DISSERTATION ON

CLINICO-PATHOLOGICAL CORRELATION AND ASSESSMENT OF BURN WOUNDS

Dissertation submitted to

THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY

In partial fulfillment of the regulations for the award of the degree of

MASTER OF SURGERY

IN

GENERAL SURGERY

THANJAVUR MEDICAL COLLEGE,

THANJAVUR - 613 004

THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY

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APRIL -2015

CERTIFICATE

This is to certify that this dissertation entitled "**CLINICO-PATHOLOGICAL CORRELATION AND ASSESSMENT OF BURN WOUNDS"** is the bonafide work of **Dr.J.Rajarajan** in partial fulfilment of the requirements for M.S Branch -I (General Surgery) Examination of the Tamilnadu Dr. M.G.R. Medical University to be held in APRIL - 2015 under my guidance and supervision during the academic year January- 2014 to July - 2014.

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DECLARATION

I, **Dr.J.RAJARAJAN**, solemnly declare that the dissertation titled **"CLINICO-PATHOLOGICAL CORRELATION AND ASSESSMENT OF BURN WOUNDS"** is a bonafide work done by me at Thanjavur Medical College, Thanjavur during January - 2014 to July - 2014 under the guidance and supervision of **Prof. Dr. G.RAJENDRAN M.S., F.I.C.S.,** Thanjavur Medical College, Thanjavur.

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ABSTRACT

CLINICO-PATHOLOGICAL CORRELATION AND ASSESSMENT OF BURN WOUNDS

INTRODUCTION:

Trauma can be defined as bodily injury severe enough to pose a threat to life, limbs, and tissues and organs, which requires the immediate intervention of specialized teams to provide adequate outcomes. Burn wound biopsies classified as to the depth of infections,confirm the frequent occurrence of bacterial, fungal and viral infection in burn wounds and also provide document for the importance of increasing severity of infection on successive biopsies. Burn wound biopsy can distinguish microbial colonization from invasive infection which can guide patient's treatment.

AIMS AND OBJECTIVES: 1.The study is designed to analyse the clinico-pathological profile of burn patients with wound sepsis.

2. To carry out histo pathological assessment of burn wounds and burn wound infections.3. To correlate histo pathological findings with the clinical findings.

MATERIALS AND METHODS:

The present study was conducted in Thanjavur Medical College, Tamil Nadu . 132 patients with varying extent of burns, starting from 30% of Total Body Surface Area (TBSA), were studied prospectively over a period of two years from September 2012 to September 2014. All the relevant demographic, clinical and laboratory data required were obtained from clinical records. Serial wound evaluation along with general condition of the patient, serial wound swabs for culture and sensitivity and biopsies were taken.

OBSERVATIONS AND RESULTS:

The maximum number of patients comprised of age group 21-30 years (37.88%). The commonest cause of burn was flame burn (93.93%) followed by scald (2.27%), chemical burn(2.27%) and electrical burn (1.51%) respectively. Maximum cases had burns in the range of 30-40% TBSA (24.24%). This was followed by burns in the range of 41-50%(15.15%), 51-60%(12.88%), 71-80%(12.88%), 61-70%(12.12%),81-90%(11.36%),91-100%(11.36%) TBSA respectively. Patients having burn more than 60% TBSA had 100% mortality when followed up.

The evaluation of degree (depth) of burn was found to be more accurate by histological assessment than by clinical assessment. It was seen that maximum number of cases had deep burns followed by mixed or indeterminate type of

involvement. Presence of bacterial growth on the surface as well as in the eschar and sub-eschar tissue was seen in most biopsies. This represented ‘colonization’ and not true ‘invasion’ which was seen as presence of bacteria in the adjoining viable tissue.

The microbiological studies revealed that Pseudomonas is predominant organism isolated from burn wound followed by Klebsiella, Proteus, Staphylococcus and Escherichia coli in decreasing order. There was a good correlation between surface swab culture reports and tissue biopsy culture reports as far as the type of organism isolated from the burn wound is concerned. However the surface swab culture reports showed growth in almost all cases, which was probably due to surface contamination.Whereas tissue biopsy culture reports showed positive findings (82.5%) mostly in cases with suspicion of infection. This finding suggested that tissue biopsy culture is a more reliable indicator of wound infection than surface swab culture where chances of contamination are more.The calculation of bacterial load per gram of tissue, done in 45 cases, showed positive results (count>10^5) in 35 cases and all the 35 cases went into septicemia.

CONCLUSION

Thus we concluded that, biopsy of the burn wound plays an important role in proper assessment of burn wound and in making accurate diagnosis. It not only helps in identifying the healing potential of a burn wound but also helps in detecting burn wound infection/sepsis, if aided by proper microbiological assessment.

CLINICO-PATHOLOGICAL CORRELATION AND ASSESSMENT OF BURN WOUNDS

INTRODUCTION

Trauma can be defined as bodily injury severe enough to pose a threat to life, limbs, and tissues and organs, which requires the immediate intervention of specialized teams to provide adequate outcomes. Burn injury, unlike other traumas, can be quantified as to the exact percentage of body injured, and can be viewed as a paradigm of injury from which many lessons can be learned about critical illness involving multiple organ systems. Proper initial management is critical for the survival and good outcome of the victim of minor and major thermal trauma. Tissue burns involve direct coagulation and microvascular reactions in the surrounding dermis that may result in extension of the injury. Large injuries are associated with a systemic response caused by a loss of the skin barrier, the release of vasoactive mediators from the wound and subsequent infection. Infection is an inevitable complication of extensive burns (more than 30% body surface) and a major cause of morbidity and mortality. In burns,skin barrier is replaced by eschar. This moist, protein rich avascular environment encourages microbial growth. Migration of immune cells is hampered, and there is a release of intermediaries that impede the immune response. Eschar also restricts distribution of systemically administered antibiotics because of its avascularity. Burn wound infection has to be differentiated between colonization of the burn wound and burn wound sepsis which is characterized by microbial invasion of viable tissue beneath the eschar. Gauging burn wound sepsis by clinical signs and symptoms is difficult. Burn wound biopsies classified as to the depth of infections,confirm the frequent occurrence of bacterial, fungal and viral infection in burn wounds and also provide document for the importance of increasing severity of infection on successive biopsies.Wound swab culture /sensitivity cannot differentiate between wound colonization and wound sepsis. Burn wound biopsy can distinguish microbial colonization from invasive infection which can guide patient's treatment.

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REVIEW OF LITERATURE

ANATOMY AND FUNCTION OF SKIN

The skin is the largest organ in the body, making up 15% of body weight,and covering approximately 1.7 m^2 in the average adult. The function of the skin is complex: it warms, it senses, and it protects. A burn injury implies damage or destruction of skin and/or its contents by thermal, chemical, electrical, or radiation energies or combinations thereof. Thermal injuries are by far the most common and frequently present with concomitant inhalation injuries. Of its two layers,only the epidermis is capable of true regeneration. When the skin is seriously damaged, this external barrier is violated and the internal milieu is altered.Following a major burn injury, myriad physiological changes occur that together comprise the clinical scenario of the burn patient. These derangements include the following:

Fluid and electrolyte imbalance: The burn wound becomes rapidly edematous.In burns over 25% BSA, this edema develops in normal noninjured tissues. This results in systemic intravascular losses of water, sodium, albumin, and red blood cells and henceby shock if untreated.

Metabolic disturbances: This is evidenced by hypermetabolism and muscle catabolism. Unless early enteral nutrition and pharmacological intervention restore it, malnutrition and organ dysfunction develop.

Bacterial contamination of tissues.

Complications from vital organs.

TABLE Functions of Skin

– Protective Barrier

Immunological

Fluid evaporation

Thermal (insulation, sweat production, vasomotor thermoregulation)

– Sensory

– Metabolic (vitamin D synthesis and excretory function)

– Social (self-image, social image)

The successful treatment of burn patients includes the intervention of a multidisciplinary burn team. The philosophy of care is based on the concept that each patient is an individual with special needs. Each patient's care, from the day of admission, is designed to return him or her to society as a functional, adaptable, and integrated citizen.

INITIAL BURN MANAGEMENT

The general trauma guidelines apply to the initial burn assessment. A primary survey should be undertaken in the burn admission's room or in the Accidents and Emergency Department, followed by a secondary survey when resuscitation is underway.

The primary survey should focus on the following areas:

Airway (with C-spine control): Voice, air exchange, and patency should be noted.

Breathing: Check breath sounds, chest wall excursion, and neck veins.

Circulation: Mentation should be noted. Check skin color, pulse, blood pressure, neck veins, and any external bleeding.

Disability-Neurological assessment: Check Glasgow coma score.

Expose the patient and environment control-keep warm

At this point a rough estimate of the extent of the injury should be made and resuscitation efforts focus on physiological derangements.

INITIAL ASSESSMENT OF THE BURNED PATIENT

Treatment of the burn injury begins at the scene of the accident. The first priority is to stop the burning. The patient must be separated from the burning source. For thermal burns, immediate application of cold compresses can reduce the amount of damaged tissue. Prolonged cooling, however, can precipitate a dangerous hypothermia. For electrical burns, the source should be removed with a nonconducting object. In cases of chemical burns, the agent should be diluted with copious irrigation, not immersion. The initial physical examination of the burn victim should focus on assessing the airway, evaluating hemodynamic status, accurately determining burn size, and assessing burn wound depth. Immediate assessment of the airway is always the first priority. Massive airway edema can occur, leading to acute airway obstruction and death. If there is any question as to the adequacy of the airway, prompt endotracheal intubation is mandated. All burn victims should initially receive 100% oxygen by mask or tube to reduce the likelihood of problems from pulmonary dysfunction or carbon monoxide poisoning. The next step is to place two large-bore peripheral intravenous catheters,since delays in resuscitation carry a high mortality. Patients with burns of less than 15% (10% in children) BSA who are conscious and cooperative can often be resuscitated orally. The patient with more than 15% (10% in children)

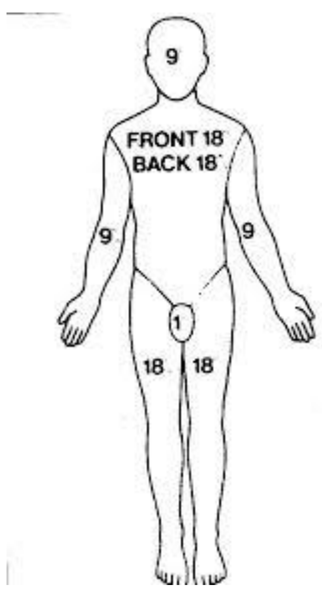
BSA burn requires IV access. Begin infusion of Ringer's lactate solution of about 1000 ml/h in adults, 400–500 ml/m2 BSA/h in children, until more accurate assessments of burn size and fluid requirements can be made. An indwelling Foley catheter should be placed to monitor urinary output. A nasogastric tube is inserted for gastric decompression.It is also imperative during the initial assessment to make a brief survey of associated injuries. A thorough secondary survey can be postponed, but lifethreatening injuries such as cardiac tamponade, pneumothorax, hemothorax, external hemorrhage, and flail chest must be identified and treated promptly.

Patient evaluation should include what is termed an AMPLE history: allergies, medications, pre-existing diseases, last meal, and events of the injury, including time, location, and insults. In children the developmental status should be investigated and any suspicious injuries should raise the possibility of child abuse. A history of loss of consciousness should be sought. A complete physical examination should include a careful neurological examination, since evidence of cerebral anoxic injury can be subtle. While the initial resuscitation has been started,a thorough physical examination is performed. All systems should be examined,including genital and rectal examination. Associated injuries should be ruled out at this stage and treated accordingly. All extremities should be examined for pulses, especially in patients with circumferential burns. Evaluation of pulses can be assisted by use of a Doppler ultrasound flowmeter. If pulses are absent, and fluid resuscitation is adequate, the involved limb should undergo urgent escharotomy to release the constrictive eschar. It must be noted, however, that the most common cause of pulseless limbs is inadequate resuscitation. Therefore, the intravascular status of the patient must be assessed before proceeding with escharotomies.

The primary and secondary survey as well as the initial resuscitation should be performed under thermal panels or in a high-temperature environment. Burned patients can become rapidly hypothermic. Should this complication occur, it carries a high mortality. Thermal blankets and fluid warmers are good aids in fighting hypothermia.

Burn Wound Assessment

After the patient's stabilization and initial resuscitation, physicians should focus on the burn wound. Burns are gently cleansed with warm saline and antiseptics, and the extent of the burn is assessed. Burn injury must be categorized as the exact percentage of BSA involved. The rule of nines is a very good approximation as an initial assessment .Another good rule of thumb is measuring the extent of the injury with the palm of the burn victim, which is estimated as 1% BSA. The area burned is transformed as the number of hand palms affected and then multiplied by 1%.



Secondary Assessment

1. Initial trauma assessment and primary assessment completed.

2. Thorough head-to-toe evaluation.

3. Careful determination of trauma other than obvious burn wounds.

4. Use cervical collars, backboards, and splints before moving the patient.

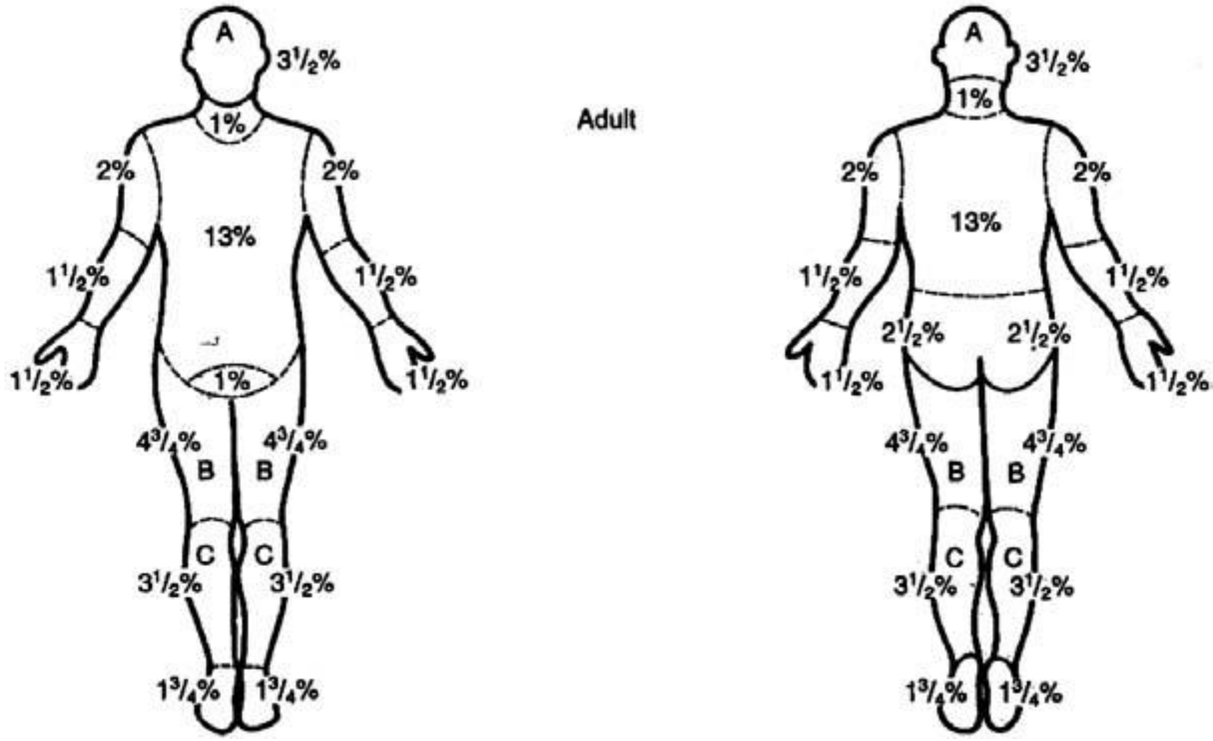
5. Examine past medical history, medications, allergies, and mechanism of injury.

6. Establish intravenous access through large peripheral catheters and administer intravenous fluids through a warming system.

7. Protect wounds from the environment with application of clean dressings

8. Determine needs for transportation. Contact receiving facility for further instructions.

Age	0–1	1–4	5–9	10–14	15
A – $\frac{1}{2}$ of head	$9\frac{1}{2}\%$	$8\frac{1}{2}\%$	$6\frac{1}{2}\%$	$5\frac{1}{2}\%$	$4\frac{1}{2}\%$
B – $\frac{1}{2}$ of one thigh	$2\frac{3}{4}\%$	$3\frac{1}{4}\%$	4%	$4\frac{1}{4}\%$	$4\frac{1}{2}\%$
C – $\frac{1}{2}$ of one leg	$2\frac{1}{2}\%$	$2\frac{1}{2}\%$	$2\frac{3}{4}\%$	3%	$3\frac{1}{4}\%$



Lund and Browder Chart

The best way to measure the area burned accurately is the Lund and Browder Chart In this method, the areas burned are plotted in the burn diagram,and every area burned is assigned an exact percentage. The Lund and Browder method takes into consideration the differences in anatomical location that exist in the pediatric population and therefore does not over or underestimate the burn size in patients of different ages. After the burn size is determined, the individual characteristics of the patient should be plotted in a standard nomogram to determine the body surface area and burned surface area of the patient .Measuring and weighing the patient in centimeters and kilograms provides the surface area of the patient in square meters. This measurement will help to calculate metabolic needs, blood loss, hemodynamic parameters, and skin substitutes.

At this point, the specific anatomical location of the burn should be noted as well as the depth of the burn per location. These measurements are to be noted also in the burn diagram, and will help in planning individual treatment for the patient. The eyes are to be explored with fluorescein and green lamp to rule out corneal damage; the oral cavity and perineum are explored to rule out any obvious internal damage.

In ventilated patients or patients with suspected smoke inhalation injury, direct bronchoscopy should be performed to determine the extent of the injury, and also aids in diagnosis and therapeutic lavage of soot and damaged epithelium. After direct bronchoscopic examination is completed, a definitive diagnosis is made based on clinical, laboratory, and bronchoscopic findings.After definitive assessment in the burn center, a final diagnosis regarding the burn wounds (extent and depth), accompanying injuries, and smoke inhalation injury is reached. At this point burn wounds should be covered with a clean burn wound dressing. Compressive dressings should be avoided, because they can induce further hypoperfusion and conversion of partial-thickness wounds to full-thickness. When the treatment of choice of full-thickness burns is early burn wound excision in 72 h, after resuscitation is completed, burns can be treated either with 1% silver sulfadiazine during the period between the accident and the definitive surgery. Partial-thickness burns are treated in a similar initial manner.

Determining burn depth requires experience. It is an important part of the burn assessment because the depth of the burn will determine the treatment option and the patient's outcome. It must be noted, however, that even in the hands of experienced burn surgeons clinical inspection alone can be misleading in more than 40% of patients, leading to an under-or overestimate of the depth of the burn wound. Laser Doppler scanning has emerged as a good tool in the proper assessment of depth but its expensive and available in only few centres. The evaluation of degree (depth) of burn was found to be more accurate by histological assessment than by clinical assessment in many studies and is economical .

A **B**

The laser Doppler scanner (A) is helpful for the diagnosis of burn wound depth. Its sensitivity and specificity are best between 48 and 72 h after the injury.

It is placed over the area to be scanned (B), and in few seconds it produces a digitized image of the burn wound.

Partial-Thickness Burns

Cover burns with clean dressing until definitive diagnosis by experienced burn surgeon .

Minor burn: semiocclusive dressing (special locations: silver sulfadiazine)

Large burn: Synthetic artificial skin or pig skin

Full-Thickness Burns

Immediate burn wound excision protocol (24 h): – Telfa clear or plastic film

Early burn wound excision protocol (72 h): silver sulfadiazine or cerium nitrate–silver sulfadiazine

Staged excision protocol (first week): cerium nitrate silver sulfadiazine

of burn depth. It provides good mapping of the depth of the wound, especially in those burns defined as of indeterminate depth

BURN WOUND CATEGORIZATION

Burn wound have been classically categorized as first-, second-, and third degree.

First-degree burns are superficial and involve just the epidermis. Typified by sunburn, first-degree burns are inconsequential in subsequent burn management.They heal in 5–7 days. Oral intolerance and severe discomfort requiring hospitalization may accompany large first-degree burns. These burns have a red,hyperemic appearance of the surface, which, along with the hypersensibility and discomfort, is typical of these injuries

Second-degree burns, also called partial-thickness burns, involve variable amounts of dermis .Second-degree burns are subdivided into superficial and deep second-degree wounds.

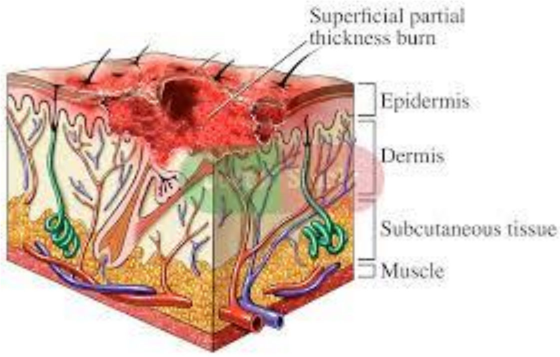
In **superficial** second-degree burns, the epidermis and the superficial (papillary) dermis have been damaged. Blistering and extreme pain are typical. Sensation is preserved with different degrees of hyperesthesia. A moist, pink appearance that blanches with pressure, along with extreme pain and hyperesthesia, is common in these injuries. Regeneration occurs by proliferation of epithelial cells from hair follicles and sweat gland ducts. Healing is almost complete within 3 weeks, leaving no scarring if no complications occur. Surgery is seldom needed in this injury.

In **deep** second-degree burns, however, the epidermis, papillary dermis, and various depths of the reticular (deep) dermis have been damaged. Regeneration occurs much more slowly than in superficial burns. Complete healing take more than 3 weeks and scarring and infection are common. These injuries are best treated surgically, since excision of the dead tissue and skin grafting shorten hospital stay and improve outcomes. Deep second-degree burns tend to be hypoesthetic,presenting with less pain than superficial burns. They have a white–pink appearance and blistering does not normally occur, or is present many hours after the injury. A dry appearance is common.

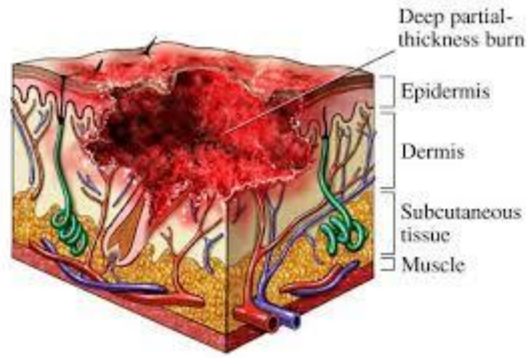
1st degree burn

First-degree burns. Only the epidermis has been damaged. Typical appearance is that of a hyperemic area with severe discomfort and hyperesthesia.

Such burns do not blister, and they generally desquamate between 4 and 7 days after injury.



Second-degree burn injuries (or partial-thickness burns) present with different degrees of damage to the dermis. Pain is very intense . They usually blanch with pressure and do not usually leave any permanent scarring.

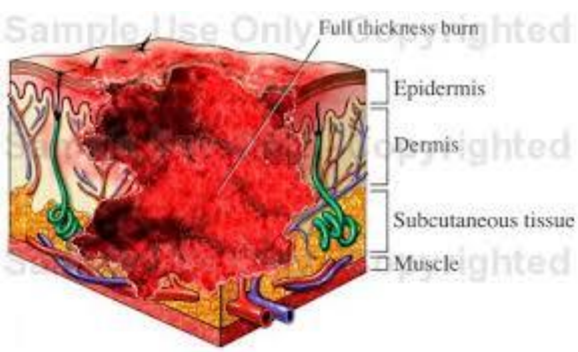


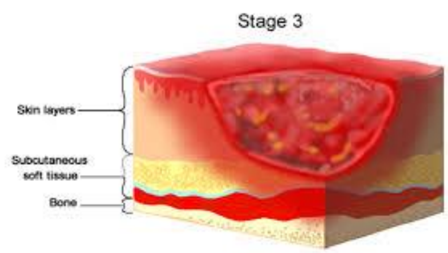
Deep second-degree burns present with lesser degrees of pain

and usually a prolonged healing time. Deep portions of the dermis have been

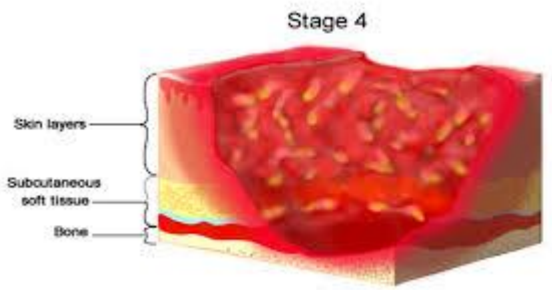
damaged and they tend to leave permanent changes on the skin .

In contrast to the former injuries, **third degree burns or full-thickness burns** never heal spontaneously, and treatment involves excision of all injured tissue In these injuries, epidermis, dermis, and different depths of subcutaneous and deep tissues have been damaged. Pain involved is very low (usually with marginal partial-thickness burns) or absent. The potential for infection if left non excised is very high. A dry, white, or charred appearance is common. In infants and patients with immersion scalds, the burns may appear cherry red, and they may be misleading .





Third-degree burns present with complete destruction of the skin and different degrees of soft tissues .Their appearance ranges from white, nonblanching,and leathery to nonblanching, red discoloration due to hemoglobin denaturation



Burns that affect deep structures, such as bones and internal organs, are categorized as **fourth-degree burns**. These injuries are typical of high-voltage electrical injuries and flammable agents, and have a high mortality rate. Some partial-thickness burns, however, present with a mixture of depths, with areas that are very difficult to categorize either as superficial or deep partial-thickness. They are usually termed indeterminate depth burns. Management of these injuries has been conservative treatment for 10–14 days followed by a second assessment and definitive diagnosis. Burns that then have the potential to heal in less than 3 weeks do not require skin grafting. In contrast, burns that will not heal at that point within 3 weeks are then operated on and skin grafted.

After a definitive diagnosis has been made regarding size and depth, burns can be classified as minor, moderate, or major injuries A **major** burn injury is defined as greater than 25% BSA involvement (15% in children) or more than 10% BSA full-thickness involvement. Major burns require aggressive resuscitation, hospitalization, and appropriate burn care. Additional criteria for major burns include deep burns of the hands, feet, eyes, ears, face, or perineum; inhalation injuries; associated medical conditions; extreme age; and electrical burns.

Moderate thermal burns of 15–25% BSA or 3–10% BSA full-thickness often require hospitalization to ensure optimal patient care. Other criteria for admission include concomitant trauma, significant pre-existing disease, and suspicion of child abuse.

Minor burns can generally be treated on an outpatient basis.

LABORATORY AND COMPLEMENTARY TESTS

Routine admission laboratory evaluations should include the following:

Complete blood count

Coagulation tests, including D-dimmers and fibrinogen

Blood group type and screen

Glucose

Blood urea nitrogen (BUN)

Creatinine

Total proteins, albumin, and globulins

Serum electrolytes

Calcium, phosphorus, and magnesium

Osmolality

Liver function test

C-reactive protein

Total CO2

Arterial blood gas, including lactate and Carboxyhemoglobin (HbCO)

Urine analysis, including urine electrolytes

Creatine phosphokinase (CPK), CPK-MB, and troponine in electrical injuries

Other complementary tests include chest x-ray and other x-ray examinations performed on an individual basis. A 12 lead electrocardiogram should be obtained in all patients on admission and should repeated periodically in all electrical injuries.Routine cultures are obtained on admission as part of the infection control protocol. They are then repeated twice per week unless dictated otherwise by the patient's clinical picture. Cultures should include blood, urine, sputum, throat, wound, and gastric/jejunal aspirates. Feces are sent for culture when available. Ultrasonography, endoscopy, bronchoscopy, and other evaluations should be readily available on an individual patient basis.

FLUID RESUSCITATION

The most crucial aspect of early care of the burn patient is prompt initiation of volume replacement of large quantities of salt-containing fluids to maintain adequate perfusion of vital organs. Many formulas for burn resuscitation have proven clinically efficacious, and each differs in volume, sodium, and colloid content. The aim of any fluid resuscitation is to have a lucid, alert, and cooperative patient with good urine output.

Guidelines for correct resuscitation include the following:

Do not delay resuscitation.

Estimate burn size and calculate fluid requirements.

Fluid formulas are only a guideline; monitor urine output and tailor intravenous fluids to the response of the patient.

Monitor peripheral pulses, blood pressure, respiration rate, heart rate, urine output, oxygen saturation, and temperature (core/peripheral).

Monitor central venous pressure and/or cardiac output and hemodynamic parameters in severe burns or patients at risk for complications.

Achieve a urine output of 0.5 ml/kg/h in adults and 1 ml/kg/h in children,

no more, no less

Elevate the head, limbs, and genitalia; elevate all that can be elevated.

Maintain the core temperature of the patient over 37_C.

Start enteral feeding on admission.

The aim is to obtain an awake, alert, conscious, and cooperative patient.

Do not obtain a replica of the Michelin Man; prevent edema.

The recommended resuscitation formulas for adults and children are the modified Parkland formula for adults and the Galveston formula for children. In each, half of the volume is administered in the first 8 h and the rest in the second 16 h.

Adult burn patients are resuscitated with the modified Parkland formula.

It calls for the infusion of 3 ml/kg/% burn in the first 24 h postburn of Ringer's lactate solution. In the subsequent 24 h, transcutaneous evaporative losses from burn wounds are replaced at 1 ml/kg/% burn daily. The rate is adjusted hourly to ensure a urinary output of 0.5 ml/h.

RESUSCITATION IN PEDIATRIC BURNS

Resuscitation of burned children differs in two aspects. First, the Parkland formula commonly underestimates fluid requirements in a burned child and may not provide even the usual daily maintenance requirements. There is great variability between body surface area and weight in a growing child. More accurate estimation of resuscitation requirements in burned children can be based on BSA determined from nomograms of height and weight .For children, recommended initial resuscitation is 5000 ml/m2 BSA burned/day plus 2000 ml/m2 BSA total/day of Ringer's lactate. Again, one-half is given over the first 8 h and the rest in the next 16 h during the first 24 h postburn. Due to small glycogen stores, infants require glucose since they are prone to hypoglycemia in the initial resuscitation period; therefore, the basal maintenance fluid administration is given as 5% glucose-containing solutions. In the subsequent 24 h fluid requirements are 3750 ml/m2 BSA burned/day plus 1500 ml/m2 BSA total/day. Care should be taken to avoid rapid shifts in serum sodium concentration, which may cause cerebral edema and neuroconvulsive activity. The rate is adjusted to ensure a urinary output of 1 ml/kg/h . Patients in air-fluidized beds should receive 1000 ml/m2 BSA/24 h extra fluids to replace the evaporative fluid loss produced by the bed.

Enteral feeding is usually started on admission and gradually increased until the maximum full rate is achieved. As the enteral feeding volume is increased and absorbed by the patient, intravenous fluid are diminished at the same rate, so that the total amount of resuscitation needs are met as a mixture of IV fluids and enteral feeding. By 48 h, most of the fluid replacement should be provided via the enteral route.

All resuscitation formulas are meant to serve as guides only. The response to fluid administration and physiological tolerance of the patient is most important.

Resuscitation Formulas for Pediatric and Adult Patients

Pediatric Patients

First 24 h:

5000 ml/m2 BSA burned/day + 2000 ml/m2 BSA total/day of Ringer's lactate (give half in first 8 h and the second half in the following 16 h)

Subsequent 24 h:

3750 ml/m2 BSA burned/day + 1500 ml/m2 BSA total/day (to maintain urine output of 1ml/kg/h)

Adult Patients

First 24 h: 3 ml/kg/% BSA burned of Ringer's lactate (give half in first 8 h and the second half in the following 16 h)

Subsequent 24 h: 1 ml/kg/% burn daily (to maintain urine output of 0.5 ml/kg/h)

Additional fluids are commonly needed in patients with inhalation injuries, electrical burns, associated trauma, and delayed resuscitation. Fluid resuscitation should be started according to the fluid resuscitation formula. Fluid administration needs then to be tailored to the response of the patient based on urine output in a stable, lucid cooperative patient. The ideal is to reach the smallest fluid administration rate that provides an adequate urine output. The appropriate resuscitation regimen administers the minimal amount of fluid necessary for maintenance of vital organ perfusion. Inadequate resuscitation can cause further insult to pulmonary, renal, and mesenteric vascular beds. Fluid overload can produce undersized pulmonary or cerebral edema. It will also increase wound edema and thereby dermal ischemia, producing increased depth and extent of cutaneous damage.

Fluid requirements in patients with electrical injuries are often greater than those in patients with thermal injury. The main threat in the initial period is the development of acute tubular necrosis and acute renal insufficiency related to the precipitation of myoglobulin and other cellular products. A common finding in patients with electrical injuries is myoglobinuria, manifested as highly concentrated and pigmented urine. The goal under these circumstances is to maintain a urine output of 1–2 ml/kg/h until the urine clears. In nonresponding patients,alkalization of the urine and the use of osmotic agents may prevent death.

The use of colloid solutions for acute burn resuscitation remains debated. Development of hypoproteinemia in the early resuscitation period increases edema in nonburned tissues. In the absence of inhalation injury, however, lung water content does not increase. Early infusion of colloid solutions may decrease overall fluid requirements in the initial resuscitation period and reduce nonburn edema. However, injudicious use of colloid infusion may cause iatrogenic pulmonary edema, increasing pulmonary complications and mortality. The current recommendation is to add 25% albumin solution to maintain serum albumin 2.5

g/100 ml after the first 8 h. In selected cases, it can be supplemented in the first 8 h postburn. Albumin solution 5% should be used instead of 25% solution in unstable patients with hypovolemia.

Fluid resuscitation should be monitored using clinical parameters. The best single indicator is urine output. Hypotension is a late finding in burn shock; therefore, pulse rate is much more sensitive than blood pressure. Normal sensorium,core temperature, and adequate peripheral capillary refill are additional clinical indicators of adequate organ perfusion. Fluid shifts are rapid during the acute resuscitation period (24–72 h), and serial determinations of hematocrit, serum electrolytes, osmolality, calcium, glucose, and albumin can help to direct appropriate fluid replacement.

Although overresuscitation is usually easy to detect, based on increasing edema and high urine output; underresuscitation may be much more difficult to diagnose and categorize. Persistent metabolic acidosis on measurement of arterial blood gases may be indicative of continuing hypoperfusion from hypovolemia. Patients with a low cardiac output despite correct resuscitation are candidates for inotropic support. On the other hand, if cardiac output is normal, patients are candidates for colloid administration. If patients do not respond to any of the resuscitation measures, continuous hemofiltration or plasmapheresis should be attempted

MONITORING AND PATIENT CONTROL

Patients with major burns should receive full monitoring, including:

Continuous electrocardiograph monitoring

Continuous respiratory rate monitoring

Pulse oximetry

Central venous pressure

Arterial line

Foley catheter and urine output

Temperature probes

Capnometry (ventilated patients)

Pulmonary artery catheter (unstable severe burn patients)

Esophageal Doppler monitoring (alternative to Swan-Ganz catheters)

Doppler monitor for compartment syndromes

Central lines and arterial lines do carry some morbidity in burned patients. Judicious use of these otherwise helpful monitoring devices is advised. Monitoring of central venous pressure is indicated in patients with massive burns, those refractory to normal resuscitation maneuvers, elderly patients, and patients with significant pre-existing diseases. In general, a stable patient with burns under

40%BSA without significant pre-existing diseases can be managed without central line catheters. Control of blood pressure, pulse rate, pulse oximetry, respiratory rate,temperature, weight, and urine output should suffice in most of the patients. Blood pressure is often monitored using arterial lines. In most cases, however, indirect measure of blood pressure along with the physiological parameters mentioned earlier and the valuable addition of pulse oximetry are more than enough to monitor the patient. Arterial lines should be reserved for use in unstable patients,those with inhalation injury, unstable patients receiving ventilatory support, and patients who will need repeated blood gas analysis. Catheter-related sepsis has plagued burn patients for decades. With the advent of modern indwelling catheters,and strong policies for periodical line change, the incidence of catheter related sepsis has declined dramatically. The usual recommendation is to change all lines every 7 days. Nevertheless, increasing evidence suggests that lines do not need to be changed unless they become infected. Care of the line should include daily inspection of entry point and daily dressing with dry compresses. Occlusive dressings and antibiotic creams are not effective to control infection, and there are reports that they may even increase the risk of infection.

After initial management in the admission room, patients are then transferred to their room. A controlled environment should be provided, with a high temperature (24–28 deg C) and at least 50%humidity. Patients are covered and placed under thermal panels. These panels provide a central area just over the patient with a high temperature (ideally 36 deg C) whereas in the rest of the room the environmental conditions, although still warm, are cool enough to allow reasonable comfort for health personnel. Head, limbs, and genitalia are to be elevated, and the patient should be positioned comfortably over the patient, allowing a lower temperature in the rest of the environment for staff and visitor comfort.

Patients should be encouraged to walk and mobilize as soon as possible, and early physiotherapy should be started. Patients should never be at bed rest unless absolutely necessary. Patients must be comfortable and pain free and patients and families should be trained in wound care and rehabilitation.

All patients need to be closely monitored by burn physicians. A formal morning round should be established, with review of all systems and wounds when deemed necessary. All altered parameters need to be corrected. Performing an informal evening round to check the daily progress of the patient, and corrections undertaken is useful to decide which patients need to have their wounds inspected the next morning. These multidisciplinary visits are completed with a biweekly multidisciplinary meeting at which the discharge planning for patients is discussed in full.

Emergency treatment focuses on stabilization of patients, treatment of associated injuries, fluid resuscitation, initial respiratory support, and emergency treatment of the burn wound. Soon after stabilization and resuscitation, a formal discharge plan (treatment plan, rehabilitation plan, and social support) is established.Focus of burn treatment is then shifted to the definitive burn wound treatment and to the general support of the patient, which include:

Nutritional support

General patient support

Support of the hypermetabolic response

Treatment of inhalation injury

Pain management and psychosocial support

Infection control and treatment of critical conditions

Rehabilitation

NUTRITIONAL SUPPORT

The hypermetabolic response to burns is the greatest of any other trauma or infection.A major burn injury provokes a complex disruption of hormonal homeostasis that induces an increased resting metabolic rate and oxygen consumption, increased nitrogen loss, increased lipolysis, increased glucose flow, and loss of body mass. To meet postburn energy demands, all main metabolic pathways are utilized. Carbohydrate stores are small; therefore, carbohydrate intermediate metabolites, which are also essential for fat catabolism, are obtained from skeletal muscle breakdown, thus increasing muscle catabolism. Prolonged inflammation,pain or anxiety, environmental cooling, and sepsis can further exaggerate this postburn hypermetabolic response.

One of the main principles underlying successful management of the postburn hypermetabolic response is providing adequate nutritional support. In general, patients affected with more than 25% body surface area (BSA) burned and those patients with malnutrition or who cannot cope with their metabolic demands as a result of concomitant injuries or diseases should receive nutritional support. The nutritional formula of choice is enteral nutrition. Total parenteral nutrition should be abandoned and reserved for patients who cannot tolerate the enteral route. It carries a high mortality in burn patients.

A nasogastric tube should suffice in most patients. In tubefeeding regimen, the gastric residuals should be checked regularly. Once the residual has been checked, it is then infused back to the stomach to avoid electrolytic imbalances and alkalosis. If these residuals are more than a 2 h tube feeding infusion rate, the feeding should be stopped and the cause investigated. The most common cause of enteral feeding intolerance is tube malposition, although important causes of intolerance that all physicians should bear in mind are sepsis and multiple organ failure. The enteral feeding should be started on admission and continued until the wounds are 90% healed and the patient can maintain an oral intake of his or her caloric demand.

Enteral feeding is started on admission and, if absorbed, it is increased until full strength is obtained, ideally in the first 24 h. The hourly absorbed nutrition is subtracted from the total resuscitation hourly fluids the patient is receiving, in order to avoid overloading. When patients are scheduled for surgery, nutrition is stopped 2–4 h before surgery, and the stomach is aspirated prior to the induction of anesthesia. In ventilated patients, enteral nutrition is not stopped but is continued during surgery.Caloric requirements in burn patients should be ideally calculated by means of indirect calorimetric measurement. This is an easy noninvasive bedside method.When indirect calorimetry is not available, calorie requirements are measured calculated on linear regression analysis of intake vs. weight loss. Patients should be assessed for nutritional status on admission, and

Initial Nutritional Assessment

Determine the caloric and protein needs of patients immediately upon admission

Assessment by physician and dietician

– Personal background

– Chronic conditions

– Hypermetabolic conditions

– Physical conditions that may interfere with food intake

– Predisposing factors

– Recent weight loss or gain

– Food preference and allergies

– Weight and height for age and gender

– Total lymphocyte count

– White blood cells

– Hemoglobin and hematocrit/ Mean corpuscular volume

Perform indirect calorimetry if available

Calculate daily calorie and protein needs

reassessed on a daily basis.Patients should be weighed regularly.Inadequate intake necessitates an alteration of the regimen .

Measurement of these variables, together with indirect calorimetry and the weight gain/loss of the patient will give a good estimate of his or her nutritional status. Burn patients who can eat normally receive a high-protein, high-calorie diet. Liquids should be supplemented in the form of high-calorie fluids, such as milk or commercial milkshakes. Patients with burns over 25%BSA burned cannot cope with the caloric demands that trauma imposes on them, so that in all of them enteral supplementation is indicated.

Different enteral formulas are available. The most popular ones are Curreri and Harris Benedict for adults, and Galveston formula for children. Some of them (Curreri) may overestimate calorie requirements, whereasothers (Harris-Benedict) may underestimate these needs. Therefore, they should be used as initial estimates, with patients needs titrated to their hypermetabolic response as measured by indirect calorimetry. It must be noted, however, that human hypermetabolic response reaches a maximum of about 200% of basal requirements. Above that, human physiology cannot increase the rate at which the fuels are utilized to transform them into energy and proteins. It means that supplementing above the 200% resting energy expenditure (REE) does not increase the absorption of nutrients. There is general agreement that this increase to 200% REE reaches the maximum with burn at or over 50% BSA.The composition of the nutritional component is also important. Caloric replacement should be based on nonprotein calories only.

Nutritional Formulas

Nutritional formulas for pediatric burn patients

0–12 months: 2100 kcal/m2 surface area + 1000 kcal/m2 surface area burned

1–11 years: 1800 kcal/m2 surface area + 1300 kcal/m2 surface area burned

> **1**2 years: 1500 kcal/m2 surface area +1500 kcal/m2 surface area burned

Nutritional formulas for adult burn patients

Curreri: 16–59 years: 25 kcal/kg + 40 kcal for each percentage of burn area

60 years and more: 20 kcal/kg + 65 kcal for each percentage of burn area

Harris-Benedict: Basal energy expenditure (BEE) in kcal/day (at rest):

Males: BEE = 66 +13.7 (kg) +5 (cm)-6.8 (years)

Females: BEE = 655 + 9.6 (kg) +1.8 (cm)- 4.7 (years)

Activity/injury factor:

Bed rest 1.2, ambulatory 1.3, minor surgery 1.2, trauma 1.35, sepsis 1.6, severe burn 2.1

Calculated caloric requirements

= BEE * activity/injury factor

Approximately 50% of the calories should be supplied as carbohydrates, 20% as proteins, and approximately 30% of the calories should be supplied as fat. Protein needs are 4.4 g/kg in infants (less than 6 months), 4.0 g/kg in small children (6–24 months), and a calorie to nitrogen ratio of 120:1 (kcal/N) in the rest of patients. For a balanced daily diet, administration of vitamins C, A, and E, B complex, zinc, iron, folate,and trace minerals is essential.

When the patient's wounds are virtually covered, the diet should transition from one in which the majority of the nutrition is supplied via tube feedings to a total oral diet. The transition should be slow and may take several days. The following steps should be followed:

1. Reduce tube feedings to a rate that with the oral intake equals 100% of reassessed goal.
2. As oral intake increases, provide only nocturnal tube feedings to equal 100% of goal.
3. When oral intake is at least 50% of goal, begin 3 day trial of oral diet with tube feedings held.
4. If goal is not being met at the end of the trial, re-evaluate feeding methods and, if necessary, resume tube feedings.
5. During all of the above steps, specific fluid orders with guidelines as to amounts and contents should be written

PATIENT SUPPORT

Hypoproteinemia and Anemia

Hypoproteinemia due to malnutrition, continuing serum protein losses, and postburn sepsis and hepatic dysfunction will persist until wound closure is achieved.

Intravascular proteins can be replaced by processed albumin (generally preferred), or fresh frozen plasma if a significant coagulopathy is also present. The efficacy of colloids is the subject of debate; therefore every effort should be made to correct hypoproteinemia with early enteral nutrition. Colloids should be reserved for patients with severely low protein levels and those with significant clinical effects of such hypoproteinemia.

Anemia is very common among burn patients. The initial thermal injury is accompanied by direct destruction of red cells. Other cells are not initially destroyed, but they are structurally damaged and the half-life of the red cell pool is significantly decreased. Repeated trips to the operating room makes this anemia even more profound, as a joint effect of hemorrhage and blood replacement, which decreases again the half-life of red cells. Initial blood loss can be corrected with incremental transfusions of 10–15 ml blood/kg/day. Operating blood loss should be replaced with 0.5–1 ml/cm2 excised.

Environmental Control

Control of the surrounding environment is a well-recognized part of appropriate burn care. Burn patients lose some of their thermoregulatory abilities and are prone to hypothermia. An ambient room temperature of 28–33ºC keeps the patient more comfortable and reduces his or her heat losses from evaporation. Natural light and large windows help patients to maintain their well being. Strong noises should be avoided; and the area needs to be kept pleasant, clean, and relaxing.

Stress Ulcer Prophylaxis

The acid pH of the stomach plays an important role in infection control in the human body. This acid serves as a topical treatment for all foods that enter the digestive tube. This acid pH can be problematic when different problems collide in the same clinical situation. Tissue hypoperfusion (frequently measured by gastric tonometry) and the depletion of reduction agents and free radical scavengers promote a progressive damage of gastric mucosa. This erodes and progresses to small ulcers by the action of gastric acid and digestive enzymes. Maintaining good patient support and preventing sepsis and multiple organ dysfunction is extremely important to prevent stress ulcers.

The best prophylaxis for stress ulcers is enteral nutrition. Burn patients need something in their stomachs at all times to prevent ulceration. Enteral feeding maintains gastric and intestinal mucosal integrity. It maintains organ perfusion and serves as a scavenger for gastric acid. Patients who are not receiving any enteral nutrition at any given time should receive sucralfate, which coats the gastric mucosa and prevents ulceration. H2 blockers and antacids should be reserved for patients whose condition cannot be managed properly with enteral nutrition and sucralfate. Changing the gastric pH encourages bacterial overgrowth and leads to a higher incidence of pneumonia. Acid kills bacteria, which is the most important action of acid in our stomachs.

Deep Venous Thrombosis Prophylaxis

Burn patients should be encouraged to be mobile except in the immediate postoperative period or if they are attached to a ventilator. Even ventilated patients, should be exercising. The rest of the patients should be up with their limbs sufficiently wrapped to prevent edema and graft loss. Early mobilization and ambulation are the best prophylaxis for deep venous thrombosis (DVT). Patients who are not able to exercise and ambulate should be started on subcutaneous low-molecular-weight heparin. Pneumatic boots with intermittent compression should be used during surgery to prevent the development of DVT during surgery. Patients in the intensive care unit (ICU) should be closely monitored for signs and symptoms of DVT and pulmonary embolism, and proper treatment begun as soon as the diagnosis is made.

TREATMENT OF INHALATION INJURY

Inhalation injury is evident in over 30% of hospitalized burn patients and in 20–84% of burn-related deaths. Heat can result in damage and edema to the upper airway, but uncommonly produces injury below the vocal cords except with steam burns. Acute asphyxia can occur due to environmental oxygen consumption or by reduction of oxygen transportation by carbon monoxide or cyanides.

The majority of tissue damage attributed to inhalation injury is mediated by a chemical injury from incomplete combustion products carried by smoke, including aldehydes, oxides, sulfur, nitrogen compounds, and hydrochloric gases. This chemical damage to the lower airways and parenchyma is propagated by neutrophils. Lung vascular permeability is increased, promoting pulmonary edema. Desquamation of small airways along with inflammation produces airway casts, leading to areas of atelectatic lung alternating with emphysematous regions, acute pulmonary insufficiency, and bronchopneumonia.

Diagnosis of inhalation injury should be suspected in patients with facial burns, singed nasal hair, cough, carbonaceous sputum, or evidence of upper airway edema, including hoarseness, stridor, or wheezing. It should be considered in any patient with a history of burn in a closed space, loss of consciousness, or altered mental status. Arterial blood gases and carboxyhemoglobin content should be determined, but it may be misleading if initially normal. Diagnosis of inhalation injury is best confirmed by results of fiberoptic bronchoscopy. Chest x-ray is an insensitive initial test.

Treatment of inhalation injury should begin at the scene of the accident with immediate administration of 100% oxygen. Carbon monoxide poisoning produces asphyxia by binding competitively to hemoglobin and reducing oxygen carrying capacity. Hemoglobin has a 210-times greater affinity for carbon monoxide than oxygen. On room air, carboxyhemoglobin (CO-Hgb) has a half-life of about 4 h in the bloodstream. The half-life of CO-Hgb is reduced to 20 min when the subject is breathing 100% oxygen. If oxygen supplementation is started promptly, anoxic cerebral injuries are reduced. Levels of CO-Hgb greater than 15% are clinically significant, and levels above 40% can produce coma.

Great debate still exists regarding intubation in patients with suspected inhalation injury. Maintenance of the airway is critical. If early evidence of upper airway edema is present, then early intubation is mandatory since airway edema increases over 12–18 h. Prophylactic intubation without a good indication should not be done, because intubation may otherwise increase pulmonary complications in burn patients. Early extubation should be performed in all patients (within 48–72 h), as soon as an air leak is detected around the tube cuff. Other patients who benefit from early intubation and extubation (after 48–72 h) are those with severe life-threatening burns. Controlling the upper airway by means of early intubation makes resuscitation much easier. The patients, however, should be extubated when resuscitation is over, in order to prevent the development of airway complications and acute respiratory distress syndrome (ARDS).

All patients with positive findings at bronchoscopy or with a suggestive history should be placed in an inhalation injury protocol.

The nebulization of various substances and different respiratory therapy maneuvers have proved beneficial in the prevention of progression to tracheobronchitis, pulmonary edema,ARDS, and bronchopneumonia. The protocol is universal, and

Inhalation Injury Protocol

1. Titrate high-flow humidified o_2 to maintain arterial o_2 saturation >90%
2. Cough, deep breathing exercises every 2 h
3. Turn patient from one side to the other every 2 h
4. Chest physiology and physiotherapy every 4 h
5. Nebulize 3 ml N-acetylcysteine 20% solution every 4 h for 7 days
6. Nebulize 500 units of heparin with 3 ml normal saline every 4 h for 7 days
7. Nebulize bronchodilators every 4 h for 7 days
8. Nasotracheal suctioning as needed
9. Early ambulation
10. Sputum cultures Monday, Wednesday, and Friday
11. Pulmonary function studies before discharge and at scheduled outpatients visits
12. Patient/parent education regarding injury process

can be applied to patients with any sort of burn .

In general, aggressive bronchial toilet with direct bronchoscopy and lavage to remove bronchial casts is one of the pillars of such strategy. In addition, tailoring ventilatory support to the individual needs helps to prevent barotrauma and other complications. When patients can no longer maintain their normal gas exchange, ventilatory support is necessary.. In general, the physician should choose a ventilator mode shown to be capable of supporting gas exchange in that particular circumstance. Acceptable oxygen saturation should be targeted, but normal levels should be not pursued. Oxygen saturation >90% should suffice in most of the cases. More important is to maintain good tissue oxygenation and an acceptable mixed venous oxygen tension.

PAIN MANAGEMENT

Burns hurt, and so does burn treatment. Pain is the most immediate concern of the burn patients. Suffering a combination of physical discomfort and mental torment increases the postburn hypermetabolic stress response. Treatment for a patient's suffering, however, involves more than control of pain. Emotional support is essential, and uninterrupted sleep is beneficial. Other problems burn patientsoften experience are anxiety, itching, and posttraumatic stress disorder. There are two types of burn pain. The first type is background pain. Background pain is always present and its range of fluctuation is very small. The second type of pain is the excruciating, intolerable pain that occurs when something is done to the patient, such as procedural pain during dressing changes, line change, or physiotherapy. It is the worst pain a patient can encounter, and patients cannot make any comparison to other experiences in life. Pain control is one of the great challenges in the burn unit, and it is an unsolved problem. Anxiety, sleep disorders, and posttraumatic stress are problems often encountered along with pain.

They need to be treated at the same time in order to obtain a perfect response.

It must be remembered, however, that anxiety or other disorders are not treated with opioids, and pain should likewise not be treated with anxiolytics. Patient responses to pain stimulus vary significantly. The patient's pre-existing psychological make-up, ethnocultural background, the experience of the injury, and its meaning modulate the individual response to pain.

General recommendations for Pain control

1. If patient says he or she has pain, then he or she has pain.

2. Analgesics are most effective when given on a regular basis (not as needed or required).

3. Intramuscular injections are not usually appropriate because the patient fears the injection and intramuscular flow may be altered.

4. Bowel management begins with the narcotic pain management.

5. Pain management protocol should be initiated with the starting doses, which can be modified as the situation dictates.

Pain Assessment

The patient's pain can be assessed using the 10-point scale or the Faces scale

In the 10-point scale, the sliding scale is moved until the patient feels that the number expressed matches the pain he or she is experiencing.

For children less than 3 years old, the Faces pain-rating scale is best used.

For children who are preverbal or communicate nonverbally, the observer scale is used .

Both background and procedural pain occur in the emergency, acute, and rehabilitation phase. Therefore different methodologies should be applied depending on the patient's phase of the disease in order to obtain good pain control. In general, liberal use of opioids and benzodiazepines is advised. Unless patients have a pre-existing drug abuse problem, they will not become opioid dependent from its use during the acute phase of the burn.

Burn patients should always receive baseline analgesia. Drugs need to be scheduled in order to maintain a basal level of painkillers that will make controlling the pain much easier. Therefore, do not order analgesics at the patient's request (PRN). The best practice in patients who are candidates for opioid analgesia is patient-controlled analgesia (PCA) pumps. They decrease patients' anxiety by putting them in control of the pain regimen. Children of 8 years and older are candidates for PCA. Patients receiving opioids need to be started on a bowel regimen to prevent the development of constipation.In general, prune juice or lactulose will suffice in most. When patients get constipated,mineral oil should be started, followed by enemas if a good response is

not obtained.

Pain vs. Anxiety

Anxiety can be very debilitating in the acute situation, and it often accompanies pain. It can be very diffcult to differentiate between them. It can not be overemphasized,however, that pain should not be treated with anxiolytics, and, likewise,anxiety is not treated with opiates. Pain must be always addressed first as well as acute stress disorder problems. When pain is under control, anxiety may disappear in some patients. Anxiety can be measured similarly to pain. Anxiety can be defined in a simplistic manner as fear. Often it is experienced as an anticipation of extreme pain. Patients learn quickly their routine in the burn unit and anticipate the pain with enormous amounts of stress and anxiety. The fear thermometer is a good way of measuring anxiety. A fear scale of 1 means no fear at all, a fear scale of 5 means very much fear. Patients point at the scale that best represents their fear at a specific time, and treatment is given accordingly. It is important to note that anxiolytics are also not to be given PRN. In order to achieve a good level of anxiolysis, patients need to receive a regular dose of drugs. Anxiolytics can be added to the procedural pain management regimen to decrease fear and add a certain degree of amnestic properties to the analgesia.

Pain Management Protocol

Background Pain Management

Start with one drug. Do not give drugs PRN. If pain is not controlled, give additional drugs on top of the previously administered drug. Consider posttraumatic stress disorder and anxiety if pain is not well controlled.

For **ICU patients:**

Morphine or fentanyl drips or morphine via PCA, and

Midazolam or lorazepam for anxiety or agitation

When patients are stable and in an subacute phase, change to slow-release oral morphine

For **patients** not in the ICU:

Slow-release oral morphine or morphine via PCA, or

Acetaminophen +codeine, or Tramadol

Consider ibuprofen when anti-inflammatory action is also indicated (not in young children)

Sympathetic discharge symptoms such as sweating, palpitations, and abdominal pain can be blocked by clonidine. Hypotension may occur; thus monitoring is a must.

Procedural Pain Management

Many regimens may be useful. Each must be tailored on an individual basis and per procedure. In general, a protocol including an anxiolytic and a hypnotic or analgesic should be used. Procedural pain management is indicated for all age groups and is administered in addition to background pain management.

For ICU and non-ICU patients, the general regimens available include: Morphine or fentanyl +lorazepam or midazolam; and Morphine + nitrous oxide. When the patient is undergoing major dressing change with debridement, regimens include ketamine (+ bezodiazepine in patients >16 years or >50 kg); and propofol.

It is important to mention that when patients receive procedural pain management regimens, they require full monitoring (pulse oxygen, electrocardiogram, blood pressure) monitoring of vital signs every 5 min. A physician or registered anesthesia nurse should be present. Procedural pain medication should be scheduled 30 min to 1 h pre-procedure rather than PRN.

Management of Anxiety

Burns hurt. This is well known, and, as such, people fear pain. Besides the fear that patients experience when they are confronted with multiple, repetitive, painful procedures, they may feel that they have lost control of life events. Both pain and loss of control are intensely anxiety-provoking situations. The anticipation of pain provokes a rise in the anxiety level, which is normally highest when health personnel enter the room. The loss of control maintains a background level of anxiety, which may increase in time as painful situations follow.Fear and anxiety are best treated with the addition of anxiolytics. Before using them, however, pain management and acute stress disorder needs to be addressed first. The following agents are used:

1. Lorazepam: first choice in the acute phase

2. Diazepam: useful for rehabilitation therapy because it relaxes skeletal muscle

3. Midazolam: only when a short-acting agent is needed.

Patients who receive lorazepam for more than 15 days will need to have their dosage tapered. Diazepam has a longer half-life than lorazepam, and no taper in dosage is necessary.

Management of Acute Stress Disorder

A significant number of burn survivors will experience symptoms of posttraumatic stress disorder, including intrusive memories of the injury, during their acute recovery. If anxiety is associated with other symptoms of posttraumatic stress, such as hypervigilance or poor sleep, treatment should be considered. Symptoms commonly described include nightmares, flashbacks (re-experiencing the trauma while awake), difficulty falling sleep, difficulty staying asleep, hypervigilance,startle response, and dissociative feelings. Pharmacological management is usually the most helpful intervention in the acute phase. Treatment agents include imipramine and fluoxetine.

INFECTION CONTROL

Despite improvements in antimicrobial therapies and programs of early excision and grafting, sepsis continue to account for 50–60% of deaths in burn patients today. The burn wound is an ideal substrate for bacterial growth and provides a wide portal for microbial invasion. Microbial colonization of the open burn wounds, primarily from an endogenous source, is usually established by the end of the first week. Organisms isolated after the burn injury are predominantly gram positive. Seven days after the injury the burn wounds are colonized by the patient's endogenous flora, predominantly hospital-acquired gram-negative flora. Infection is promoted by loss of the epithelial barrier, by malnutrition induced by the hypermetabolic response to burn injury, and by a generalized postburn suppression of nearly all aspects of immune response. Postburn serum levels of immunoglobulins, fibronectin, and complement levels are reduced, as is the ability for opsonization. Chemotaxis, phagocytosis, and killing function of neutrophils, monocytes, and macrophages are impaired, and cellular immune response is impaired.

This decrease in the immune response explains why bacteria that in normal hosts are not harmful present a high risk to burned patients. The avascular burn eschar is rapidly colonized despite the use of antimicrobial agents. If this bacterial density exceeds the immune defenses of the host, then invasive burn sepsis may ensue. When bacterial wound counts are > 10^5 micro-organisms per gram of tissue, risk of wound infection is great, skin graft survival is poor, and wound closure is delayed.

The goals of wound management are the prevention of desiccation of viable tissue and the control of bacteria. It is unrealistic to expect to keep a burn wound sterile. Bacterial counts less than 10^3 organisms per gram of tissue are not usually invasive and allow skin graft survival rates of more than 90%. The isolation of *Streptococcus* in the wound should be considered an exception to the former, since bacterial counts of less than 10^3 bacteria per gram of tissue can provoke invasive burn wound infection and should be treated.

Great debate still exists regarding the appropriate isolation regimen for burn patients. For decades, burned patients were treated in dedicated burn centers with strict isolation techniques. It is now common knowledge, however, that burned patients do become infected from endogenous gram-negative flora. Cross-contamination among patients is minimal; therefore, the standard practice of strict isolation is no longer needed. In general, barrier nursing and hand washing after every patient contact should suffice to control infection in the burn unit. More strict measures need to be implemented with the appearance of multiple resistant organisms.Studies from several burn centers have laid to rest the idea that prophylactic antibiotics should be given to burn patients. This practice does not decrease the incidence of infection. It increases strains of multiple resistant organisms and challenges the postoperative management of burn patients. It is advisable to administer anti streptococcal antibiotics in infants and small children for 24–48 h when surgery or application of synthetic dressing is considered. Children are often colonized by these organisms and are very sensitive to their growth. Perioperative systemic broad-spectrum antibiotics are advised when major surgery is performed.It is advised to add this perioperative prophylaxis, which should be based on endogenous flora surveillance and include an anti staphylococcal agent in the acute period. Several studies have shown that burn patients experience sepsis 72 h after surgery if no antibiotics are used during major burn surgery. These agents should only be continued after surgery if evidence of sepsis is confirmed.

Bacterial surveillance through routine surface wound cultures is strongly advised. When patients become septic, cultures are helpful to direct antimicrobial therapy. Knowledge of local bacterial flora and local sensitivities patterns helps to rationalize antibiotic use, but they do not provide definitive data for the diagnosis of sepsis. Quantitative wound biopsies are a better determinant of significant pathogens than qualitative surface swabs. If bacterial counts are $>10^5$ (10^3 in *Streptococcus* isolates), wound infection should be suspected. Burn wound sepsis can however, only be determined by results of histopathological examination.Diagnosis of sepsis in burn patients can be difficult to differentiate from the usual hyperdynamic, hyperthermic, hypermetabolic postburn state. Any significant burn will start an SIRS in patients. Fever spikes are not always related to underlying infection, and blood cultures are commonly negative. Close monitoring and daily physical examination of burn patients are crucial for the prompt diagnosis of septic complications. In general, the most clinical subjective sign of infection is a sudden unexpected change in the patient's progress. An increase in metabolic rate, feeding intolerance, change in mental orientation or gas exchange, increasing pain scores, or change in biochemistry will signal impending infections.Once this change has been detected, the cause should be investigated. Infection is the leading cause. Local evidence of invasive wound infection includes the following: Black or brown patches of wound discoloration

Rapid eschar separation

Conversion of wounds to full thickness

Spreading periwound erythema

Punctuate hemorrhagic subeschar lesions

Violaceous or black lesions in nonburned tissue (ecthyma gangrenosum)

Definition of SIRS

Two or more of the following conditions must be present:

Body temperature >38 °C or < 36 °C

Heart rate > 90 beats/min

Respiratory rate >20/min or $PaCO_2$ <32 mmHg

Leukocyte count > 12,000/µl, < 4000/ µl, or 10% immature forms

The diagnosis of sepsis is made when at least five of the clinical criteria below are met, in addition to the documentation of a septic source such as:

burn wound biopsy with > 10^5 organisms/g tissue and/or histological evidence of viable tissue invasion,

positive blood culture,

urinary tract infection with > 10^5 organisms/ml urine,

pulmonary infection with positive bacteria and white cells on a class III or better sputum specimen

Clinical criteria for diagnosis of sepsis include the presence of at least five of the following:

1. Tachypnea (> 40 breaths/min in adults)

2. Prolonged paralytic ileus

3. Hyper- or hypothermia (< 36.5ºC or > 38.5ºC)

4. Altered mental status

5. Thrombocytopenia (<50,000 platelets/mm3)

6. Leukocytosis or leukopenia (>15,000 or <3500 cells/ mm3)

7. Unexplained acidosis

8. Hyperglycemia

Other parameters often seen associated with sepsis are enteral feeding intolerance, hypernatremia, and coagulopathy.

In the absence of a confirmed organism or site, antibiotic selection should be based on routine surveillance cultures. Empirical antibiotic choice should also be based on sensitivities of the burn facility's endogenous organisms. Routine perioperative antibiotics should also take ward-endogenous organisms into account.Systemic empirical antibiotics should be continued until micro-organisms are identified; use of agents is changed based on microbiology results. Treatment is continued for at least 72 h after evidence of sepsis has resolved.

If the wounds appear clean and there is no suspicion of burn wound sepsis, other sources such as the lungs, urinary tract, and catheter should be suspected.

Gram-positive sepsis

1. Burn wound biopsy with $>10^5$ organisms/ g tissue and/ or histological evidence of viable tissue invasion
2. Symptoms develop gradually
3. Increased temperature to > 40°C or higher
4. Leukocytosis >20,000/µl
5. Decreased hematocrit
6. Wound macerated in appearance with exudates
7. Anorexic and irrational
8. Decreased bowel sounds
9. Decreased blood pressure and urinary output

Gram-negative sepsis

1. Burn wound biopsy with $> 10^5$ organisms/ g tissue and/ or histological evidence of viable tissue invasion
2. Rapid onset (8–12 h)
3. Increased temperature 38–39°C (may be normal)
4. Normal or high white cell count
5. If not controlled, patient become hypothermic (34–35°C) plus leukopenia
6. Decreased bowel sounds
7. Decreased blood pressure and urinary output
8. Wounds develop focal gangrene
9. Satellite lesions away from burn wound
10. Mental obtundation

Pneumonia or bronchopneumonia is the most frequent site of infection in burn patients after burn wounds.

Pneumonia

The diagnosis of pneumonia in severely burned patients is exceedingly problematic.Many of the usual signs and symptoms of pneumonia are unreliable in burn patients. Fever, leukocytosis, tachypnea, and tachycardia may all be present in the absence of infection. Sputum examination is often contaminated with oropharyngeal flora. A class III sputum sample should be obtained in order to make a diagnosis. More invasive sampling techniques such as bronchoalveolar lavage have been advocated; however, these have been also shown to be less than ideal for establishing a diagnosis of pneumonia. Concomitant inhalation injury and changes in pulmonary vascular permeability result in diffuse nonspecific radiographic changes. Radiographic findings can only be helpful if they reveal lobar consolidation. Pneumonia can result from descending infection of the tracheobronchial tree or from hematogenous dissemination of microbial pathogens. Inhalation injury is associated with descending infection. Patients with inhalation injury who sustain nosocomial pneumonia have concomitant atelectasis, ventilation–perfusion mismatch, arterial hypoxia, and respiratory failure. Critically ill burned patients present with a high risk for respiratory infections. Besides the already mentioned inhalation injury, patients have consecutive septic showers, during subsequent trips for surgery, dressing changes, or septic episodes. Moreover,burn patients often have problems with deglutition that pose a risk of

Diagnosis of Pneumonia

Systemic inflammatory response syndrome

Radiographic evidence of a new or progressive infiltrate

Class 3 sputum or better with presence of micro-organisms and white blood cells

aspiration pneumonia. Sudden changes in the patient's hospital course and in his or her respiratory status should alert the physician to seek respiratory complications. Aggressive respiratory toilet and empirical systemic antibiotics should be started and ventilatory support reserved for cases of frank respiratory failure. Nosocomial pneumonia is generally a gram-negative infection and systemic antimicrobial therapy with multiple agents is generally required until the infection resolves clinically. Burn wound bacterial surveillance is of added value to direct empirical antibiotics, since organisms isolated in respiratory infections reflect burn wound flora in many instances. On the other hand, patients with ventilatory support present with a microbial spectrum that resembles the typical ventilatory-dependent patient pneumonia. Tracheobronchitis presents with a heavy gram-positive colonization, putting patients at risk for gram-positive pneumonia.

Urinary Tract Infections

Urinary tract infections can be classified into upper and lower urinary tract infection.True pyelonephritis is very rare in burn patients; however, lower urinary tract infection can occur as a result of a chronic indwelling Foley catheter. Urinary tract infections are diagnosed based on positive culture greater than 1×10^5 organisms cultured from a urine specimen. Urinalysis may reveal white cells and cellular debris associated with active infection. Positive urinary cultures are common during the course of sepsis, and they are also treated in the general context of that particular septic episode. It must be noted, however, that the association of clinical signs of sepsis with burn wound cultures or blood cultures with positive urinary cultures make the final diagnosis of sepsis. If there is suspicion of an ascending infection or sepsis, more aggressive treatment with prolonged systemic antimicrobials is warranted.

Catheter Related Infections

Catheter-related sepsis is associated with prolonged indwelling central and arterial catheters. Catheter sepsis may be primary, in which the catheter is the original focus of infection; or secondary, in which the catheter tip is seeded and serves as a nidus for continued shedding of micro-organisms into the bloodstream. Lines can be associated with the development of both gram negative and gram-positive sepsis. Central and arterial lines represent an avascular foreign body and, as such, are prone to microbial seeding. Infectious complications associated with indwelling catheters represent a major problem. Burned patients appear to be especially susceptible to this complication, with rates quoted as high as 50%. There is a strong correlation between micro-organisms recovered from catheter tips and skin flora, and pathogens can be traced in up to 96% of cases to bacteria isolated in the burn wound. The former supports the idea that bacteria migrate down the catheter to the tip. Persistent positive blood cultures, redness and purulent discharge around catheter insertion, and persistent high fever without other signs or sites of sepsis should arise the suspicion of catheter-related sepsis. Contemporary cultures from the central line and peripheral blood semiquantitative culture aid in the diagnosis, although many physicians choose to remove of the suspected infected line and catheter tip culture. Treatment involves removal of all infected lines and placement of new lines through new sites. Suppurative thrombophlebitis should be suspected in patients who do not recover from the septic episode and show persistent positive cultures despite appropriate treatment.Immediate operative excision of the affected vein to the port of entry into the central circulation and packing of subcutaneous tissue are essential for the treatment of this complication.

Other sources of septic complications in burned patients that need to be ruled out include the following:

Acalculous cholecystitis

Cholangitis

Regional enteritis

Necrotizing enterocolitis

Pancreatitis

Suppurative thrombophlebitis

Pelvic infections

Suppurative chondritis

Subacute bacterial endocarditis

Suppurative sinusitis

BURN WOUND EXCISION

Burns involving the superficial dermis heal within 3 weeks, generally without hypertrophic scarring. Since these burns generally cause no functional and little cosmetic impairment, primary skin grafting does not reduce morbidity or improve appearance and function. Full-thickness burns do not present a decision problem either. They will eventually need skin grafting and the sooner they are grafted the sooner the wounds will be healed.

Many burns, however, cannot be defined into either of these categories.

Burns that are very large, of indeterminate depth, or very deep, pose difficult questions. The decision of what to excise and when is crucial. Extensive burns can be too large for complete excision and grafting in one operation. This leaves a large open surface that must be covered temporarily. Tools to evaluate indeterminate wounds are being sought. The use of immunohistochemisty ,infrared fluorescence , and laser Doppler studies all show promise in vitro, but a trained surgeon has been shown to be at least as good . This leaves a surgeon with the decision based on clinical grounds. The cause of the burn, inspection and palpation of the wound, and sensory nerve function are all important clues. Finally, excision of very deep burns over joints, tendons, and bones may leave a wound that may not accept a skin graft.

Some truisms regarding burns and burn care include the following:

Burns in patients at the extremes of age are not shallow.

Immersion burns are not shallow.

Except for contact burns, most burns of the palms and soles heal within 3 weeks.

Patients whose clothing or bedding has been on fire rarely escape without some full-thickness burns.

All electrical burns are full-thickness and should be assumed to be fourthdegree.

Flash burns are rarely full-thickness, except in areas of very thin skin.

Burns are dynamic and deepen over the first 48 h. Wounds that appear shallow on day 1 may be indeterminate on day 3. Burns never get shallower.

Burns from hot soups and sauces are deeper than those from hot water alone.

Early excision requires an experienced surgeon. Inadequate excision with skin grafting on a poor bed leads to skin graft loss, adds the size of the donor site to the total area of open wounds, and may necessitate another operation.

Non-life-threatening burns in patients with associated medical problems or injuries should not be excised until the associated problems are under control and the operation can be done with low morbidity and essentially no mortality.

Patients with burns of the hands and feet will be able to return to work sooner if their burns are excised and skin grafted shortly after hospital admission.

Large, superficial burns with scattered small deeper components are best treated nonoperatively until the shallow areas have healed.

Early excision decreases the need for wound cleansing and daily debridement.

If pain management becomes a significant problem, this in itself is an indication for excision.

A patient with a small burn who can continue to work despite the burn and who can manage the wound at home will have the least expensive care and, in the long run, will miss much less work than if the burn is excised.

Small deep burns can be treated initially on an outpatient basis and then excised and skin grafted electively on a day surgery schedule.

Excision of major burns

Life-threatening burns should be excised only in a specialized burn treatment facility, where the entire burn team is experienced in excision techniques and has a thorough understanding of burn pathophysiology, critical care, nutrition, and monitoring. Excision of a burn should be an elective procedure and done in a timely fashion.In patients with very large total body surface area (TBSA) burns, the highest priority is to diminish overall burn size. The trunk and extremities are excised first, followed by face and hands.

The overall strategy for excision should be designed upon admission. Excision of the obviously full-thickness areas should be done first and indeterminate areas allowed to declare themselves. Excision of the posterior trunk requires the patient to be in the prone position, the most dangerous of all anesthetic positions; therefore it should be done when the patient is most stable medically. This is generally postburn day 3, after resuscitation is complete. Pulmonary complications that occur later in a patient's course may inhibit placing him or her in the prone position. If anterior burns are excised and grafted before those on the posterior trunk, there is a risk of graft shearing when the patient is placed in the prone position to have the back burns excised. Proper dressings (to be discussed later) minimize shear, permit excellent graft take, and allow the patient to resume normal activities.

Tangential excision

The principle of tangential excision is to shave very thin layers of eschar sequentially until viable tissue is reached. Even though this concept is extraordinarily simple, the technique requires considerable experience and excellent operating room support.

Excision can be done with a variety of power or handheld instruments.

Power dermatomes may be more precise in depth setting but can dull rapidly and become clogged with debris.Proper skin tension above and below the area to be excised is necessary in order to use a manual dermatome properly. Broad slices are taken with the knife and the back of the instrument is then used to wipe the area to inspect the bed. If the bed does not bleed briskly, another slice of the same depth is taken.Healthy dermis appears white and shiny, therefore if the area is dull and gray or if clotted blood vessels are seen, the excision needs to be carried deeper.

As excision continues to the deeper layers of the dermis and into fat, vessels with pulsatile flow may be transected. Any fat that has brownish discoloration

Use of Watson blade for burn excision

or bloodstaining will not support a skin graft and needs to be excised. Fat should appear uniformly yellow with briskly bleeding vessels.

Pulsatile blood vessels are controlled with electrocautery and the wound is then covered with a Telfa dressing soaked in 1:10,000 epinephrine solution before the surgeon moves on to the next area. The Telfa dressing is applied cellophaneside down to minimize adherence to the wound, with removal this may stimulate bleeding that was under control. When the burn to be excised is completed , epinephrine-soaked Telfa is applied, then an epinephrine-soaked laparotomy pad is added on top of the Telfa. Extremities are wrapped in elastic bandages and suspended. Direct pressure is applied to areas that cannot be suspended.These dressings are left undisturbed for 10 min. The outer wraps are carefully removed and the Telfa dressing is removed after being soaked in saline. Any persistent bleeding points can be controlled with electrocautery. This process is repeated until the wound bed is hemostatic .

The surgeon must be sure the bed is adequately excised prior to the application of epinephrine. Once the dressings are removed, the bed appears avascular and further excision risks removal of viable tissue.

The fear that reactive vasodilatation would cause postoperative bleeding has not been realized. Major bleeding has been extremely rare and its occurrence was a result of inadequate cauterization of a pulsatile vessel.

Minor bleeding is vented into the dressings through the interstices of mesh grafts. Sheet grafts need to be inspected frequently during the postoperative period and any hematomas evacuated.

Extremities should be excised under tourniquet, but the cadaver-like appearance of the dermis and lack of brisk bleeding make this technique more difficult.

Fascial Excision

Fascial excision is reserved for patients with very deep burns or very large, lifethreatening,full-thickness burns.Our fascial excision technique uses electrocautery for excision. Inflatable tourniquets are placed as high as possible on the affected extremity and inflated.The initial incision is made around the periphery of the tourniquet and carried down to the investing fascia. The flap is grasped with penetrating clamps and pulled by an assistant .The eschar flap is the separated at the level just above the fascia, with great care being taken to identify perforating vessels and coagulate them appropriately. All fat tissue should be removed, with the exception of areas of tendons and bony prominences. Epinephrine-soaked sponges are applied as the excision progresses.

When the excision is completed, the extremity is wrapped with epinephrine soaked sponges and laparotomy pads held in place by an elastic bandage.The tourniquet is deflated and the dressings are left intact for 10 min.

Donor sites

When treating a patient with extensive burns, the decision of where to create donor sites is easy: You take what you can get. In those with lesser burns, the decision is slightly more complicated. Since all donor sites scar to some degree, it is best to take skin from an area that will be otherwise hidden under most circumstances. Donors should also be taken from an area that allows ease in harvesting and donor site care.

Our first choice of donor site for children still in diapers is the buttocks.

This allows for a hidden donor site and use of the diaper to hold the silver sulfadiazine in place for wound care. The use of the buttocks in others is not forbidden, but we have found that it is more painful in older patients than other sites and wound care is more difficult. The thighs are excellent sites for donors.

It is less difficult to harvest because the femur provides excellent support during harvesting and there is minimal motion even with ambulation so that the dressings remain intact during the healing period.

The lower back is another area that is less difficult to harvest and provides ample skin. It also tends to be hidden with most clothing. The difficulty with using the lower back is that most often it requires a patient to change position during the operation.

The key points in harvesting donors are traction and countertraction. The use of clysis can help provide support to the area to be excised so that the best donor may be harvested. We use lactated Ringer's solution to inject and use clysis on any site that needs additional support, especially the abdomen and chest. Using assistants to provide traction to the skin and surgical soap for lubrication can also help.

The maximum area that should be excised at one sitting is about 20% TBSA, and the maximum operating time should be about 2 h.

Donor skin left as sheet graft will shrink by about one-third. Meshing 1.5:1 will leave it only slightly larger than the original size. Meshing 3:1 will leave it about twice the original size.

Donor sites taken at a depth of 0.010 inch take 10–14 days to heal to a point that they can be taken again.

Scalp is the premier donor site for face and neck. The face should never be grafted with expanded skin.

Sheet grafts should always be used on the fingers and hands.

The posterior trunk is a premier donor site. Skin is easy to take, and the skin is very thick, which allows numerous harvests.

BURN WOUND COVERAGE

Autograft

Sheet autograft is the ideal covering for all excised burn wounds. Its use is necessarily limited as the burn size becomes larger. Many of our ideas about the use of sheet grafts have already been discussed, but their use can not be overemphasized for those special areas. It is our opinion that sheet grafts for hands, fingers ,and faces are the only way to cover those excised areas. The use of sheet grafts on the face will give the best functional and most cosmetically pleasing result.The hands and fingers require skin with excellent pliability to achieve full range of motion of all joints, which is necessary to perform most activities of daily living.When using sheet graft for primary coverage after excision, the wound bed must be hemostatic. Fluid collections that form under the graft do not allow graft adherence and thus lead to graft failure in those areas. Frequent inspection of the grafted area is necessary in the early postoperative period is necessary to achieve the best result. Any collections of fluid found can be drained by incising the skin graft with a surgical blade and expressing the fluid with cotton-tipped applicators. There are many ways to secure sheet grafts, including various suture materials and staples or to dress the wound with a petroleum-jellyimpregnated gauze, wrap with cotton gauze, and support with elastic wraps. The dressing is taken down the following day and the wound inspected for fluid collections that are drained if present. This is continued on a daily basis until no fluid collections are found, at which point the dressing is left intact until postoperative day 5. If the graft appears intact, the mechanical holding devices are removed, and range-of-motion exercises are begun.

Allograft

The decision to excise burns early led to the need to find a suitable, temporary covering until autograft was available. The first reported use of cadaveric skin was in 1881 to cover a burn wound. This might also be the first reported case of possible rejection: what was termed erysipelatous inflammation occurred and the graft was lost in the second week .Many burn centers,use allograft as a temporary wound covering; to test the bed of an infected area;to provide temporary coverage for large nonburned, open wounds; and to provide protection for widely meshed autograft. Allograft rejection begins about 14 days after application: replacement or final closure is needed before that time. There are published reports of the successful use of allograft with systemic immunosuppression to achieve wound closure. This idea has not been widely accepted up to now.Many centers have tissue banks closely associated with them so that unfrozen allograft is readily available.

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Integra

Integra is a bilayer material: the inner layer is a combination of bovine collagen and glycosaminoglycan chondroitin-6-sulfate; the outer layer is a polysiloxane polymer that functions as a temporary epidermis. Integra was developed in the early 1980s by researchers from the Massachusetts General Hospital and Massachusetts Institute of Technology ,and is now approved by the US Food and Drug Administration for use in life-threatening burns. Early studies of its use found no significant immunoreactivity, which led to its adoption as a

viable temporary wound coverage. Many studies support out its is for massive burns , purpura fulminans , neck contracture , burn scars ,

and other complex wounds .

TREATMENT OF SPECIFIC AREAS OF THE BODY

Not all areas of the body are as easy to excise and graft as others. It is fortunate that the perineum and perianal areas are burned infrequently as these are the most difficult areas to care for. Integra is an option for wound coverage in all of the areas described below. The following sections outline the care for specific body areas.

Posterior Trunk

Treatment of the posterior trunks includes the following:

Shallow burns are allowed to heal spontaneously.If the overall burn size is less than 30%, indeterminate and full-thickness burns should be excised and grafted.In larger burns, the back needing excision and grafting can have 3:1 meshed skin applied since this is a relatively low-priority area cosmetically.Charred burns to the back should be excised to the fascia. The removal of all fat of questionable viability improves the chances of graft take.

Dressing the back can be difficult. Prone positioning is not recommended because this can lead to problematic airway and facial edema. Physical therapy is nearly impossible, which is also detrimental to the patient.

Shear can be limited with the use of Biobrane to cover the grafts and hold them in place. The grafted area is then allowed to dry and the Biobrane removed after the area heals. If wet dressings are desired, the use of a quilt dressing as described by Sheridan and others is also an option.

Buttocks

Burned buttock can be very difficult to manage because continued fecal soilage facilitates early bacterial invasion of deep burns. This can lead to infectious graft loss as well. We follow the principles listed below:

Remove necrotic tissue early to diminish burn wound sepsis.

In patients with large burns, allow partial-thickness burns to remain unexcised.

Meticulous wound debridement is needed.

Skin graft take over the inferior gluteal creases is poor as a result of shearing.

This area is fortunately narrow enough to heal from the periphery.

If fascial excision is required for deep burns to the buttocks, do not excise the fat from the perirectal spaces because the resulting defect is nearly ungraftable.Biobrane makes an excellent skin graft dressing because it conforms well.Frequent evaluation is needed: the dressing should be removed if fecal soilage occurs.Preoperative mechanical bowel preparation, followed by a somewhat constipating diet, may give up to 5 days of avoidance of fecal soilage. This may be enough time for graft take that is more resistant to infection.

Chest and Abdomen

Fascial excision of the chest and abdomen is reserved for char burns and patients with massive burns. Excision in the early postburn course allows easier excision: the fluid under the eschar facilitates sequential excision without the use of clysis.

Care must be taken with excision near the umbilicus: many patients have asymptomatic defects in the abdominal wall. Inattentive excision in this area could lead to invasion of the peritoneal cavity that would carry an increased risk of peritoneal infection.

Breast

The management of the burned breast depends on the total burn size, depth of burn, age of the patient, and occasionally the social circumstances of the patient. The most common burn to the breast in western centres is a scald burn in a preadolescent girl. Partial-thickness burns should be allowed to heal. Deeper burns, if allowed to heal, can lead to significant scarring and later displacement of the breast. When excision is indicated, great care should be taken to avoid excision of the subareolar tissue, as it contains the breast bud.

Sheet grafts should be applied when possible.Deep flame burns of the chest should be managed in the same way.Burns needing excision of the developed female breast are difficult to treat.Sheet and meshed grafts give equally poor cosmetic results.Extensive burns with limited donor sites and involved breasts are often an indication for simple mastectomy: this will lessen the need for skin to cover the anterior chest.Severe breast burns in the elderly woman most often are caused when a nightgown or bathrobe catches fire and this leads to deep burns.

Axilla

Fascial excision of the axilla can lead to neurovascular disruption and a very poor bed to allow good skin graft take. Tangential excision is used whenever possible. This area also tends to contract easily, which leads to functional deficits. Grafts are held in place with tie-over dressings or Biobrane. Arms are abducted to 90 degrees and splinted in position until graft take, and then range-of-motion exercises are begun. Physical therapy is crucial to achieve adequate arm function and avoid contraction.

Perineum

The perineum is spared in almost all but the most extensive burns. Scald burns to the genitalia frequently heal without operative intervention. Meticulous hygiene is paramount to good wound healing. Most of our experience with skin grafts to the perineum is in patients with necrotizing soft tissue infections. Many fullthickness burns to the penis and scrotum will heal with minimal deformity. Skin grafts to the penis heal without resultant chordae or voiding difficulty.

Lower Extremities

Thighs

For circumferential burns to the thighs, excision is carried out under tourniquet that is placed as high as possible on the thigh. The lower extremity is suspended from ceiling hooks to allow access to the entire thigh.If fascial excision is deemed necessary, the fascia lata should probably also be removed.

Legs

The legs have several areas that can be troublesome should they have deep burns. Great care needs to be taken when excising near the anterior tibia, the medial and lateral maleolus, and the Achilles tendon. It is best to leave as much viable fat as possible to protect the tenuous blood supply.

In patients with deep burns to the Achilles tendon and heel, we often will excise only to the area just above the ankle and allow the area surrounding the ankle and tendon to granulate. The patient with more extensive burns is usually suspended at all times using balanced skeletal traction pins to keep the area free from any pressure while he or she is lying in bed.

Another area of concern, especially during fascial excision of the leg, is the proximal fibular region. Damage to the peroneal nerve can easily occur, even without evidence of direct nerve damage with excision. This overall incidence of neurological deficits in the lower extremity is quite high in patients with lower extremity burns . Foot drop can occur postoperatively with improper use of splints and foot positioning, as well as generalized weakness from intensive care unit neuropathy.

Feet

Burns to the feet are the most difficult of all burns to treat on an outpatient basis. Patients are usually unwilling or unable to keep their feet elevated, and the incidence of edema and cellulitis leading to hospital admission is quite high. Burns that do not require grafting often blister significantly from friction caused by normal footwear. Sheet graft the feet whenever possible to provide a more durable covering.In patients with extensive burns and severe burns to the toes, graft the great toe and leave the others to granulate or autoamputate. If burns to the feet are part of less extensive burns, the toes can be excised and grafted in a manner similar to fingers.Full-thickness burns to the sole of the foot are rare in patients with survivable burns. Electrical burns, immersion scalds, and contact burns are the exceptions.

Upper Extremities

Hand

There is more written about the treatment of burns to the hands than any other area of the body. Proper care of hand burns is essential to get a patient back to his or her preburn level of activity. The care of the badly burned hand should be reserved for those who understand the technical and treatment aspects of properly caring for such patients.

Arms

As described for lower extremities, excision of burns to the arms requires great care in areas near tendons and bony prominences. Fascial excision is reserved for char burns and does carry a significant risk of chronic hand edema.

Patients with indeterminate burns to the hands have a shorter hospital stay and return to work more quickly after early excision and grafting than will patients with managed non surgically.

Sheet grafts to the hands offer superior functional and cosmetic results to meshed grafts.Most palm burns should be allowed to heal without operative intervention.Very deep burns to the dorsum of the hand may require flaps to provide coverage.The use of tourniquets allows for less intraoperative blood loss, but may lead to excision of unnecessary tissue by less experienced surgeons.

Head and Neck

Face

All burns to the face are treated with daily dressing changes until day 10, when a judgment is made whether the burn will heal by day 14. If it is judged that the burn will not be healed, plans for surgery are made. Excision is the first stage. Tangential excision is performed following aesthetic units that can include small areas of unburned skin. Blood loss can be excessive and is minimized with the liberal use of epinephrine-soaked nonadherent sponges. Electrocautery can be used with caution to stop bleeding that is uncontrollable with epinephrine sponges.

The area is then grafted with sheet allograft sewn tautly into position. The grafts are covered with petroleum-jelly-impregnated gauze, followed by a conforming,elastic head dressing. A padded neck splint is also used to prevent head movement. The grafts are checked at least daily to drain any fluid collections.

The patient can return to the operating room between postoperative days 7 and 10 for autografting if the allograft is stuck and intact.

Scalp provides the best color match for face grafts and should be used when possible. The head should be shaved and the hairline clearly marked. The needed donor should then be outlined and harvested after the scalp is injected with clysis solution. The sheet autograft is then sutured to the hemostatic wound bed with slight tension on the graft. The same dressing plan is then done as outlined above.

Scalp

Most scalp burns are treated nonoperatively. For burns to the skull, flaps are often needed. The more traditional method of drilling holes in the skull table to allow granulation tissue to develop with subsequent grafting usually leaves less than ideal skin. These grafts are susceptible to loss from shear forces,hence often a neurosurgical halo device is applied in supine position.

TOPICAL ANTIMICROBIAL AGENTS

After the burn wound has been cleansed and debrided, an appropriate dressing is placed. A burn dressing should serve three principal functions:

1. It must protect the damaged skin and should isolate the wound from the surrounding normal tissue. It should also provide appropriate splinting or allow early mobilization, depending on the extent and anatomical site.
2. The dressing should be occlusive to reduce evaporation heat loss and minimize cold stress.
3. The dressing should provide comfort .

Superficial burns have been treated conservatively in the past with daily or twicedaily application of topical antimicrobials. A good alternative, is the utilization of biological or synthetic materials to dress the burn wound. The aim of management of superficial partial-thickness burns (or superficial second-degree burns) is to promote rapid spontaneous re-epithelialization with the minimum number of painful dressing changes and to allow early mobilization and early discharge from the hospital. At the same time treatment of superficial burns should prevent infection, which can convert the injury to a deeper one that requires grafting.

Commonly used topical antimicrobials

– Silver sulfadiazine

– Mafenide acetate

– 0.5% Silver nitrate solution

– Cerium nitrate–silver sulfadiazine

– Acticoat

– Nitrofurantoin

– Chorhexidine

– Povidone–iodine

– Nystatin

– 0.025% Sodium hypochlorite

– Gentamycin sulfate

– Mupirocin

– Bacitracin/polymyxin

– Combination therapy

A number of topical agents are available to assist in antimicrobial control of the burn wound. No single agent is totally effective, and each has advantages and disadvantages.

Silver sulfadiazine is the most commonly used topical antimicrobial agent in the treatment of burns. Its antimicrobial properties are derived from the dual mechanisms of its silver and sulfonamide components, and it has a broad spectrum of antimicrobial coverage, including gram-positive bacteria, most gram-negative bacteria, and some yeast forms. Silver sulfadiazine does not hinder epithelialization , but it does hamper contraction of fibroblasts and retards wound healing. It is a white, highly insoluble compound synthesized from silver nitrate and sodium sulfadiazine. It is available in 1% concentration in a water-soluble cream base.The cream is relatively painless to apply and does not stain bed linens or other objects. The most common toxicity is a transient leukopenia, which typically recovers spontaneously, whether or not the agent has been discontinued. The agent is usually applied on a daily or twice-daily basis (antibacterial activity lasts up to 24 h, unless a slough exudate appears on the wound, when a more frequent application is needed). When it is used on superficial burns, a yellow–grey pseudoeschar typically forms after several days, which can be confusing and misleading to inexperienced surgeons. This film of pseudoeschar, results from interaction between the cream and the wound exudate .It is harmless and can be easily lifted; however that action may prolong healing time and is accompanied by different degrees of procedural pain.

Cerium nitrate–silver sulfadiazine was introduced in the mid-1970s, but its popularity increased 10 years later. It is frequently used in Europe, especially in centers where deep burns are managed with a more conservative approach. Cerium is one of the lanthanide rare earth series of elements that has antimicrobial activity in vitro and is relatively nontoxic. Wound bacteriostasis may be more efficient with its use in major burns than with silver sulfadiazine. The efficacy of cerium nitrate–silver sulfadiazine may be due in part to an effect on immune function. Methemoglobinemia due to nitrate reduction and absorption has been rarely observed with this agent. Initial application of cerium nitrate–silver sulfadiazine can be painful, but this problem resolves after few applications. Perilesional rash may also appear on initial application and it may be difficult to differentiate from true cellulitis. A leathery hard eschar with deposition of calcium occurs in deep dermal and full-thickness burns, which prevents bacterial invasion and permits easy delayed tangential excision .Conversion of partial-thickness wound to full-thickness skin loss has occurred as well as deepening of donor sites with the use of this agent. It should be reserved for use in cases of deep partial and full-thickness burns awaiting excision. It is a good alternative in elderly patients who are not candidates for surgical intervention. Facial burns can also be treated with cerium nitrate–silver sulfadiazine. After regular application for 48–72 h, the pseudoeschar is left in place without new applications of the agents. Superficial and deep partial burns heal uneventfully and separate the pseudoeschar.

The use of many other topical antimicrobials depends on the surgeon's choice, characteristics of the wound, and anatomical site of the burn. Nevertheless, the most commonly used topical antimicrobial in partial-thickness wounds continues to be 1%silver sulfadiazine. Antimicrobial activity differs depending on the agent. **Mafenide acetate** is the only agent with good eschar penetration, and it is particularly suited for infected wounds. However, it presents with systemic toxicity since it is a potent carbonic anhydrase inhibitor. It produces considerable pain on application, and it should be reserved for short-term control of invasive burn wound infections.

Topical antimicrobial creams are generally used with closed dressings. This provides for greater patient comfort and less desiccation than with use of the open technique. The creams are spread on fine-mesh gauze, applied on the wounds, and then covered with bulky protective gauze dressings and an elastic compressive wrap. As an alternative, silver sulfadiazine cream can be directly applied on the wound and then wrapped accordingly. Dressings are changed based on the antimicrobial activity of the agent. When silver sulfadiazine is used, dressings should be changed ideally every 12–24 h.

SYNTHETIC AND BIOLOGICAL DRESSINGS

Topical antimicrobial agents are used to limit proliferation and fungal colonization of wounds, with the ultimate goal of preventing invasive infection until the burn wound re-epithelializes or can be excised and grafted. All topical antimicrobial agents, however, adversely affect wound healing, alter the metabolic rate, and require reapplication and daily maintenance.

Synthetic and biological dressing are an excellent alternative to topical antimicrobial agents. Temporary skin substitutes provide transient physiological closure by creating a wound environment that prevents desiccation; diminishes bacterial proliferation; reduces loss of heat,water, protein, and red blood cells; and promotes more rapid wound healing.Such temporary physiological closure of wounds implies protection from trauma,vapor transmission characteristics similar to skin, and a physical barrier to bacteria.These membranes create a moist wound environment with a low bacterial density and they also reduce burn wound pain. These materials may be organic or synthetic in origin, but good wound adherence is the key to their function.

Human allograft (also called homograft) is generally used as a split-thickness graft after being procured from organ donors. It remains the gold standard of temporary wound closures. It can be refrigerated for up to 7 days, but can be stored for extended periods when cryopreserved. It is also used in a nonviable state after preservation in glycerol or after lyophilization. Numerous laboratory tests to exclude the possibility of viral disease transmission are followed,and with modern screening techniques the risk of viral disease transmission is exceedingly small. When used in deep excised burns, viable and cryopreserved allografts vascularize (this usually does not occur when used in superficial burns),providing durable biological cover until the patient’s own skin has regenerated under the skin allograft.

Porcine xenograft is commonly distributed as a reconstituted product consisting of homogenized porcine dermis fashioned into sheets and also meshed. It is nonviable, adheres more poorly than allograft, and does not undergo revascularization by the recipient bed. Xenografts undergo progressive degenerative necrosis rather than classic rejection. They do not provide the same level of protection from infection as allograft, and so they often contain embedded salts of antimicrobial agents. Porcine xenograft or pigskin is well suited for temporary coverage of partial-thickness wounds to allow spontaneous healing. It is less expensive than allograft and more readily available. Other uses include temporary cover of clean granulating wound beds awaiting autografting, and use as a test graft to determine suitability for autografting. When used in partial-thickness burns, it is applied after cleansing and superficial debridement of the wound.

Synthetic and biological materials commonly used in superficial burns

Biological materials	Synthetic materials
Human allograft	Biobrane
Human amnion	Transcyte
Allogenic epithelial sheets	Mepitel
Xenografts (pig skin)	Opsite
	Duoderm

It is secured with tape and a light dressing for 24 h, leaving it exposed when it appears well fixed to wound. The patient is allowed to shower and pigskin is left in place until complete wound healing is achieved, when the porcine xenograft would be completely detached from the wound.

Synthetic biological dressings also provide wound protection from desiccation and contamination, increase the rate of wound healing, and reduce patient discomfort. Good wound adherence is needed, and any necrotic tissue needs to be debrided to prevent infection. Diligence in application is essential. It should be applied as soon as possible before bacterial colonization has taken place. When used to cover partial-thickness burns, the dressing detaches as re-epithelialization and keratinization occur underneath. A number of semipermeable membrane dressings can provide a vapor and bacterial barrier and reduce pain while the underlying wound heals. These synthetic materials typically consist of a single semipermeable layer that provides a mechanical barrier to bacteria and has physiological vapor transmission characteristics. All synthetic membranes are occlusive and can foster infection. Appropriate monitoring is essential to their proper use.

Biobrane is a synthetic, bilaminate membrane with an outer semipermeable silicone layer bonded to an inner collagen-nylon matrix (Fig. 7). Its elasticity and transparency allow easy drapability, full range of movement, and easy wound inspection. It is widely used to provide temporary closure of superficial burns and donor sites. It significantly reduces pain and allows early discharge of patients. Biobrane gloves on superficial hand burns reduce discomfort and increase motion, allowing earlier aggressive physiotherapy. The major problems with Biobrane are its expense and its lack of inherent antimicrobial properties. Wound infections with its use are not uncommon.

TransCyte is a bioengineered human fibroblast-derived temporary skin substitute that has similar properties to Biobrane and can be used in a similar way .The outer layer of TransCyte,the synthetic epidermal layer of nonporous silicone net, is biocompatible and protects the wound surface from detrimental environmental effects. It is semipermeable to allow fluid and gas exchange, which keeps a healthy moist, wound healing environment. The inner layer, the bioengineered human dermal matrix,adheres quickly to the wound surface and contains the dermal components known to promote healing of the burn. The product contains essential human structural and provisional matrix proteins, glycosaminoglycans, and growth factors known to facilitate healing. The patient's epithelial cells proliferate and migrate across the wound, resulting in rapid wound healing.

Mepitel is made of an elastic, transparent polyamide net enclosed by a soft silicone layer. This layer is inert and adheres only to dry healthy skin and not to the moist wound bed. The release film is transparent, allowing the wound to be visible during application. The structure of Mepitel allows exudate to pass into an outer absorbent dressing. Mepitel prevents the outer dressing from sticking to the wound and therefore minimizes trauma and pain during dressing changes. Dressings can be left in place for several days, avoiding repetitive dressing changes and minimizing pain. It provides a moist wound environment that promotes re-epithelialization. It is very useful for the treatment of small partial thickness burns in the outpatient setting.

A variety of hydrocolloid dressings are currently available in the market for the treatment of burns. These dressings are generally designed with a three layer structure:

A porous adherent inner layer

A middle layer composed of a methyl cellulose absorbent material

A semipermeable outer layer

They provide a moist environment, which has been shown to favor wound healing, while absorbing exudate. They require repeated application every 2–4 days depending on the agent, although patient comfort with their use is high.

OBSERVATIONS AND RESULTS:

The maximum number of patients comprised of age group 21-30 years (37.88%). This was followed by age groups 31-40 years(26.51%) and 11-20 years (19.69%). This trend was followed among both male as well as female patients.

The commonest cause of burn was flame burn (93.93%) followed by scald (2.27%), chemical burn(2.27%) and electrical burn (1.51%) respectively.

It was seen that flame burn was more common among females.

Maximum cases had burns in the range of 30-40% TBSA (24.24%). This was followed by burns in the range of 41-50%(15.15%), 51-60%(12.88%), 71-80%(12.88%), 61-70%(12.12%),81-90%(11.36%),91-100%(11.36%) TBSA respectively.

Patients having burn more than 60% TBSA had 100% mortality when followed up.

Patients with 30-40% TBSA burn had a mortality rate of 18.75%. The overall mortality rate was 71.21%.

The evaluation of degree (depth) of burn was found to be more accurate by histological assessment than by clinical assessment. It was seen that maximum number of cases had deep burns followed by mixed or indeterminate type of involvement. There were only 5 pure superficial degree burn cases.

The inflammatory response was found to be maximum within the first week which was neutrophilic mainly. This response decreased with the passage of time. However, in patients going into septicemia, this response either persisted or increased. Most patients however died within the first 2 weeks.

Macrophage response mixed with neutrophils was seen in response to the applied topical antibiotic or chemotherapeutic cream.

A large amount of coagulative necrosis was seen in maximum cases where biopsy was taken within the first week. This was seen along with eschar formation which was seen as necrotic material separated from the rest of the tissue. Sub-epidermal blister formation was seen in 30 cases with second degree burn. Electrical burn showed maximum burn with minimum regeneration irrespective of the extent and degree (depth) of burn. Electrical burn involved intense necrotic destruction of the skin including the appendages as well as blood vessel.

Fibroblast proliferation started late in the first week,reached peak in the second week and continued thereafter. Congestion and fibrinoid necrosis in the blood vessels was common during the first two weeks. Thrombus, if present, was observed towards the end of second week. The presence of thrombus heralded the onset of disseminated intravascular coagulation and hence heralded the onset of septicemia.

Presence of bacterial growth on the surface as well as in the eschar and sub-eschar tissue was seen in most biopsies. This represented 'colonization' and not true 'invasion' which was seen as presence of bacteria in the adjoining viable tissue. This was seen in 35 cases and that too late in the course. It was seen by the end of second week only.

The microbiological studies revealed that Pseudomonas is predominant organism isolated from burn wound followed by Klebsiella, Proteus, Staphylococcus and Escherichia coli in decreasing order. There was a good correlation between surface swab culture reports and tissue biopsy culture reports as far as the type of organism isolated from the burn wound is concerned. However the surface swab culture reports showed growth in almost all cases, which was probably due to surface contamination.Whereas tissue biopsy culture reports showed positive findings (82.5%) mostly in cases with suspicion of infection. This finding suggested that tissue biopsy culture is a more reliable indicator of wound infection than surface swab culture where chances of contamination are more.

The calculation of bacterial load per gram of tissue, done in 45 cases, showed positive results (count>10^5) in 35 cases and all the 35 cases went into septicemia.

DISCUSSION

Age distribution in our study revealed that the maximum number of cases were in the age group 11-40 years (84.09%). These observations were in accordance with the other previously carried out studies as shown below.

TABLE 1 : Comparison of age distribution with other studies

Study	Predominant age group affected
Bariar et al (1996)	11-30 years (62%)
Abrol et al (2005)	11-30 years (69%)
Khan et al (2006)	11-30 years (66%)
Present study	11-30 years (57.57%)

In our study the major cause of burn was flame burn with total of 124 (93.93%) cases followed by electrical burn with a total of 3 (2.27%) cases , chemical burn 3 cases (2.27%),and scald burn (1.51%) .These findings also correlated well with other previous studies.

In the present study it was found that the incidence of burns was much higher in females. This may be due to the fact that females are usually exposed to hazard of burns while cooking and higher incidence of attempted suicides in females.

TABLE 2 : Comparison of causes of burn with other studies

STUDY	FLAME	ELECTRICAL	SCALDS	CHEMICAL	OTHERS
Sinha (1976)	51.64%	3.59%	33.35%	2.79%	8.45%
Bariar (1996)	91.18%	5.88%	-	2.94%	-
Macedo &Santos (2005)	57.64%	9.36%	28.57%	-	-
Abrol (2005)	77%	9%	9%	-	5%
Presentstudy	93.93%	1.51%	2.27%	2.27%	-

In the present study maximum cases were in the range of 30-40% Total Body Surface Area (TBSA) (24.24%) followed by 41-50%(15.15%),51-60%(12.88%), 71-80%(12.88%) , 61-70%(12.12%) ,81-90%(11.36%),91-100%(11.36%)TBSA. A total of 75.7% patients had burn more than 40% TBSA.

TABLE 3 : Comparison of extent of burns in burn patients with other studies

Study	**Patients with burn >40% TBSA**
Bariar et al (1996)	50%
Abrol et al (2005)	55%
Present study	75.7%

It was seen that punch biopsy provided a more adequate biopsy sample as compared to wedge biopsy. Uppal et al (2007) had also used punch biopsy in their study because of the same reason. The 200 surface swab culture reports showed a predominance of monomicrobial growth (83.5%). Six cases did not show any growth.

TABLE 4 : Comparison of types of growth identified on swab cultures with previous study

Study	Monomicrobial growth	Polymicrobial growth	No growth
Bariar et al (1996)	47.06%	52.94%	
Khan et al(2011) study	89.55%	8.96%	1.49%
Present Study	83.5%	13.5%%	3%

The predominant organism isolated from surface swab culture was Pseudomonas followed by Klebsiella. These findings show more incidence of Pseudomonas compared to previous studies.

TABLE 5 : Comparison of organisms isolated in swab cultures with other studies

Study	Pseudo-monas	Klebsiella	Staphylo-coccus	Proteus	E.coli	Others
Bariar et al (1996)	31.8%	31.8%	26%	4.5%	9.1%	23%
Khan et al (2006)	54.4%	33.2%	3.1%	1.0%	3.1%	5.2%
Present study	69.38%	12.71%	5.78%	6.93%	5.20%	

Out of the 200 tissue culture reports 35(17.5%) cases showed no growth while monomicrobial and polymicrobial growth was seen in 153 (76.5%) and 12(6%) cases respectively. This finding was comparable with findings of previous studies

TABLE 6: Comparison of types of growth identified in tissue biopsy cultures with other studies

As in the case of surface swab culture, the predominant organism isolated was Pseudomonas followed by Klebsiella.

Study	**Monomicrobial growth**	**Polymicrobial growth**	**No growth**
Kaushik et al (2001)	78%	9%	4.48%
Singh et al (2003)	45%	40%	13%
Ramakrishnan et al(2006)	84%	9%	15%
Present study	76.5%	6%	17.5%

TABLE 7 : Comparison of organisms isolated in tissue biopsy cultures with other studies

Study	Pseudo-monas	Klebsiella	Staphylo-coccus	Proteus	E.coli	Others
Kaushik et al (2001)	63.3%	4.7%	24.7%	3.5%	3.5%	
Singh et al (2003)	35.2%	21.6%	25%	2.3%	4.5%	11.4%
Ramakrishnan et al(2006)	41.8%	10.2%	37.8%	10.28%		
Khan et al(2006)	59.3%	32.1%	3.1%	4.9%	0.6%	
Present study	69.88%	13.07%	5.29%	7.19%	4.57%	

Uppel et al (2007), had concluded in their study that biopsy culture is more valuable than surface swab culture as it also gives the critical load (10^5 Colony Forming Units/gram of tissue) of the organism beyond which metastatic invasion of the organism takes place, thus obviating the repeated need for blood culture in burn patients.

So we have performed a quantitative bacterial study on cases. It was seen that out of the 45 quantitative cultures performed, 35 culture showed a count of $>10^5$ /gram of tissue. All of them went into septicemia and had a fatal outcome.

Conclusion

Thus we concluded that, biopsy of the burn wound plays an important role in proper assessment of burn wound and in making accurate diagnosis. It not only helps in identifying the healing potential of a burn wound but also helps in detecting burn wound infection/sepsis, if aided by proper microbiological assessment.

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