increases the chance of graft adherance. This technique is used with the elderly, patients with medical complications, and patients with massive burns.

In situations where necrotic tissue and eschar prevent the application of autograft or biologic dressing, debridement of the wound is necessary. The goals of debridement include the removal of dead and contaminated tissue and to provide a red, beefy surface of granulation tissue on which a graft will take. Methods of debridement include mechanical, using forceps and scissors; surgical, using graft knives; and enzymatic, in which proteolytic and fibrinolytic enzymes are used to remove dead tissue. Some debridement may also be achieved by agitation in the whirlpool, yet the therapist must be aware that the pressure of agitation can damage the wound bed and that the whirlpool may cause maceration, especially at high temperatures. Furthermore, the wound may be contaminated by the whirlpool, as bacteria may come from previous users or from the patient's skin or body orifices. Other methods of cleaning the burn wound may be less likely to promote infection.

When dressing wounds it is important to consider the following points. The dressings should be wrapped distal to proximal, thus minimizing edema. No two burned surfaces should be allowed to touch; for example, fingers/toes should be wrapped separately and the ear should not be allowed to touch the head. Coarse meshed gauze is helpful in removing exudate, while fine meshed gauze protects the healing surface. This layer should be followed by a cushioning layer and then a layer of surgical net and/or self adherent elastic wrap to secure the dressings. Whatever dressings are chosen, they must
preserve the moist healing environment, secure topical antimicrobials, and protect the wound. Once a burn wound is closed by secondary intention or covered by a secure autograft, the patient will advance to the rehabilitation phase of treatment where scarring and function become the focus.

Pain Considerations in the Care of Pediatric Burn Wounds

Dressing changes and debridement are times of extreme pain and fear for the pediatric burn patient. It is important that steps are taken to minimize the pain and anxiety associated with wound care.

Children as young as seven years of age are able to understand that pain may be a necessary part of recovery, yet it is important to assure all children that you are trying to help, not punish. A 1981 study at the Boston Shriner's Burns Institute showed that children who understood a procedure beforehand and were allowed to assist in its execution were better able to cope with the negative symptoms than those who were simply distracted during the procedure. If children are allowed to assist in applying creams and dressings and even to participate in debridement, they may show less distress. Tarnowski et al compared the level of distress in pediatric burn victims during self-mediated debridement and during therapist-mediated debridement. This study found that the children displayed less pain behavior during self-mediated debridement (where the patient actually does his/her own debridement.) However, to ensure an adequate job of debridement, the therapist would inevitably have to perform some debridement, and when this occurred, the pain behavior and distress were
higher than ever. Tarnowski's group recommended that self-mediated debridement be used only with children with active coping styles.\textsuperscript{33}

Patient education with very young children needs to be active, simple, and visual.\textsuperscript{14} Letting the children play with dressings and equipment similar to those used on them may be beneficial. Allowing them to dress a doll can be educational for the child and can indicate the child's perceptions of his/her care to the clinician.\textsuperscript{14}

Many other steps can be taken to ease pain. Children are extremely modest by age four, so it is important to consider draping and to let them wear soft clothing over their dressings.\textsuperscript{14} Children and parents both respond positively to very structured activity and proactive scheduling.\textsuperscript{14,34} It has been found that parental participation in procedures helps them to understand the processes and the rationale behind them; this may increase future compliance.\textsuperscript{36} Some children may cope better when their parents are not present,\textsuperscript{14} while others show less anxiety with a parent in the room.\textsuperscript{14,36} Some facilities perform all painful procedures in a room other than the child's room; thus, the child can retain his/her bedroom as a safe place.\textsuperscript{14} Parents need education regarding the healing process and need to be aware of what is to come.\textsuperscript{36} Doing the little things, like putting topical antibiotics directly on the dressings, can eliminate a step in a painful process.\textsuperscript{14} Also, removal of dressings\textsuperscript{1} and early exercise\textsuperscript{32} are less painful if done underwater.\textsuperscript{1} Finally, massage, deep breathing, hypnosis,\textsuperscript{37} guided imagery,\textsuperscript{37} music, and distraction may all ease a child's pain.\textsuperscript{14}
If parents elect not to participate in procedures directly, they may benefit the child by reading or singing with the child during procedures and comforting the child thereafter. Also, in cases where the parent was injured or cannot be present for any reason, a tape recording of the voices of family members can comfort a child who is suddenly isolated from his/her normal life.

Techniques related to behavioral psychology have been shown to reduce pain behavior in adults and children. This is done by reinforcing well behaviors with the hope of reducing pain behaviors. Verni et al. presented a case of a three-year-old girl with severe burns to her buttocks, perineum, and legs with whom a program of reinforcing well behaviors and program compliance and ignoring pain behaviors “decreased crying and verbal and non-verbal pain responses to a near zero level.” This program was also found to increase the child’s positive statements and increased self care behaviors while decreasing crying during naps and night sleep. There seems to be a fine line between showing empathy and promoting pain behavior, and this needs to be approached on an individual patient/clinician basis.

Therapists should be aware that brisk washing, prolonged soaking, shearing forces, excessive cream, and tight clothing can all increase itching. Children should not be allowed to scratch their wounds, but should pat them instead. Lotions, cool compresses or baths, distraction, and relaxation techniques have all been advocated for pruritus reduction. Pruritus is a more difficult problem in children than adults, and it is also more common in bedridden patients as compared to ambulatory patients. If a child is prone to scratching,
mittens can be placed on his/her hands\textsuperscript{41} to reduce this behavior and oral or topical medications should be used against pruritis.\textsuperscript{1,14} Morphine and fentanyl are medications used during dressing changes, and methadone is a 24-hour analgesic used with children.\textsuperscript{19} Acetaminophen and codeine are medications used against pain in smaller burns.\textsuperscript{19}

Finally, it is important to guard all conversations when in the presence of the young child.\textsuperscript{14} Words like "blood," "dead tissue," and "cut" can evoke increased fear in the child.\textsuperscript{14} Each person who works with the child should introduce himself/herself and explain each procedure, especially if the child cannot see the clinician.\textsuperscript{34} These simple steps can make a very difficult situation more comfortable for all involved.
CHAPTER V
PSYCHOLOGICAL ASPECTS OF PEDIATRIC BURN INJURY

The burn injury presents a unique and very serious psychological threat to a child. The child's basic assumptions about himself/herself, such as the concept of invulnerability and the assumption that the world is a safe place, can be shattered.\(^{42}\) Worst of all, the burn injury is not a single incident of trauma, but an ongoing trauma which continues with each treatment during hospitalization and with adjusting to a new identity after discharge.\(^{35,42}\)

The list of psychological symptoms which a young burn patient may experience is long and may include agitation,\(^{19}\) withdrawal,\(^{4,19,35,42}\) extreme fright,\(^{19,43}\) regression to immature behavior,\(^{4,19,43}\) dependence,\(^{6,19}\) nightmares,\(^{15}\) sleep disturbances,\(^{15,32}\) delirium,\(^{15,34}\) disorientation,\(^{15}\) confusion,\(^{15}\) altered consciousness,\(^{15}\) hyperactivity,\(^{15}\) anxiety,\(^{4,42-44}\) depression,\(^{4,32,42}\) enuresis,\(^{43}\) encopresis,\(^{43}\) and guilt or shame.\(^{42}\) It is very important that the victim and his or her family are aware that these symptoms are normal and treatable.\(^{34,42}\) It is very important that the burn team includes a psychologist to diagnose and treat psychological symptoms, and it is also meaningful if at least one staff member is available for counseling without the threat of painful treatment.\(^{34}\)

Gilboa et al\(^{42}\) discussed the burn injury as a "Continuous Traumatic Stress Disorder" (CTS) and pointed out that these situations need to be approached
differently than "Posttraumatic Stress Disorder" (PTSD). They claim that the burn victim receives damage to his/her stimulus barrier which renders him/her unable to distinguish between internal and external stimuli. This overstimulation leads to confusion, decreased ability to concentrate, and decreased ability to judge reality.\textsuperscript{1} They point out that while it is beneficial for patients with PTSD to express thoughts and emotions while reliving the experience, it may be detrimental to patients with CTS; i.e., burn victims, to relive their painful experience because treatments and constant pain are continuously reminding them of the incident already. It has been found that burn patients who relive the experience have more depression, anxiety, and guilt than those who avoid thinking about it.\textsuperscript{42} The patient should not be encouraged to talk about the burn injury, but if he/she chooses to do so, clinicians should listen empathetically.\textsuperscript{42}

How should clinicians approach CTS? First of all, the staff should reassure the patient and family that the psychological symptoms are normal.\textsuperscript{34,42} Next, the staff should emphasize the patient's strengths, both past and present.\textsuperscript{42} The staff should encourage hope and independence while letting the patient choose his or her own coping method.\textsuperscript{42} In doing so, the staff should respect defense mechanisms, such as denial, as it is important to the patient's coping process.\textsuperscript{42} Finally, it is important that the burn team work to minimize pain as it only increases anxiety and is emotionally exhausting.\textsuperscript{42} Play therapy can play an important role in a young child's psychological recovery.\textsuperscript{38} During play, dolls can be used for purposes of patient education.\textsuperscript{38} Mahaney\textsuperscript{38} pointed out that play therapy is a natural way to promote cognition, affectivity, social learning, coping
behavior and language learning. During play, a child is allowed to control his/her fantasy world; this promotes active coping.\textsuperscript{1,38} It encourages physical and psychological activity and helps the child to "free up emotions" in a safe environment.\textsuperscript{38}

When a child is ready to be discharged and to re-enter the school environment, the transition can be made much easier if burn staff is involved.\textsuperscript{45} When the child returns to his/her normal environment, he/she will continue to modify his/her self-image based both on reality and on how other people react to his/her appearance.\textsuperscript{45} It is natural for people to stare at burn victims; most species stare at their kind who appear different, possibly as a defense mechanism.\textsuperscript{34} Furthermore, human beings are naturally curious about fire.\textsuperscript{34} For these reasons, it is imperative that schoolmates are educated about the reasons for the child's altered appearance and his/her use of splints, orthotics, and pressure garments.\textsuperscript{46} This can be accomplished in a question-and-answer session for the schoolmates presented by the burn staff; often, the child is also involved.\textsuperscript{46}

In addition, physical therapists can help to educate the patient's school therapists and academic staff regarding appropriate physical activities and disabilities as well as equipment.\textsuperscript{45} This consultation should also include, with the family's permission, information on the history of the burn, psychological adjustment, exercise program, skin care, and possible side effects of medication.\textsuperscript{46}
As mentioned previously, dealing with the family is central to the final physical and psychosocial outcome for the victim. The therapist should be aware that parental anger toward the staff may be common and that this is often a reflection of their own guilt, anxiety, and anger. Family depression and guilt are common. These problems must be dealt with as they can hinder the child's self-concept and may make the parents lenient with ongoing treatment. It has been shown that children who have families who value independence, open expressiveness, and family cohesion have much better long-term psychological adjustment. Family support may be the most powerful determinant of adjustment. With proper care and a positive family environment, pediatric burn patients are able to attain a level of self esteem similar to that of their peers.
CHAPTER VI
PATHOPHYSIOLOGY AND TREATMENT OF BURN SCARS

Contractures and other scar related problems are a major obstacle to function and future therapy.\textsuperscript{1,2,48} Decreased survival rates have led to a higher incidence of this sort of problem.\textsuperscript{49} The contracture process involves the skin, joint capsules, tendons, and muscles.\textsuperscript{50} This is a very progressive problem, which leads to significant disability related to decreased range of motion and increased pain.\textsuperscript{51} Contracture formation is especially common in the hands, head, neck, and axilla. This is due to the difficulty in positioning and splinting these areas.\textsuperscript{2,49} The chest, back, shoulders, buttocks, and deltoid region are also mentioned as problem areas because they are areas of high skin tension.\textsuperscript{52} Patients may use postures which shorten the structures in these areas to increase comfort. Consequently, in time, patients tend to lose the ability to move out of the shortened, contracted position and contractures occur.\textsuperscript{2} Contracture problems involving the face are especially complex and problematic due to their threats to cosmesis, feeding, and speech.\textsuperscript{34,48} Regardless of treatment method, all deep second-degree and third-degree burns will produce scars.\textsuperscript{53}

Certain burn patients are predisposed to contracture and/or hypertrophic scarring.\textsuperscript{49,52} First of all, children are vulnerable to contracture and hypertrophic scarring\textsuperscript{2,49} as a result of not only the contracture process but also the growth
process. Other people at increased risk are those with extremely fair skin, black people, and those with a family history of hypertrophic scarring. The chance of scar hypertrophy increases with increased healing time.

Ward reports that split-thickness grafts scar more easily than do full-thickness grafts, and grafts on granulation tissue are more prone to scarring than are those applied to a tangentially excised wound. Kraemer et al. found that patients whose burns were originally excised to fascia had worse long-term results than did those who had burns excised to dermis or fat or who healed by secondary intention. Finally, the contractures of children need surgical reconstruction nearly four times more often than do those of adults with burns of comparable size.

Even after the burn wound is "healed" and the proliferative phase is complete, the area of the burn is one of increased metabolic activity and inflammation. Hyperemia is a sign of a non-mature wound where contracture and hypertrophic scarring will likely follow if the wound is left to its own mechanisms.

Linares et al. suggested that granulation tissue is inflammatory tissue and the source of hypertrophic scarring. This thought is supported by their finding that, in burns where biopsies of granulation tissue prior to grafting showed whorled granulation, hypertrophic scars followed, while those without whorled granulation did not develop hypertrophic scars.
Contracture is caused, at least in part, by excess collagen production by fibroblasts and by the presence of myofibroblasts (contractile fibroblasts).\textsuperscript{17,48,55}\textsuperscript{17,48,55} Fine collagen bundles lie in the papillary dermis and larger bundles lie in the deeper reticular dermis.\textsuperscript{24} Due to the contraction of myofibroblasts, these layers become “whorled,” disorganized, and are much more random than the parallel bundles of normal skin.\textsuperscript{24,48,54,55}\textsuperscript{24,48,54,55} This disorganized collagen soon forms cross links with other fibers in the area and progressive contraction follows.\textsuperscript{24}\textsuperscript{24} Voluntary muscle contraction adds to this problem of shortened and compacted collagen.\textsuperscript{2}\textsuperscript{2} Head and Helm\textsuperscript{51(p136)}\textsuperscript{51(p136)} describe the stiff joints of burn victims as resulting from “collagen synthesis, collagen degradation, and rapid remodeling of mature collagenous tissue in joint capsules and collateral ligaments.”

The treatment of burn scars begins within a few days of admission and continues long after discharge, lasting up to two years.\textsuperscript{17,24}\textsuperscript{17,24} The clinician will set up a program designed to maintain or increase function, maximize cosmetic results, and help the patient to return to pre-injury lifestyle.\textsuperscript{24}\textsuperscript{24} This program will include elastic garments, stretching, exercise, positioning, and splinting.\textsuperscript{2,48}\textsuperscript{2,48} It is thought that massage and soft tissue techniques can soften scars, although their effectiveness has not been proven.\textsuperscript{30}\textsuperscript{30} This aspect of treatment is especially important when working with children as they form more scar tissue than do adults and they have less muscle strength with which to combat scar contraction.\textsuperscript{2}\textsuperscript{2} “The dreaded myofibroblast never sleeps.”\textsuperscript{56(p496)}\textsuperscript{56(p496)}
Positioning

Positioning is started very early and is an important part of contracture prevention. Initially, the patient should be positioned with the extremities elevated to decrease edema and the patient should change positions every two to four hours. In addition, Schnebly et al. recommended active range of motion exercises through all available range at least ten times per hour to maintain strength, joint function, and tissue extensibility while decreasing edema. Plantarflexion and equinovarus contractures can be caused by improper attention to positioning, as can contractures of forefoot adduction and supination.

It is also important to position the patient in a manner which discourages rounded shoulders, kyphotic posturing, and decreased shoulder ROM. Shoulder retraction can be promoted using a figure of eight brace (clavicle fracture brace). When supine, a towel roll can be used to promote neck extension and shoulder retraction, while it fights kyphotic posturing. The axilla should be positioned in 90° of abduction and 10° of horizontal adduction with pillows and arm boards as the axilla is also very prone to contracture. Neck extension splints should be used when the patient is sitting or standing and the head section of a sectional bed can be removed to promote extension. It is important that the burn patient does not use a pillow as this would promote kyphotic posture. If the axilla is positioned in more than 100° of abduction, the brachial plexus may be stretched. See the appendix for considerations to be made for other joints.
Splinting

Splinting can be useful in the prevention of contractures as they help maintain ROM increases resulting from exercise or surgery while protecting the involved joint.\textsuperscript{1} Helm et al\textsuperscript{58(p521)} reasoned that splinting is needed stating, "Even the most motivated patient will rarely comply and exercise independently at the minimal level required to prevent joints and skin contractures when he/she is in severe pain." Other researchers have also found that early splinting and positioning can decrease the incidence of contractures.\textsuperscript{49} However, support for splinting is not universal. Schnebly et al\textsuperscript{23} evince that splint use should be minimized because they decrease independence, promote passivity, do not allow exercise while donned, may cause areas of pressure,\textsuperscript{14} and are time consuming to make, fit, and alter. They advocate "only occasional intermittent use of splints for maintenance of achieved motion."\textsuperscript{23(p263)} In addition, the risk of decubiti is increased when splints are used.\textsuperscript{2}

Children may not understand positioning so they may be at increased risk of contracture and need splinting more than adults.\textsuperscript{2} Twenty-four hour splinting is advocated if the patient is unable to move the involved limb voluntarily and/or if tendons are exposed.\textsuperscript{2} Splints should be checked every one to two hours as they can shift and cause pressure necrosis.\textsuperscript{14} Signs of improper fit include maceration, tingling, inflammation, and numbness.\textsuperscript{2} Night splinting is especially important as substantial progress can be lost overnight.\textsuperscript{4} Dynamic splints using three point pressure and springs can apply pressure which opposes contracture
while allowing the tendon to move in either direction, thereby reducing tendon adhesions.\(^2\)

**Serial Casting**

Serial casting can slow the contractile process of the healing scar\(^{50}\). Connective tissue is viscoelastic\(^{57}\). This means that it contains a viscous component which can be permanently deformed (like plastic) and an elastic component which is only temporarily elongated\(^{57}\). The goal of serial casting is to help realign collagen by applying linear pressure to a contracting wound near a joint\(^{57}\). Ridgway et al\(^{57}\) reported the reduction of bilateral plantarflexion contractures (40° and 55°) to neutral in six days after daily cast changes.

Serial casting has shown promise in fighting contractures\(^{50,57}\), although some authors\(^{50}\) seem to indicate that it is a last resort. Contractures of the knees, ankles, elbow, and wrist are the targets of serial casting. This procedure has been most effective on elbows and knees as these joints have fewer planes of movement and long lever arms\(^{50}\). Standard plaster of Paris is used because synthetic materials are too hot\(^{50}\). Wedging is a technique which limits the amount of times the joint must be recasted. With wedging, the cast is cut perpendicular to the joint, the joint is stretched, and then the wedge is recasted\(^{50}\). For best results, the casts should be changed either every day\(^{57}\) or wedged daily and changed every other day\(^{50}\). Serial casting may be especially useful in pediatric burn therapy as it nearly eliminates compliance issues\(^{50}\).

It is reported that casting over wounds does not hamper healing\(^{50}\). It is fast, simple, and inexpensive and provides a prolonged stretch, conforms to the
extremity, and does not cause pressure areas. Serial casts can be made to fit even very large and small limbs. However, serial casting must be followed by traditional burn therapy or range of motion gains will be lost.

Compression Therapy

Pressure applied to the healed skin in the form of elastic wraps, fitted garments, and other methods has been widely accepted for the purposes of reducing the effects of scarring. The characteristics of the burn scar can be described using the three Rs: red, raised, and rigid. The goal of pressure therapy is to change the condition of the scar from the immature state where the three Rs dominate to the mature condition when the scar is pale, flat, and soft.

The positive effects of pressure are thought to be related to the fact that the pressure decreases blood supply to the inflamed scar tissue. This is thought to promote parallel realignment and decreased synthesis of collagen. The exact reason for the success of pressure on burn scars is not known. Pressure is thought to loosen the bonds of the underlying collagen bundles by promoting collagen lysis. Pressure decreases mucopolysaccharide content and edema. Pressure is also thought to decrease the activity of myofibroblast cells. Furthermore, pressure treatment can protect skin grafts, decrease itching, minimize scarring, and help maintain ROM and function. It is thought that by decreasing scarring and promoting more organized and less random tissue, pressure therapy promotes normal sensory return and more organized tactile sensory input. Stap et al completed a study involving 20 children with burns, including 16 who wore pressure
garments and 4 who did not. The two children who scored lowest for light touch and temperature sensation had not worn pressure garments.

The American Burn Association has the following recommendations, based on healing time, to help clinicians decide who needs pressure therapy.24,52

1. Prophylactic pressure therapy is not required in patients whose wounds are expected to heal in less than ten days.

2. When a burn is expected to require 10 to 14 days to heal, pressure therapy should be offered to black patients, regardless of age.

3. When burns require 14 to 21 days to heal, prophylactic pressure therapy should be offered to all patients.

4. Prophylactic pressure is mandatory for all burn wounds which require more than 21 days to heal.

Early on, elastic wraps can be used over dressings to help reduce edema.24 Elastic wraps should be used until the skin can tolerate the shearing force of pressure garment application and the patient has minimal open areas.1 A figure-of-eight wrap can provide pressure in a distal to proximal direction and has been shown to decrease edema.24 A figure-of-eight pattern can be used on the lower extremities, spiral patterns should be used to wrap upper extremities, and the trunk can be wrapped using a circular pattern.1 It is important to look for ridges in the tissue as these are signs of uneven pressure.24 Fitted garments can cause shear, so they are not used over open wounds or until edema has stabilized.24 In the meantime, spandex or isotoner gloves can provide temporary pressure.24
Once edema has subsided and the skin has healed a pressure garment should be used.\textsuperscript{24,52} Keep in mind, new skin is fragile, so methods of minimizing friction during donning and doffing should be used if possible.\textsuperscript{1,24} These include the use of nylons underneath the garment and the installation of zippers on the garment if appropriate.\textsuperscript{1,24} Also, it is important to avoid pressure treating proximal to open areas; for example, the forearm should not receive pressure treatment when the hand has open areas because edema would be promoted in the hand.\textsuperscript{24} The patient should have two pressure garments at all times (one to wear and one to wash).\textsuperscript{24} The garments last around three months and they are ineffective if the patient gains or loses ten pounds.\textsuperscript{2} It is thought that the pressure must be around 25 mmHg or more to cause significant restructuring, although much higher pressures are needed and used in some cases.\textsuperscript{2,24,48}

The pressure applied to the skin depends on the tension inside the garment, local geometry of body parts, and tissue compliance of the body part.\textsuperscript{59} Inserts or conformers are needed when a body contour causes bridging of fabric.\textsuperscript{48} Areas prone to hypertrophy due to lack of pressure which would benefit from inserts include the sternum,\textsuperscript{1} face, volar hand, angle of mandible, web spaces, and across the flexor surfaces of a joint.\textsuperscript{2} These inserts can be made of silastic elastomers,\textsuperscript{60} rubber,\textsuperscript{2} foam,\textsuperscript{2} gel,\textsuperscript{2} or silicone.\textsuperscript{61} Silastic elastomers are synthetic compounds which are similar to rubber.

Due to the fact that pressure therapy is costly, inconvenient, and long lasting, compliance is crucial and challenging.\textsuperscript{2} A few improvements that can increase compliance among pediatric burn patients include three-piece garments
for the lower body which have a removable crotch for diaper users, cooled garments, and colored garments.\textsuperscript{2}

While trying to prevent the deformities caused by contracture and hypertrophic scarring, pressure therapy can cause problems of its own.\textsuperscript{59} These include distal extremity swelling and regressed skeletal growth, especially of the chin and thoracic cage.\textsuperscript{59} Pressure has been found to affect mandible and maxilla growth.\textsuperscript{2} Pressure on the mandible can also lead to sleep apnea\textsuperscript{2} and the "bird face deformity" which is marked by a retracted mandible.\textsuperscript{59} Lueng et al\textsuperscript{59} suggest that mandible deformity can be decreased if the pressure device is worn only 12 hours per day, and local steroids may supplement this.

Pressure garments are to be worn 23 to 24 hours per day until consistent scar maturity has been demonstrated for several weeks with evidence of softening, pallor, and flattening for several weeks.\textsuperscript{2,5}

Stretching

Stretching must accompany pressure treatment.\textsuperscript{24} Stretching programs are very painful and patient compliance is again a challenge.\textsuperscript{4,24,58} Compliance can be improved by setting gradual goals and by giving an unsupervised exercise program which replaces therapist driven stretches if specific range of motion goals are met.\textsuperscript{58} This sort of program also helps to discourage the patient from falling into passivity.\textsuperscript{58}

Several considerations can make stretching more effective and/or less painful. It is important to lubricate dry, flaky, or cracking skin before it is stretched.\textsuperscript{4,24} Stretching must be slow and sustained and blanching must be
evident if a scar is to be influenced. Gravity, pulleys, and traction can all be used. If the burn crosses two joints, they should both be stretched at the same time. In addition, although the effects of ultrasound on scar tissue have not been proven, it is thought that by increasing tissue temperature and collagen extensibility, and decreasing pain, ultrasound can be a beneficial part of a scar stretching program.

Similarly, the use of paraffin is thought to decrease pain, increase extensibility associated with scar stretching, and has been used with sustained stretching. Paraffin should be used late in the acute phase of treatment, after the skin has healed, and it can be continued throughout treatment. Moore reported increases of 5° to 10° after 20 to 30 minutes using paraffin and sustained stretch, and the increases were reported to last up to four hours. Head and Helm collected information on 20 patients and reported an average increase of 8° immediately after paraffin stretch of the same duration. They also reported that a 7° to 10° carryover should be apparent after three to five treatments, and that after six weeks, up to 30° improvement in range of motion can be achieved at the shoulder or elbow.

It is reported that paraffin can cause blistering in immature burn scars. Head and Helm reported that the normal temperatures of 37°C to 38°C are unnecessarily high and that 33°C is high enough. They also report that 29°C to 30°C can give adequate heat when stretching children. However, Moore reported that paraffin of substantially higher temperatures can be used. She states that the paraffin should be 46°C to 48°C. Ridgway et al reported that
the collagen loosening effects of stretching are maximized when tissues are stretched at elevated temperatures and then allowed to cool before releasing the tension, thus allowing “collagenous microstructure to restabilize toward a new stretched length.”

The use of contact media has been reported to greatly decrease maturation time and improve the cosmesis of burn scars. These include silastic elastomer, silastic foam dressing, silicone gelsheets, and various other synthetic dressings, some of which are adhesive. Perkins et al compared a group of 50 children who were treated in 1978 or 1979 to a group of 50 who were treated in 1983 or 1984. Those treated in 1983 or 1984 were treated with contact media, while those treated in 1978 or 1979 were treated with pressure therapy. They found that the average treatment time of the earlier group was 30 months, while the group treated with contact media required an average of nine months. Furthermore, ten children in the first group required surgical release within two years of injury, while none of the children treated with contact media had received surgical release when the article was written in 1987.

Contact media and pressure can be used together. Silicone products are thought to improve scars by hydrating the stratum corneum. Ahn et al reported that scars which were treated with 3.5 millimeter thick silicone gel sheets showed significant improvements at four and eight weeks when compared to scars which were not treated with silicone. However, maceration, rashes, and increased itching may occur in patients treated with silicone.
Continuous Passive Motion

Continuous passive motion (CPM) has been used with success in burn therapy, and positive effects on tissue remodeling, joint nutrition, wound healing, and venous dynamics have been documented, though not with burn patients. CPM is also thought to reduce the risk of heterotopic ossification at the elbow joint, which is thought to be related to more aggressive therapies.

Continuous passive motion machines can be used to improve motion at the shoulder, elbow, hands, hips, knees, and ankles. Some machines can even produce pronation and supination at the elbow and can produce all six major shoulder motions. Some studies have reported a decrease in pain with CPM treatments that may be due to increased afferent activity caused by the moving joint, which may block pain signals. Covey et al reported that CPM did not disrupt skin grafts which were five days old. CPM is especially useful in patients with involvement at multiple joints, patients who cannot actively participate in therapy due to physical or cognitive problems, and patients with excessive pain and/or anxiety. On the other hand, patients who are combative or mentally involved can risk further injury when CPM is used and close monitoring is essential in all cases. Finally, it may be difficult to fit pediatric patients with continuous passive motion.

PROM Under Anesthesia

Passive range of motion of the joints of burn patients under anesthesia has been shown to be effective. Nicosia et al compared the passive range of motion of 110 joints before, during, and after anesthesia, and reported an
average increase of 46% of normal range during anesthesia. Each joint received several minutes of sustained tension during anesthesia.\textsuperscript{65} Range of motion under anesthesia allows the therapist to discern whether the patient is limited by pain or by tissue characteristics.\textsuperscript{65} Nicosia et al\textsuperscript{65(p203)} found that “every joint functioned at least as well in the days after manipulation under anesthesia as it had before; in most cases, the range of motion was increased permanently.” These authors stress the importance of gentle stretching as the patient no longer feels the pain which usually protects him/her from capsular injury and tendon rupture; other concerns included myositis ossificans and heterotopic bone formation which could be caused by overly aggressive stretching.\textsuperscript{56,63,65}
CHAPTER VII
EXERCISE AND THE PEDIATRIC BURN PATIENT

Engrav et al\textsuperscript{26(p1003)} emphasize the importance of physical therapy and exercise treatment by stating, “Function of underlying joints may well be more dependent on the quality of physiotherapy than it is on whether or not such burns are grafted. Full range of motion can be expected in dermal burns regardless of burn wound treatment, provided aggressive physiotherapy is instituted early and the patient is compliant.” Experienced burn teams have found several ways to make exercise more effective.\textsuperscript{32} These include regular scheduling,\textsuperscript{32} scheduling exercise after pain medication,\textsuperscript{2,32} setting clear goals for each session,\textsuperscript{4} and using frequent, short rest periods.\textsuperscript{4} Also, PNF patterns with gentle resistance may actually reduce exercise related pain.\textsuperscript{4} It is also beneficial to treat inpatients in the same gym as outpatients are treated, as the outpatients can lend support and provide an example for the former.\textsuperscript{67} Exercise is contraindicated in patients with dislocations, fractures, tendon or ligament rupture, unstable vital signs, and when patients are combative.\textsuperscript{4}

Compliance is extremely important throughout the exercise program.\textsuperscript{2,25,68} Sheffield et al\textsuperscript{68} used the valid and reliable Quality of Life Index and found that while extent of injury was not significantly related to Quality of Life, noncompliance was significantly related to both decreased Quality of Life and...
range of motion limitation. Furthermore, Moore\textsuperscript{2} stated that noncompliant patients report a more diminished quality of life and report that their lives were impacted by their burn to a greater degree than do compliant patients. Wright\textsuperscript{4} proposed that compliance can be increased by clearly informing the parents on burn treatment issues.

Therapists should consider the following, as children are more prone to pain, fear, and apprehension during exercise than are adults who have similar burns.\textsuperscript{2} Children should be introduced to painful exercises more slowly than are adults,\textsuperscript{4} and their first treatment should not be painful.\textsuperscript{4} Play should be incorporated into therapy and small rewards should be included during the session.\textsuperscript{2,4,14} Each session should start with the most relaxing exercises and work toward the more painful treatments.\textsuperscript{2} Finally, anesthesia, hypnosis, and behavior modification have all been used to ease this often difficult situation.\textsuperscript{2}

Exercise During the Acute Stage

During the initial visit, it is important that a thorough evaluation of range of motion, strength, gait, wounds and dressings, functional status, sensation, pulmonary status, neurological status, and developmental level is conducted.\textsuperscript{4} Range of motion is not lost immediately after a burn, but it is lost as a result of the progressive changes which result from the burn.\textsuperscript{4,32} Exercise begins when the patient has been resuscitated and is medically stable.\textsuperscript{4,69} Early exercise is important in the prevention of joint deformity and the return of strength, endurance, and functional ability.\textsuperscript{1,32,64,69}
Early exercise sessions take place two to three times per day and are aimed primarily at preventing loss of ROM and strength. Pain, edema, and psychological considerations also create obstacles during the acute phase. Wright suggested that acute phase exercise sessions may include passive, active-assistive, and stretching exercises. Giuliani and Perry suggested the use of active exercise and self care during the early treatments. Wright stated that passive exercises are very difficult for the patient and should be used only when the other options are impossible, such as in the case of a comatose patient. Active assistive movements are used if the patient can begin a movement but is unable to move through full range of motion. Finally, Wright stated that stretching can be incorporated into the active assistive exercises. It may be beneficial to use PNF techniques during this phase, and self care should always be promoted.

Wright suggested two types of stretching exercises. First, she proposed passive stretching to the point of blanching for ten repetitions of one minute intervals; second, she suggested that gravity or a small weight be used to work against the contracture for 15 to 20 minutes. Moore suggested that stretching is to be sustained for 10 to 15 seconds at the point of blanching. Stretching is contraindicated by exposed joints or tendons, heterotopic bone formation, underlying fractures, osteopenia, and osteomyelitis.

Exercise and Ambulation after Skin Graft Surgery

The question of exercise after grafting is one of considerable controversy, and each hospital seems to have its own system for instituting exercise after
grafting has taken place. Many burn centers will prohibit exercise of joints near grafts for four to ten days, while others suggest that the graft rest for up to 14 days. If grafts are allowed to rest this long, muscles will atrophy and strength, endurance, and coordination will decrease. Moore stated that approximately 25% of ROM is lost during the post graft stage. She suggested that AROM is instituted four to six days post graft, followed by PROM on the 6th or 7th day.

Burnsworth et al reported that 109 hospitals surveyed reported an average wait of 4.8 days after grafting to begin walking with lower extremity grafts. Interestingly, Burnsworth et al also reported that patients at Mercy Hospital in Pittsburgh were asked to ambulate immediately after recovery from anaesthetic, with 58 patients averaging 30 feet on post operative day 1.7, and graft take was 96.4%. They reported that waiting five days to ambulate caused increases in the areas of dependence on assistive devices, fear of walking, helplessness, complaints of pain, time for return of ankle and knee range of motion, and also increased losses in strength and endurance. Furthermore, Moore reported that a study by Kowalski and colleagues found no significant difference in graft take for patients who ambulated on post operative day three or four when compared to those who waited until day seven, eight, or nine. Early ambulation after grafting has been shown to decrease length of stay. When these patients ambulate, it is important that their lower extremities are wrapped with elastic bandages to prevent venous problems even if their burns do not involve the lower extremities.
Moore supported ambulation with children as soon as vital signs are stable and they are resuscitated. In fact, she reported that children who ambulate while intubated suffer fewer pulmonary complications and have a higher survival rate.

Exercise During the Rehabilitation Phase

Giuliani and Perry defined the rehabilitation phase as the time between wound closure and community readjustment. Moore's definition is more liberal, stating that it begins when the patient gets through the catabolic state and few unhealed areas remain. Kravitz has the most liberal definition, stating that the rehabilitation phase begins when the open areas dip below 20% of body surface area and the patient can perform some self care. Regardless of definition, the focus of this phase is to restore function.

The problems of the rehabilitation phase include fragile new skin, muscle atrophy, continuing psychological problems, and decreases in strength, range of motion, endurance, body weight, coordination, and functional independence.

The therapist must be aware of the overall health of his/her client throughout exercise treatment. Burn patients are less able than others to dissipate heat during exercise because of decreased sweat gland function. Heart rate and blood pressure should be monitored as signs of overheating. The therapist should inspect the patient's skin prior to each exercise session as both grafted skin and skin which has healed by secondary intention are fragile and photosensitive. Blisters are common in these patients because it may take
several months for the dermis and epidermis to bind firmly. New skin is also prone to dryness, flaking, and itching; hence, lanolin based lotion should be used to lubricate the skin before exercise. Lubricants containing perfumes and/or alcohol should be avoided as should soaps with perfumes and/or alcohol.

Exercise during the rehabilitation phase should include continued stretching and will also include active exercise, resistive exercise, cardiopulmonary activity, and functional activities. Pulley exercises, bicycling, upper-extremity ergometer work, isometrics, chin-ups, stairs, wand exercises, and art projects for fine motor coordination are suggested. Keep in mind that these patients would still be wearing pressure garments and receiving anti-contracture therapies.

Parrott et al conducted a study comparing groups of patients with similar burn pathology who either were involved in a structured exercise program or unstructured, individualized daily OT/PT. The group who were involved in the structured exercise program performed the exercises mentioned in the previous paragraph two times per day, while the group who received unstructured treatment were treated individually for one to two hours daily. They found that although the two groups were not significantly different in terms of length of stay, the group who performed structured exercise needed significantly fewer outpatient visits (10.8 vs. 21.2 visits), and they were able to return to work earlier. They felt that the patients benefitted from an organized total body exercise program and patient questionnaires supported this view. They found that the structured group had achieved a higher level of functional independence.
before discharge and that these patients had better exercise habits after discharge than did their counterparts. They felt that structured exercise contributed to self motivation, clear goal setting, and accelerated progress with self care skills. It also allowed new therapists/assistants to jump in and provide consistent care. Finally, the structured exercise program participants were able to work as a group which was thought to be beneficial to the patients socially and made this treatment method more cost effective.

Home Exercise and Post Discharge Patient Education

After discharge the patient needs to continue to combat his/her injury. Patient education should include information on photosensitivity of the new skin. These patients need to avoid sunlight by covering themselves with clothing; exposed areas should be protected with sunscreen with an SPF of 15. Sunlight should be avoided for one year. Video can be used as an effective patient/family education device, and demonstrations of stretching and exercise routines should be sent home with the patient. Stretching and massage treatments will continue two to three times per day, and splinting and pressure treatments will continue as well.
CHAPTER VIII

CONCLUSION

As survival rates of pediatric burn victims increase, so too does the demand for competent therapy professionals who are interested in treating them. Burned children present a very challenging and unique problem to therapists; pain and compliance issues are especially complex with this population. Several differences between pediatric burn therapy and adult burn therapy were found. It is important to highlight them now. First of all, anatomical differences between children and adults, such as skin thickness and body surface to weight ratio, are influential in the treatment and prognosis of their injuries. Since compliance with scar management is very difficult with children, methods such as splinting and serial casting may be used more often than with adults, while positioning and exercise may play less of a role. Pediatric therapy may not end with scar maturity as the effects of growth on healed and/or scarred skin may force a patient to return for further therapy or surgery. The classification and documentation of burns in children are often different than classification and documentation of adult burns. Finally, the therapist must be aware of the specific burn patterns which signify abuse.

Many specifically pediatric concerns are related to pain and psychological issues. Burn therapists must strive to understand the role of child psychology
and play therapy. Therapists must watch what they say in front of young victims as words such as “cut” and “dead tissue” will only increase anxiety in an already anxious child. Also, young children do not understand that some beneficial treatments are necessarily painful. Patient education with children is simple and visual and parental participation and education are more central in pediatric burn cases. Special considerations for the modesty of the patient and consistent scheduling are important for all burn victims, especially those who are young. Finally, returning to school is an important step in recovery which can be made more smooth by a conscientious therapist.

In this review, information on various treatment methods used to treat children with burns was gathered and, where possible, outcome information was included. Continued research, especially outcome studies, can only help to make pediatric burn therapy more effective.
Positioning Table\textsuperscript{1,7,23}

<table>
<thead>
<tr>
<th>Body Part</th>
<th>Positioning Suggestions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neck</td>
<td>Slight Hyperextension</td>
</tr>
<tr>
<td>Shoulder</td>
<td>90 degrees abduction and 15-20</td>
</tr>
<tr>
<td>Wrist</td>
<td>Slight Extension and Supination</td>
</tr>
<tr>
<td>Hand</td>
<td>Anatomic Position or MCP flexion</td>
</tr>
<tr>
<td>Thumb</td>
<td>Palmar Abduction</td>
</tr>
<tr>
<td>Hip</td>
<td>Neutral or extension and abduction</td>
</tr>
<tr>
<td>Knee</td>
<td>Full Extension</td>
</tr>
<tr>
<td>Ankle/Foot</td>
<td>Neutral</td>
</tr>
</tbody>
</table>
REFERENCES


38. Mahaney NB. Restoration of play in a severely burned three-year-old child. 


