SECTION V: DAILY CARE OF THE BURN WOUND
The topics in this chapter include:
   a. General principles of wound care
   b. Superficial to mid-dermal burns
   c. Deep burns
   d. Wound conversion

A. GENERAL PRINCIPLES OF WOUND CARE

There are a number of general rules regarding burn care that must be followed. 
First, cardiopulmonary monitoring should continue during burn care. The addition of medications for wound care itself can only lead to a potential for further instability.
Second, invasive catheters, such as vascular and urethral, must not become wet at the skin site or be submerged in water. These catheters are at high risk for being a source of systemic infection.
Third, the patient must not be allowed to have a significant heat loss. Overhead heaters, warm water, and the sequential management of the wounds, rather than total patient exposure, are methods to avoid heat loss.
Fourth, the risks of bacterial cross-contamination must be controlled. Risks related to transmission from personnel are minimized by the wearing of caps, mask, gloves, and a gown. Transmission from a dirty wound to a clean wound can be minimized by exposing and cleaning these areas separately. Preferably, the less infected areas should be done first and closed before approaching dirtier areas.

The fifth principle is that adequate stress management, analgesia and sedation, should be initiated before initiation of burn care. It is much easier to control pain and anxiety by pretreatment than it is to treat once it develops. Antipyretics given before burn care attenuate the fever seen after wound manipulation. Pretreatment of the dressing change with an antipyretic such as Ibuprofen, is indicated in patients who demonstrate a marked temperature spike, i.e., >103ºF after wound care.

The sixth principle is that motion should not be impaired (exception: a new graft). The patient needs to maintain joint motion and muscle activity to avoid stiffness and atrophy.

General Principles of Daily Care

- Continue monitoring if indicated
  - Avoid hypothermia
    - warm room
    - warm water
    - do not expose entire body at once

- Avoid Cross-Contamination
  - Wear caps, masks, gown, gloves wash hands before and after
  - Expose, clean, and rewrap less infected areas first
  - Look for sources of bacteria in equipment used

- Assure Adequate Control of Pain, Anxiety, Fever
  - Pre-indication with narcotics and short-acting sedative
  - Use intravenous route
  - Consider antipyretic pre-treatment pre-burn care

- Wound Dressing
  - Use comfortable but no immobilizing dressing, as muscle activity is important!
    (exception: new grafts)
B. SUPERFICIAL TO MID-DERMAL BURNS

1. Superficial burn with blisters. Can remove blisters and loose skin, then close wound.

2. Superficial burn cleaned and ready for a dressing.

3. Superficial Partial Thickness
   - Confined to upper third of dermis
   - Cause usually hot liquids
   - Blisters, wet, pink, painful
   - Heals 10-14 days without scar
   - Conversion risk low
Loose epidermis and remaining blisters are debrided from the wound surface. Areas such as the face and ears are then treated open, usually with an ointment such as bacitracin to maintain wound moisture as well as control the predominantly gram-positive bacteria. The open areas are usually gently washed daily with a dilute chlorhexidine solution to remove crust and surface exudates. Areas such as the hands, upper and lower extremities, and trunk can be treated with a grease gauze impregnated with antibiotic ointment, usually Bacitracin. The grease gauze is covered with several layers of dry absorbant gauze. If the grease gauze appears well adhered to the superficial wound with no underlying exudates, the gauze does not need to be changed, as is the case with a donor site dressing. If some exudates is present, the dressing should be removed, the wound gently washed with dilute soap and the dressing reapplied. Exceptions would be the dirty wound that has not been totally cleaned of initial dirt and debris or the perineal or buttock wound where a silver based topical antibiotic is usually required.

The wound can also be managed with a temporary skin substitute, such as biobrane, once wound adherence has occurred. Only the outer layer of gauze needs to be changed once wound adherence has occurred, usually once a day when it becomes saturated with plasma from the wound surface.

1. **Managing the Dressing**
   Areas Covered with Grease Gauze:
   - Inspect daily
   - If gauze adherent and no exudates, simply change outer dry gauze
   - Change dressing, wash surface and reapply if exudates present
   - Use topical antibiotic if infection considered

2. **Areas Treated Open with Bacitracin**
   - Reapply ointment two to three times daily
   - Gently wash off crusts, exudates, especially on face and neck
3. Areas Covered with Temporary Skin Substitutes

- Change outer dry gauze daily to remove collected exudates
- Roll out small pockets of exudates from beneath substitute
- Can leave open without dressing once drainage has ceased if substitute well adhered
- Remove skin substitute if exudate extensive or if nonadherent with topical agent and change to grease gauze method
- Remove once wound reepithelialized

The mid-dermal burn is at higher risk of infection or conversion compared to the more superficial burn. Skin substitutes appear to provide better wound protection than grease gauze but they are also more expensive.
**Mid Dermal Partial Thickness**

- Infection risk: moderate
- Silver dressing applied
- Debride loose dead skin including blisters
- Cover wound with grease gauze
- Cover with secondary dressing, except face
- Can use temporary skin substitute

**Advantages of skin substitutes for superficial burns**

- Restores skin barrier function
- Decreases pain, increases mobility
- Can decrease scar
- Can remain in place until wound re-epithelializes beneath

**Cover burn wound with secondary dressing.**

**Debrided mid dermal burn awaiting closure with grease gauze or skin substitute.**

**Skin substitute adherent on day one. Barrier functions restored.**

**Healing beneath skin substitute.**

Ready for removal of skin substitute
C. DEEP BURNS

Deep Dermal to Full Thickness Burn
- Infection risk: high
- Need topical antibiotics (silversulfadiazine)
- Debride loose, dead tissue
- Cover antibiotic cream with secondary dressing
- Can use silver release dressing (Acticoat)
- Usually excise and graft

Deep Burns (cont’d)
- Closely observe for evidence of subeschar pockets of exudate
- Unroof pockets and culture wound to determine presence of infection necessitating systemic antibiotics
- Consider changing topical agent if infection develops

Initial non-surgical management is debridement of loose dead tissue and application of a silver based cream or dressing. If using the cream silver sulfadiazine the wounds need to be gently washed daily with removal of old cream and reapplication of new cream followed by a secondary dressing.

If using a typical silver dressing, with a constant silver release for 3-7 days, an outer secondary dressing change is all that is required. Some silver dressings require application of water to release more silver but the actual silver dressing can remain in place for 3-7 days.

Early surgical excision and skin closure is recommended.

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Early surgical excision and skin closure is recommended.

Viable tissue should not be left exposed unless it is to be occluded by a graft or a skin substitute because desiccation of the tissue with reformation of eschar is likely to occur. This daily care procedure can be performed with home care (if minor) at the bedside or on a slant board in a hydrotherapy tank, avoiding total body immersion. The bedside approach is particularly useful for the critically ill patient.
Deep dermal hand burn.

For burned hand, separate fingers to improve mobility (usually excise and graft).

Silver is released from a silver sulfadiazine cream only for a matter of hours. Therefore, the cream needs to be reapplied at least once a day.

Patches of white are deep dermal burn.

Silver is released from a silver sulfadiazine cream only for a matter of hours. Therefore, the cream needs to be reapplied at least once a day

Silver Sulfadiazine placed on burn surface.
Silver sulfadiazine is removed and replaced twice a day.

Flexnet is helpful to hold dressings on, thereby avoiding circumferential wrapping.

**Pseudo eschar** is an adherent surface layer of exudates which adheres to the wound typically in deeper burns with the use of topical antibiotic creams. This film is hard to get off and also hard to distinguish from the process of wound conversion.

Pseudo eschar present on wound surface
Silver release dressings have the advantage of a steady silver release for days so there are fewer dressing changes needed and a pseudoeschar typically doesn’t develop.

- **Silver Release Dressing:**
  - Releases silver when moistened for 3-5 days
  - Very potent antimicrobial
  - Easy to use
  - Moisten silver dressing twice a day
  - Apply secondary dressing over top
  - Change dressing every 3-5 days

- **Acticoat sheets moistened and applied.**
- **Secondary dressing placed over Acticoat sheets.**
Use of Silver Release Dressing on Full thickness leg burns.

Although infection is not particularly common in the first several days postburn (unless the burn was heavily contaminated or inadequately cleaned), the wound bacterial flora should be monitored with surface cultures. Positive cultures do not mean infection. Infection is usually diagnosed by changes in the wound, systemic signs and biopsy. The information on the organisms however will assist in the assessment of the adequacy of the topical agent being used as well as provide epidemiologic information, especially important in controlling resistant hospital-based organisms.
Why is Surgery Preferred for Deep Dermal Burns?
Primary healing of a deep dermal burn often leads to hypertrophic scar or skin breakdown, especially if the burn takes over 6 weeks to heal.

(31-32)

Healed deep burn with hypertrophic scar.

Healed deep burn with subsequent breakdown from low grade infection.

(33)

Healed deep burn: thin, dry and itchy skin.
D. WOUND CONVERSION

This term refers to the dynamic process whereby the Zone of Injury progresses to the Zone of Tissue Necrosis thereby deepening the wound. Conversion is more likely with a mid to deep dermal injury because of less blood flow, longer time to healing and increased risk of excess inflammation and infection. Also environmental hazards can readily lead to conversion of an open wound. This process is in large part preventable with newer methods of early wound closure and better control of wound inflammation using slow release silver dressings or skin substitutes.

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<th>RISK FACTORS FOR WOUND CONVERSION</th>
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<tr>
<td><strong>LOCAL</strong></td>
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<tr>
<td>Impaired Blood Flow</td>
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<td>Increased inflammation (Infection, open wound, irritants)</td>
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<tr>
<td>Surface desiccation</td>
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<td>Surface exudates buildup</td>
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<tr>
<td>Mechanical trauma (dressing changes, shearing)</td>
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<td>Chemical trauma – topical agents</td>
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If conversion is going to occur, it is typically several days (sometimes weeks) post-burn.

(Wound Conversion)

- Usually occurs in first week due to infection
- Difficult to distinguish from pseudo-eschar
- Cannot be removed with blunt dissection as converted area is a true eschar
- If infection, consider systemic antibiotics and use of sulfamylon on wound
Wound conversion caused by excess inflammation, increased proteases, heavy bacterial colonization.

Mid deep dermal burn to back

Wound conversion to deeper injury, present at day 5.
SECTION VI. CARE OF BURNS TO HIGH RISK AREAS

Some Burns are considered major burns because of location, and the risk of significant morbidity. These areas which include face, hands, feet and perineum require special care preferably in a burn center. Function is so important in hands and feet that optimum care is required. Facial burns are at high risk for major cosmetic deformity if not managed correctly. Perineal burns are difficult to manage and at high risk for infection.

(6-1)

Difficult to manage burns
- Face (treat open)
- Ear
- Perineum
- Feet

A. FACE
Superficial burns of the face are best managed with a gentle wash or soak with mild soap two to three times daily. Wash is followed by application of a thin layer of bacitracin to keep the wound from drying as well as to maintain control of the predominantly gram-positive organisms on the face. Skin substitutes can also be used. Deeper burns will require a topical antibiotic cream with better eschar penetration. Silver sulfadiazine or silver dressing is the first choice, to be reapplied after a gentle wash two to three times daily. This agent can be applied without dressings or on a layer of fine mesh gauze which prevents the cream from running into the eyes, nares, and mouth.

(6-2) (6-3)
B. EYES
Burns to the eyes must always be considered with a facial burn. Superficial corneal burns should be managed like any corneal abrasion. Ophthalmic antibiotic ointment applied three to four times daily is indicated. An eye patch is then applied. Artificial tears every several hours will be required if the tear ducts are involved. Burns to the eyelids are managed in a similar fashion. As the lids retract with healing, a patch is often required at night along with the lubricant to avoid corneal drying. Tarsorrhaphy may be required with deep burns.

C. EARS
Superficial burns to the ears can be managed like those to the face. However, external pressure should not be applied to the injured helix. The cartilage is already poorly vascularized and any compression will potentate further injury. No pillows or any external pressure are allowed. In addition, the topical agent, silver sulfadiazine) or mafenide, must be applied multiple times a day, especially if any cartilage is exposed. Mafenide is the agent of choice for deep burns with a thick eschar. Chondritis is a major complication that requires an extensive (several weeks) course of systemic antibodies. Chondritis invariably leads to loss of cartilage and permanent deformity. Pseudomonas is the most common pathogen.

Burns to Ear
- Low blood flow to cartilage
- High risk of infection
- Treat with topical antibiotics
- Avoid pressure on ears
D. HANDS
Escharotomies on the hand and fingers must be considered with deep circumferential burn. Superficial burns of the hands can be effectively managed using Xeroform gauze with a thin layer of bacitracin followed by a soft gauze dressing. Temporary skin substitutes are also ideal and markedly decrease pain and improve motion. Topical antibiotics are necessary for deeper burns. Fingers should be wrapped separately to avoid any impairment. Hands must be elevated for the first 24 to 48 hours to minimize edema. Hand splints to maintain position of function are advantageous for all burns, especially if pain is limiting motion. Motion, however, must be strongly encouraged. For deeper second and third degree burns, hand splints are absolutely necessary to avoid permanent loss of tendon function and development of flexion contractures. However, active and passive range of motion exercises should begin as soon as possible after injury, during which time splints are removed.
Fitted hand splint

Early scar in web of thumb: needs continued hand therapy
E. FEET
Burned feet must also be elevated initially. A compression wrap over a bulky dressing can be used when walking. Blood supply to the feet is not as good as that to face and hands, and therefore, better topical antibiotic coverage, e.g. silver antibiotic, is usually needed except in the superficial burn. At least once a day cleaning and reapplication of the topical agent is needed with a deep burn. Because of the difficulty of function and of self-cleaning, foot burns of any significance should be admitted at least for the initial 24 to 48 hours until home care can be arranged.

Foot Burns
- Extremely debilitating
- Very painful
- High risk for infection
- Usually requires
- Topical antibiotics
- Superficial burns can be managed with skin substitutes

F. PERINEUM
Superficial burns can be managed open with an antibiotic grease-based ointment that has a broad-spectrum coverage, such as Neosporin. Hospitalization is usually necessary, at least initially, for observation of urinary obstruction secondary to edema. Deeper burns by definition require admission with two to three times daily application of topical antibiotic cream, usually silver sulfadiazine. Open technique or closed dressing, with a loose diaper dressing, can be used.
Perineal Burns
- Extremely debilitating
- High risk for infection
- Usually need to use topical antibiotics
- Need to follow very closely

High risk perineal burn
(needs topical antibiotics)
SECTION VII. SURGICAL EXCISION AND GRAFTING

Deep partial thickness burns fit into this category as healing takes longer than 3 weeks and hypertrophic scars or scar breakdown often is the result of primary healing. Early excision and grafting should be considered as a treatment option for all burns that will not heal by primary intention within 3 weeks. Full-thickness burns will by definition require grafting unless smaller than 3 to 4 cm in diameter. The more rapidly the wound is closed with skin grafts, the better. Burns, less than 30% of total body surface can be, at least theoretically, rapidly closed because adequate donor sites are available. Larger burns will be more difficult, if not impossible, to completely graft early. Initial coverage is often accomplished using available skin along with temporary skin substitute to cover ungrafted areas until skin is available. The other option is the use of a permanent skin substitute. Deep partial thickness burns are also difficult to assess clearly as to time of healing. Considerable judgment and assessment skills are therefore essential for this approach to yield optimal results.

The topics to be discussed in this chapter include both the indications and the general and specific techniques used:

A. General Principles of Early Excision
B. Types of Surgical Excision
   Tangential (Sequential) Excision
   Excision to Fascia
C. Obtaining Skin Grafts (Donor Sites)
D. Grafting and Dressing the Wound
E. Wound Conversion

A. GENERAL PRINCIPLES OF EARLY EXCISION

There are two key judgments that are required. The first judgment is determination of cardiopulmonary stability and operative risk. The patient should be reasonably stable. The second judgment is a determination as to potential morbidity of the wound itself if not rapidly removed. This judgment takes into consideration wound depth, functional loss, and the risk of the inflammatory wound on the host. A key component of this assessment is defining wound depth, i.e., what will heal and what will not heal. The following facts which can aid in decision making:

- Infants and the elderly tolerate burn inflammation and infection poorly so early burn removal is preferred.
- Burns in infants and the elderly are usually deeper than initially perceived.
- Burns can get deeper over the first several days as a result of necrosis of ischemic areas. (conversion)
- Burns caused by direct contact with flames, hot grease, chemicals, or electricity are invariably deeper than first appearances would suggest.
- Burns on the low back, scalp, palms, and soles usually have sufficient remaining dermis to allow primary healing in 3 to 5 weeks.
- Large full-thickness burns are life-threatening until closed.

General Principles

There are a number of general principles that apply to all methods of excision and grafting:

The first principle is that the patient must be thermodynamically stable before considering excision. Pulmonary function can be impaired, but the patient must be able to be safely moved to the operating room and back.

The second principle is the potential for significant blood loss must be recognized and adequate amounts of red cells, plasma, and platelets, if indicated, are available before starting an excision procedure.

The third principle is that major pulmonary abnormalities in the burn patient can become very problematic with general anesthesia if preplanned safeguards are not initiated. Stiff lungs and increased dead space often require special mechanical ventilatory needs, which must be prepared for and met in the operating room.
The fourth principle is that hypothermia must be avoided during surgery. The operating room and fluids used must be warmed to avoid severe hypothermia, a major hazard. The operating room temperature should be maintained between 80° and 85° F to minimize hypothermia and postoperative problems.

The fifth principle is that the stress induced by anesthesia and surgery must be limited to that which the patient can safely tolerate. The time in the operating room should be carefully controlled, again to avoid postoperative complications. A 2-3 hr operative period is best for a large burn. It is better to do several moderate operative procedures 1 or 2 days apart than one massive procedure. The exception is children, i.e., older than 5 years old, who tolerate large excision procedures much better than adults. A reasonable operating time limit, including anesthesia, is 2-3 hours. A shorter period is indicated for elderly or compromised patients. Total blood loss per procedure should be restricted to avoid development of a coagulopathy.

The sixth principle is that blood loss should be replaced with blood products rather than crystalloid in the major burn patient. Typically the patient already has massive edema in the first week and red cell production will be markedly depressed until the wound is healed, especially in a massive burn. It is therefore unrealistic to assume that red blood cell mass will quickly return to baseline by increased production.

**Timing of Excision**

Timing of excision relative to changes in the wound itself is crucial to minimize risks. Blood flow to the burn wound is markedly increased beginning about 4 days after injury and peaking between 5 and 14 days. The increasing blood flow, which parallels the development of wound inflammation, is present in the viable tissue beneath the eschar. A significant increase in blood loss should be expected with wound excisions after 5 to 6 days. Clotting abnormalities at this stage can also be a major problem.

In addition, colonization of the wound develops during the first week and manipulation of the colonized or infected wound runs an increasing risk of bacteremia. Because of these facts, the size of the planned excision must be determined based on a clear understanding of increasing risks of blood loss and bacteremias.

**General Principles for Burn Excision and Grafting**

- The patient must be thermodynamically stable before considering excision
- The potential for significant blood loss must be recognized
- Pulmonary problems clearly present & require a plan of management in the OR
- Hypothermia must be avoided during surgery
- The stress induced by anesthesia and surgery must be limited to that which the patient can safely tolerate
- Significant blood loss in a major burn should be replaced with blood products
B. TYPES OF SURGICAL EXCISION
There are two types of surgical procedures to remove the eschar: tangential excision and excision to fascia. There are also several types of grafts and dressing techniques, which will be described.

1. Tangential (Sequential) Excision
The principle is to excise the wound in thin layers using a blade held at a very acute angle with the skin surface. The objective is to remove only the nonviable tissue, sparing, in particular, as much viable dermis as possible in the case of the deep dermal burn. The dermis contains the elasticity in skin. In addition, the viable dermal surface is an excellent base for grafting. Fat is a less attractive bed for skin grafting because of decreased vascularity as well as the difficulty of determining viable fat on inspection.

The excision is performed with a hand-held dermatone using guards of variable thickness (0.008 to 0.020 inch) to help control depth of excision. A back and forth motion is utilized for cutting with very little forward force. Control of depth is based not only on the gauge of the guard, but also on the angle of the blade in relation to the surface. A sharp blade is needed for this approach, and frequent blade changes are required. A Goulian or a Watson knife is used, depending on the area being excised. The Watson, being larger, is used for larger flatter surfaces, whereas the Goulian is used over curvilinear areas, e.g., over bony prominences or on fingers, toes, neck, and occasionally, face. Excision over bony surfaces can be aided by injecting saline beneath the eschar to flatten and push the wound surface away from the bone. The endpoint of excision is brisk punctate bleeding and a completely viable wound base. Viable dermis is white and shiny in color. One or two large bleeders can make the wound look red, so careful inspection and considerable experience is needed to assess the adequacy of the wound bed. Injured fat is particularly difficult to diagnose. Any fat that is dark yellowish-brown in color should be removed.

Healthy fat is light yellowish in color and shiny. It is easy to under-excite, leaving a poor bed for graft take. In addition, it is easy to excise too much tissue, thereby removing potentially viable dermis.

Over-excision would be particularly detrimental if done on hands, neck or face, or over joint surfaces. It is very difficult to detect accurately the proper endpoint of this technique using tourniquets to control bleeding and therefore tourniquets are usually not used.
The procedure itself should be performed by excising small burn areas at a time controlling hemostasis in each excised area before continuing on to other areas. Usually, a maximum of 18 to 25% of total body surface can be excised at one time. Normally, this much is only feasibly excised on the first operation if done 1 to 3 days postburn. Later excisions are usually limited to 9% total body surface or less because of blood loss. Cautery is typically the first approach to bleeding. The smaller punctate bleeding from dermal vessels can often be stopped by application of the skin graft. The exposed collagen on the dermal surface of the graft stimulates hemostasis.

Other approaches to hemostasis include application of topical thrombin or a solution of 1/10,000 epinephrine. If epinephrine or thrombin is used, one must be assured of the adequacy of the wound bed before their application, since bleeding ceases, making a subsequent assessment very difficult. Microcrystalline collagen can also be applied, but a coagulum is left on the wound surface, which should be removed before graft placement.

Once the wound is excised, the wound bed must be closed. Usually, immediate application of skin grafts is performed. Sheet or mesh grafts can be used. Sheet grafts result in a better cosmetic effect but there is an increased risk of bleeding beneath the graft, impeding take while meshing with minimal opening of the mesh allows for drainage of blood or plasma. Wider meshing is used to cover larger surface areas when there is a shortage of donor skin. A functional skin will result with a wider mesh but a cosmetic problem is inevitable. The mesh, used with tangential excision, is usually no greater than 1.5 to 1 to avoid any excessive exposure of viable tissue, especially fat, which can then desiccate and form new eschar. A temporary skin (allograft or synthetic) substitute can be applied over the graft if a wider mesh, e.g. 3:1 is used to protect the interstices. A skin substitute can also be used on an area excised and not grafted. Any neighboring burn must continue to be treated with an antibacterial agent.

Deep dermal hand burn
Tangential excision of hand burn. Viable dermis is preserved.

Large tangential excision on back. Residual dermis preserved; bleeding is significant.

The wound must be closed at this stage with skin graft and or skin substitute.

Sheet graft closure

Mesh graft closure allows residual bleeding to drain thru slits.

Meshed graft (2:1) used in large surface area with limited donors.

Re-epithelialized Across the Mesh in 2 Weeks

Mesh graft appearance will diminish with time but will not disappear.
The advantages and disadvantages of tangential approach are listed:

<table>
<thead>
<tr>
<th><strong>Tangential Excision</strong></th>
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<tr>
<td><strong>Advantages:</strong></td>
</tr>
<tr>
<td>Optimal functional and cosmetic result</td>
</tr>
<tr>
<td>Can be performed rapidly</td>
</tr>
<tr>
<td><strong>Disadvantages:</strong></td>
</tr>
<tr>
<td>Large blood loss</td>
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<tr>
<td>Difficult endpoint to define</td>
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<tr>
<td>Excise to excise too much or too little</td>
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2. **EXCISION TO FASCIA**

Excision of the burn wound to fascia is used in cases of very large full-thickness burns or with very deep burns that extend well into the fat or underlying tissues. This approach is used in the large burn with limited donors for the following reasons.

*First,* this endpoint of excision is well defined and graft take is always excellent. Therefore less experience is required to define an adequately excised wound surface.

*Second,* wider meshed skin grafts can be used as the fascia appears to be less vulnerable to desiccation than fat or dermis especially when covered with a skin substitute.

*Third,* a large excision, when performed early, can be done in most body areas (exception being the face and perineum) with only modest blood loss. In the case of the very deep small wound, excision to this depth or deeper is required because of the extent of the injury itself.

Excision is performed using a combination of sharp dissection, constant tension, and electric cautery. The vessels encountered at the fascial plane are fewer in number and larger in size than encountered in a tangential excision and easier to control with cautery and ligatures. If performed in the first several days, the edema fluid separates fascia from overlying subcutaneous tissue, making excision very easy. The major bleeding occurs from the wound edge.

This bleeding can often be better controlled and the exposure of fat on the wound edge minimized if the skin edge is sutured to the fascia. This form of marsupialization can also decrease the total size of the wound as the edges are pulled toward the middle. Total excision per operation should be limited to 18 to 20% of total body surface. Tourniquets are also applicable in cases of extremity excision, especially if delayed for several days, because the endpoint is an anatomic one rather than punctate bleeding.

7-11 7-12

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**Excision to Fat or Fascia**

- Performed when no viable dermis left; very deep burn
- Performed in large burns
- Obtain plane between eschar and viable tissue
- Sharp or cautery excision beneath eschar
- Graft or close with skin substitute

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**Excision to fascia for deep burns on legs extending through fat.**
Fascial excision becomes less feasible with time after burn injury. Initially the burn edema layer helps separate the fascial plane from the fat. The reabsorption of edema over 5 to 7 days and the increase in wound blood flow increases the difficulty and risks. The separation of the fascial plane becomes more difficult. Beyond 7 days when the eschar is heavily colonized and the subeschar space is infected, fascial excision can be very dangerous. Complications of bleeding and septicemia will be much higher with time postburn. It is important to remember that this procedure is usually performed on large burns, and therefore patients tend to be at greater risk for perioperative problems.

Timing of fascial incision is very important: the earlier the better.

There are a number of disadvantages to this approach that must be outweighed by the advantages. The major disadvantage is a potential impairment in long-term function to the excised and grafted areas, especially extremities. Distal edema becomes a problem because of removal of superficial veins and lymphatics. However, in many cases they have already been heat destroyed. In addition, removal of cutaneous nerves will lead to impaired sensation. Sensation on any skin graft is decreased compared with normal skin. There is, also, a significant risk of injury to other superficial nerves that have motor function. In addition, exposure of the relatively avascular fascia near joints along with potential exposure of tendons will result in a nongraftable surface that is now prone to desiccation. Coverage of this area becomes a major problem. The second problem of fascial excision is cosmetic, since a rim of tissue remains at the edge of the excised and nonexcised tissue producing a step up defect, especially on the extremities. Tapering of the excision at its endpoints can help decrease this problem. The cosmetic defect is persistent, particularly in the obese patient. Frequently, a combination of fascial and tangential excision is used in the patient to maximize benefits of early wound closure and minimize complications.

Once excised, the fascial surface must be covered. Since donor sites are usually limited, a wider meshed graft is often used. Skin substitutes are very effective in occluding the fascial wound until the mesh fills in (10 to 14 days) or until new donor sites become available with re-healing (10 to 14 days).

<table>
<thead>
<tr>
<th>Disadvantages</th>
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<tr>
<td>Risk of injury to nerves</td>
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<td>Risk of increasing distal edema</td>
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<td>Risk of exposing joints, tendons</td>
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<td>Cosmetic defect</td>
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</table>
C. OBTAINING SKIN GRAFTS (DONOR SITES)

Donor sites are obtained wherever unburned skin is available (exception: face, hands). Preferred areas are thighs, buttocks, and abdomen. However, large burns have limited donors and other areas need to be used, e.g. arms, lower legs, back and soles of feet. The scalp is an excellent donor site when needed. As opposed to most other areas that require 14 days or more to heal sufficiently before reuse, scalp heals in 7 days and can be re-harvested 3 to 4 times. The only area in which color match between donor and recipient site is of significant concern is the face and neck. Upper chest and upper back are a good color match for face and neck. Split-thickness skin can be removed using a variety of dermatomes. Air pressure driven or electric powered dermatomes are the most common. Small free hand skin grafts can also be obtained using the Goulian knife used for tangential excision. Injection of saline beneath the dermis will greatly assist the removal of split-thickness skin from areas around changes in contour or from the scalp.

Graft thickness is dependent on the size of the burn and the potential need for re-harvesting the same donor site, the area to be grafted, and the donor site to be used. The ideal thickness for most areas to be grafted is 0.012 inch for the adult. Slightly thicker grafts (0.012 to 0.014 inch) would be ideal for face, neck, hands and over joints because less scarring and more pliability would be anticipated for a thicker graft that contains more dermis. A donor site 0.012 inch will require approximately 10 to 14 days to re-epithelialize and about 21 days or longer before it can be used again. A second use of this area will be limited because of concern over producing a full-thickness injury. A donor site where a thick graft is obtained usually cannot be used again. A thinner donor site, 0.010 inch, will often be ready for re-use in 14 days where another graft of 0.01-inch thickness can be obtained. Since fewer epidermal cells are present with a reuse donor, a less wide mesh is usually used. Skin graft thickness is also dependent on the thickness of the donor skin. Children and elderly patients have a thinner dermis and therefore a thinner graft, i.e., 0.008 to 0.010 inch, is usually obtained to avoid major morbidity at the donor site. In addition, areas such as inner arms and legs have thinner skin, and adjustments need to be made in the dermatome when obtaining skin grafts from these areas.

### Obtaining Donor Sites

<table>
<thead>
<tr>
<th>Location</th>
<th>Thickness: (thousands of inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best: thigh, buttocks</td>
<td>1. Moderate burn, most areas (0.01 to 0.012)</td>
</tr>
<tr>
<td></td>
<td>2. Hands, neck, joint areas (0.012 to 0.014)</td>
</tr>
<tr>
<td>Next: upper arms, scalp, back, abdomen</td>
<td>3. Massive burn (0.008-0.010)</td>
</tr>
<tr>
<td>Next: lower legs, arms, chest</td>
<td>4. Elderly, child (0.008 to 0.010)</td>
</tr>
<tr>
<td></td>
<td>5. A reuse site use (0.008 to 0.010)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hemostasis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pressure</td>
</tr>
<tr>
<td>2. Early application of dressing</td>
</tr>
<tr>
<td>3. Can use topical thrombin or epinephrine</td>
</tr>
<tr>
<td>1 to 10,000 dilution</td>
</tr>
</tbody>
</table>
Depth is usually the upper third of the dermis which includes mainly papillary dermis, leaving sufficient number of epidermal cells, in skin appendages, to heal.

Bleeding from a donor site is similar in amount to that of tangential excision of a fresh, deep dermal burn, i.e., diffuse, punctate, and profuse. Bleeding from a re-use donor is even more profuse and again an analogy can be made with tangential excision of a hyperemic wound. Because blood loss will be substantial, hemostasis at the donor site should be controlled before pursuing wound excision. The ideal situation is the use of two teams, one whose role is to obtain skin grafts and maintain hemostasis. Pressure followed by application of fine mesh gauze or Xeroform gauze, again followed by pressure (1 to 2 minutes), is usually adequate to control bleeding. As with the excised wound, topical thrombin or dilute epinephrine solution can also be used.

A number of dressings can be used on donor sites. Fine mesh or grease gauze is porous and allows the initial bleeding to exit from the wound surface as well as the exit of blood and plasma that leak during the postoperative period. Gauze, however, is not flexible and is not sufficiently occlusive to control pain. In fact, ambulation or motion is very difficult with donor sites covered with these dressings. In addition, there are minimal to no antibacterial properties, increasing the potential for infection if nearly open burn wounds are present. Application of moist antibiotic-moistened gauze over the xeroform for 24 to 48 hours assists in removal of blood beneath the dressing as well as provides antibacterial protection. Dilute bacitracin, neomycin, or mafenide solutions have been used with success. After 2 to 3 days, the donor site should be left exposed and the dressing allowed to dry. The exception would be if an open wound is adjacent, in which case the antibacterial solution should continue or the wound should be occluded from nearby burn. Gauze dressings are applied over the donor site covered by an outer moderate compression dressing to maintain hemostasis. The outer dressings are changed until the wound can be exposed to air. Grease gauze impregnated with antibacterial ointment, e.g., scarlet red, provides some protection against infection, but it also impairs removal of clot or exudates because of the multiple layers of gauze used. An effective alternative dressing is a skin substitute, such as biobrane or polyurethane dressing such as Opsito. The skin substitute will provide a seal, thereby eliminating the risk of external infection as well as diminishing pain. Disadvantages, however, are that excellent hemostasis must be obtained before application. In addition, these dressings have no antibacterial properties. This is less of a problem with biobrane if adherence to the wound is good. Dry dressings and moderate compression maintain hemostasis while allowing optimum wound adherence over the first 24 to 48 hours. The inner donor site dressing is gradually removed at 10 to 14 days with re-epithelialization.
**Donor Site Dressing**

**Grease Gauze Dressing**
- Reasonable hemostasis needed
- Apply grease gauze
- Apply dry gauze followed by compression
- Change outer dressing using same technique for 24 to 48 hours
  Leave exposed after 24 to 48 hrs (exception: if open wound is adjacent

**Skin Substitute Dressing**
- Complete hemostasis needed
- Apply dressing under some tension
- Apply dry gauze followed by compression for 24 to 48 hours
- Leave in place until wound heals
- Remove if purulent exudates develops beneath dressing

**Fresh Donor Site 7-16**

![Grease gauze allowed to dry](image)

**Donor Site Covered with Biologic 7-17**

![The dermal matrix OASIS® is covering this donor site which stimulates healing](image)
A number of complications can occur in the donor site. Infection can occur, which can result in deepening and possibly conversion of the wound to full thickness. Infection is usually evident from surrounding cellulites. Systemic antibiotics as well as topical antibiotics are required for treatment. Blistering and continued breakdown are also seen, especially with deep donors or donors in small children or the elderly. Healing usually occurs in time. Hyper- or hypopigmentation may persist for long periods of time and may be permanent. Hypertrophic scarring is seen, especially in dark-skinned persons and with deep donor sites.

**Complications**
1. Infection
2. Delayed healing, blistering
3. Abnormal pigment deposition
4. Hypertrophic scarring

**Delayed Donor Site Healing**

Superficial infection resulted in breakdown and delayed healing

**D. GRAFTING AND DRESSING THE WOUND**

1. **Skin Graft Placement**
   It is best to place grafts on the wound at the time of excision. Since the graft itself controls hemostasis and protects the wound, it makes little sense to wait 24 to 48 hours until bleeding has stopped. This approach requires an additional procedure and there is a significant risk of the wound bed becoming desiccated or reinfected.

   Even if skin meshing is not going to be performed, a number of small slits can be placed along the skin lines to allow efflux of any blood or plasma that collects. Grafts are best placed longitudinally in most areas and transversely across the joints to match the normal skin lines and forces during movement. It is better to have a slight overlap of skin on the wound rather than to leave excised wound uncovered. Hypertrophic scarring will result and most evident at the edges of the graft, especially if a ridge of open wound is left to heal primarily. It is important to avoid the edges of the graft from rolling up, thereby preventing skin adherence in this area. Adjacent grafts should be carefully approximated. Sutures can be used but are very time consuming. Staples or Steri-strips usually work very well to secure the graft in place.

2. **Dressing the Excised Wound**
   The dressing applied over the grafted area must accomplish two goals. First, it must protect the graft from environmental insults, in particular desiccation and avulsion as well as infection. Infection is most likely to develop from nearby areas of open wound. Secondly, the dressing must immobilize the area and allow graft vascularization to occur, i.e., graft take. To summarize, the role of dressing is as follows:
   a. Must control environmental hazards especially desiccation and avulsion, and
   b. Must immobilize the grafted area.
Sheet grafts can be managed in two ways. The most common is the application of grease gauze (Xeroform) or fine meshed gauze followed by dry gauze and moderate compression. Grafts can also be left open if there is no exposed wound not grafted. This approach is best used on face and neck. The exposure method has limited use in other areas, since the grafted area needs to be immobilized in some fashion. The usual method of immobilization is the use of a firmly placed gauze dressing followed by a compression dressing and splint. Skeletal traction can also be used, although this method is usually not necessary and further hampers patient mobility, which should be initiated in 3 to 4 days.

There are a number of techniques used for dressing mesh grafts, depending on the size of the mesh and the area grafted. A 1.5 to 1 mesh is best managed by application of a single layer of grease gauze or fine mesh gauze followed by gauze moistened in an antibiotic solution. The most common solutions used are bacitracin, 25,000 U, or neomycin (0.1 to 1 g/L of saline). The advantages of the antibiotic solution are to: 1) help remove blood and wound exudates from beneath the graft by acting as a wick; 2) protect the area between the mesh from desiccation; and 3) protect the skin graft from bacteria in any adjacent ungrafted wound. An outer dry gauze dressing is then applied, followed by a compression dressing. The grafted area needs to be immobilized. A nearly joint can be immobilized using a fabricated splint or a soft splint, such as a pillow wrapped around the extremity with an elastic bandage. The outer gauze dressings should be changed daily to remove blood and exudates. The burn wound is contaminated and should be managed like a contaminated wound rather than completely occluded for any prolonged period. The innermost grease gauze dressing is usually left in place for 3 to 5 days before changing.

Wide meshed grafts, i.e., 3 to 1, can be managed in a similar fashion. However, there is an increased risk of desiccation of tissue between the mesh, especially if the wound surface has any exposed fat. Placement of a skin substitute, i.e. biobrane, pigskin, or cadaver skin, over the wide mesh protects the intertices.

Excised but not grafted wounds need to be covered with a skin substitute because the surface will invariably desiccate with an attempt at wet dressings alone. In addition, the skin substitute restores the barrier to heat and evaporative loss as well as invasive infection.
A 1:5 to 1 mesh graft is covered and immobilized with xeroform gauze over which is placed a moist dressing followed by compression

**Mesh Graft Covered by Temporary Skin Substitute (7-20)**

The temporary skin substitute protects the graft and interstices maintaining moist wound healing.

<table>
<thead>
<tr>
<th>Second Degree</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superficial</td>
<td>low risk</td>
</tr>
<tr>
<td>Mid-Dermal</td>
<td>moderate, higher in children, elderly</td>
</tr>
<tr>
<td>Deep-Dermal</td>
<td>high risk</td>
</tr>
<tr>
<td>Indeterminate (2\textsuperscript{nd} or 3\textsuperscript{rd})</td>
<td>_</td>
</tr>
<tr>
<td>Third Degree (full thickness)</td>
<td>_</td>
</tr>
</tbody>
</table>
**TREATMENT 21**
1) Admission is preferred but can be treated briefly (24 hrs) as an outpatient prior to surgery
2) SSD used after initial washing
3) Early surgery for best cosmetic and functional result and also to minimize disability time

**TREATMENT 22**
1) Same as for deep burn
2) Maintaining body T more critical in view of size
3) Early excision and grafting
4) Consider use of permanent skin substitutes in view of burn size (70% TBS)

**TREATMENT 23**
1) Same as for deep burn
2) Maintaining body T more critical in view of size
3) Early excision and grafting
4) Consider use of permanent skin substitutes in view of burn size (70% TBS)

Note: Skin substitute (Biobrane) in place at 24 hrs
VISUALLY DECEIVING BURN

Some burns usually caused by contact with flames or extremely hot temperature, like explosion, have the destroyed epidermis still present on the wound. The depth can be underestimated unless the wound is gently washed and debrided after which the size and depth is more clearly defined.

FLAME BURN (DIRECT CONTACT) 25
Looks superficial with blisters but mechanism suggests deep burn

When gently cleaned, wound is noted to be a combination of deep second and third degree burn 26

TREATMENT 27

1) Gentle wash, removing loose epidermis
2) SSD, preferably twice daily, under closed dressing
3) Excision and grafting will be needed for deep burn
E. WOUND CONVERSION

This term refers to the dynamic process whereby the Zone of Injury progresses to the Zone of Tissue Necrosis thereby deepening the wound. Conversion is more likely with a mid to deep dermal injury because of less blood flow, longer time to healing and increased risk of excess inflammation and infection. Also environmental hazards can readily lead to conversion of an open wound.

| RISK FACTORS FOR WOUND CONVERSION | LOCAL                                 | SYSTEMATIC
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Impaired Blood Flow</td>
<td></td>
<td>Septicemia</td>
</tr>
<tr>
<td>Increased inflammation</td>
<td></td>
<td>Hypovolemia</td>
</tr>
<tr>
<td>(infection, open wound, irritants)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface desiccation</td>
<td></td>
<td>Excess catabolism</td>
</tr>
<tr>
<td>Surface exudate buildup</td>
<td></td>
<td>Chronic illness</td>
</tr>
<tr>
<td>Mechanical trauma</td>
<td></td>
<td>--</td>
</tr>
<tr>
<td>(dressing changes, shearing)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical trauma - topical agents</td>
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</tr>
</tbody>
</table>
SECTION VIII: DAILY CARE OF THE BURN WOUND

A) GENERAL PRINCIPLES OF WOUND CARE
The topics in this chapter include:
A) General Principles of wound care
B) Superficial to mid-dermal burns
C) Deep burns
D) Wound conversion