Initial Management of Acute Burns

Cassidy A. Muir, Peter Stafford, Deepak K. Ozhathil

Background:

Burn injuries are a major source of morbidity and mortality, responsible for about 100,000 deaths and 9 million injuries requiring medical attention annually. Burns are most commonly due to open flame or scalds (hot liquids), with other causes being contact, electrical, chemical, and friction injuries. While the types of burns are similar across the globe, middle income countries have the highest incidence of burn related injuries. This is important to understand as burn related injuries account for a large proportion of disability-adjusted life years lost. Women and children contribute to most of these losses in regard to gender and age group respectively. This negatively impacts a country's economic productivity now and for the future.

The severity and treatment of a burn injury is dependent upon multiple factors: the size of the burned area, the depth of the burn, the location of the burn, and the resources available to treat the injury. Obviously, large surface area burns carry high risk for morbidity and mortality with high risk for infection and chronic pain. But even smaller burns can be devastating. For example, a small full-thickness hand burn can be life altering for a patient, affecting activities of daily life and can causing occupational disability.

Burn victims are often neglected by doctors and nurses who lack the experience and knowledge to care for them. You should take a special interest in the care of these patients. Think beyond the initial healing period and help construct a plan for long term care. The long term care of a severe burn victim should include physical and occupational therapy, pain management, and psychological care. Burn wounds can cause terrible pain and potential disability. You have a unique opportunity to provide survivors with compassionate, life-changing care.

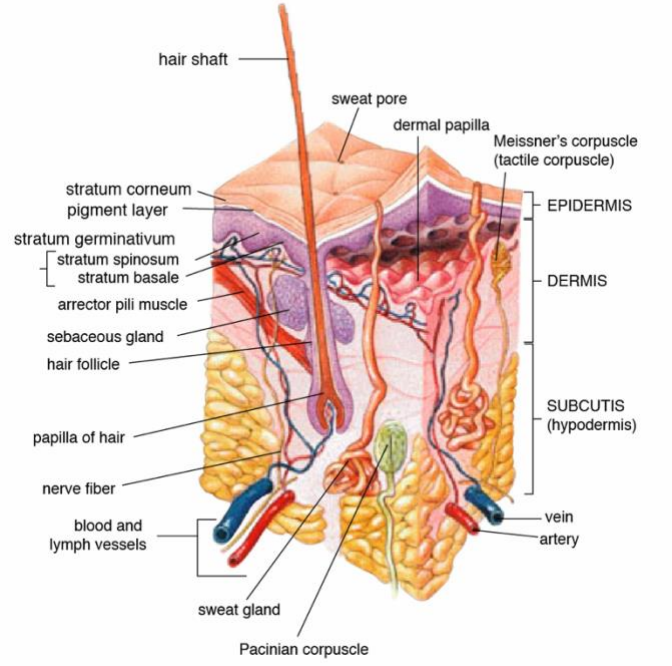
Anatomy:

The integumentary system is the largest organ of the body. It serves many functions including:

- Protecting deeper structures from mechanical, chemical, and thermal injuries
- Preventing desiccation
- Inhibiting invasion of microorganisms by releasing cytokines
- Regulating body temperature
- Containing sensory nerve endings to facilitate touch and proprioception
- Regulating hydration by preventing fluid loss
- Protecting against ultraviolet radiation
- Playing a role in endocrine function by secreting 1,25 OH Vitamin D
- Playing a role in exocrine function by secreting urea, water, sebum, ammonia, sweat, and pheromones.

The skin is composed of an outer layer, the epidermis, and a deeper layer, the dermis. The epidermis itself has up to five sublayers (depending on the body region) while the dermis has two sublayers. The thickness of these sublayers determines the thickness of skin. For example, the glabellar skin of the palm is thick due to epidermal redundancy. In contrast, the skin of the back is thick due to a thicker dermis.

The superficial sub-layer of the dermis, the papillary dermis, separates during blister formation, while the deeper dermal layer, the reticular dermis, is essential to skin regeneration. Burn injuries involving the reticular dermis and beyond will often lead to prolonged healing times, scarring, loss of function over joints, and increased rates of infection.



Layers of the skin. Generally, a superficial partial thickness burn is one in which there are many epidermal stem cells (stratum basale) remaining, while full thickness burns have no

remaining epidermal stem cells. Deep partial thickness burns are of varying depths, in between these two extremes. Note also that the hair follicle is surrounded by epidermal stem cells. Skin regeneration can be driven by these cells when more superficial layers are destroyed. Source: US Government, Public Domain, via Wikimedia Commons

Superficial burns (first degree) involving the epidermis alone are painful and characterized by redness and darker pigmentation. Superficial burns normally heal within a week. It is possible for even dark-skinned people to sustain such burns with extensive sun exposure.

Superficial (first degree) burn

Partial thickness burns (second degree) are divided into superficial partial thickness and deep partial thickness injuries.

Superficial partial thickness burns involve epidermolysis of the papillary dermis and are characterized by blistering. The wound base is pink and moist, wounds blanch (turn pale and then return to their initial color) upon pressure, and are sensate to pin prick. With preventative wound care, these burns will heal in less than 28 days.

Deep partial thickness burns involve the reticular dermis and are characterized by a dry, pale or hemorrhagic wound base. They are often insensate to pin prick and do not blanch. Healing is difficult to predict as there is a significant risk of conversion to full thickness wounds, especially with delayed presentation, imbalanced resuscitation and wound infection.

Partial thickness (second degree) burn before (above) and after (below) initial debridement

Full thickness burns (third degree) violate the reticular dermis and may extend into the hypodermis/fat, muscle, tendon, and bone. These can be desiccated, white or leathery brown, insensate, and do not blanch. If healing occurs, it does so by contraction from wound edges and often takes months to years to achieve wound closure, often leaving disabling or disfiguring scar contractures along the way.

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Full thickness (third degree and likely deeper) burn

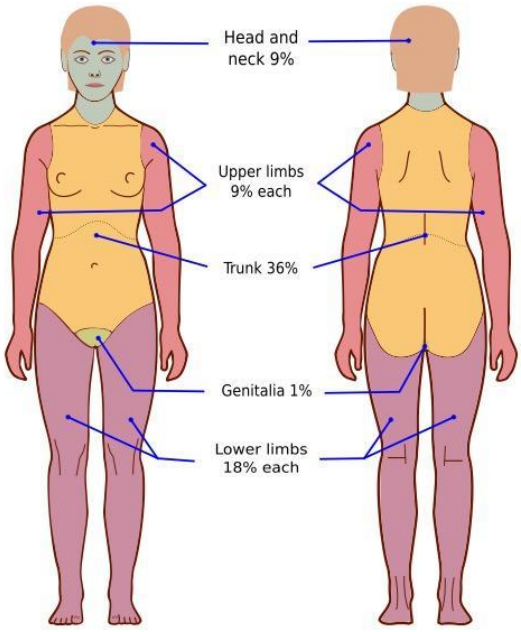
Burn wounds, however, often have varying degrees of depth. Additionally, it may not always be clear how deep the burn is initially, and the wound may undergo conversion in the first several days. It is easier to differentiate between superficial and deep wounds and more difficult to differentiate those that are of intermediate depth. Specifically, the question of whether to allow the wound to heal with time, or to excise and skin graft, can be difficult with intermediate-depth burns.

Principles:

The initial evaluation of the burned patient begins with the standard primary survey (ABCDE). Protecting the airway is of utmost importance, but local resources may limit what interventions are possible. Patients may have burns involving the face and upper airway and/or lower airway inhalation injury that compromise the patient's airway and respiratory status. If resources permit, endotracheal intubation and mechanical ventilation may be needed. Obtaining reliable vascular access is essential and can be achieved with peripheral IV, central venous catheter placement, or intraosseous access. If necessary, these may be inserted through burned skin. Recall that burned patients may have also suffered trauma, such as a motor vehicle accident, assault, or explosion, prior to or while sustaining the burn.

Upon completion of the primary survey and addressing immediately life-threatening injuries, complete a secondary survey with calculation of the percent total body surface area (TBSA) injured and assess the depth of each burn.

TBSA is calculated for partial (second degree) and full thickness (third-degree) burns only. Superficial burns (first-degree) are not included in this calculation. Rapid estimation of TBSA can be calculated in several different ways. The Rule of Nines divides the body into anatomic regions that are 9% each (i.e. multiples of 9.) It is important to recognize that even though each region is a multiple-of-9%, the typical burn does not involve the entire anatomic region. Only the fraction of the burned region should be included in the estimation. Additionally, the rule of nines is modified for infants/children due to their relatively larger head and smaller torso and legs. Burn surface area diagrams differ significantly for children of different ages, as during growth the proportional size of the head decreases, as shown further below.

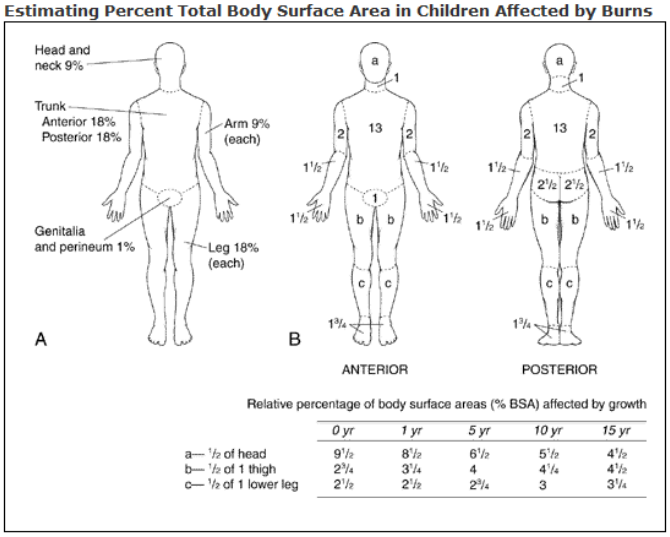


The "rule of nines" for an adult. Source: Jmarchn, CC BY-SA 3.0 via Wikimedia Commons

For smaller wounds or those that span body regions, TBSA can also be estimated using the patient's hand (palm and fingers) to equal 1% TBSA. This is particularly helpful with burns that are scattered across anatomic regions. This technique may overestimate the TBSA but provides a quick and useful metric.

Lund-Browder (LB) charts are also effective methods of determining the TBSA. Regions of the body are assigned specific percentages. Various

standardized LB charts exist for victims of different age and gender subgroups.



(A) Rule of "nines"
(B) Lund-Browder diagram for estimating extent of burns

The Lund-Browder Chart allows you to calculate the relative percentage of body surface area by age. Source: Department of Health and Human Services - available at https://commons.wikimedia.org/w/index.php?curid=25740802

Adults or children with burns ≥ 15-20% TBSA, depending on the depth of injury need fluid resuscitation due to increased capillary permeability. The impaired systemic perfusion due to loss of intravascular volume is known as "burn shock." The goal of resuscitation is to maintain critical organ perfusion while minimizing excess fluid resuscitation, as both under and over-resuscitation are harmful.

Fluid resuscitation can be given orally or intravenously depending on what local resources allow. Patients with burns <30% TBSA who are not requiring medications to augment their blood pressure may be candidates for oral resuscitation, however, IV fluid resuscitation is preferred as balanced IV solutions such as Lactated Ringers can minimize adverse electrolyte shifts from the resuscitation fluids. Burns <40% TBSA can be managed with one peripheral IV, while those >40% would benefit from two or more. The internationally accepted Consensus Formula recommends 2-4 mL/kg/TBSA with crystalloid fluids over 24 hrs which is used to guide initial fluid resuscitation. For adults providers should use 2 mL, pediatrics 3 mL and electrical injuries 4 mL. Fluid administration is titrated based on the physiologic status of the patient. A urine output of 0.5 mL/kg/hr, or approximately 30 mL/hr, for the average adult or 1 mL/kg/hr in infants/toddlers is a surrogate for adequate organ perfusion. Resuscitation of children is specific to their weight and should be calculated based on 0.5 mL/kg/hr. This metric can also be used to ensure proper fluid intake after initial fluid resuscitation is complete.

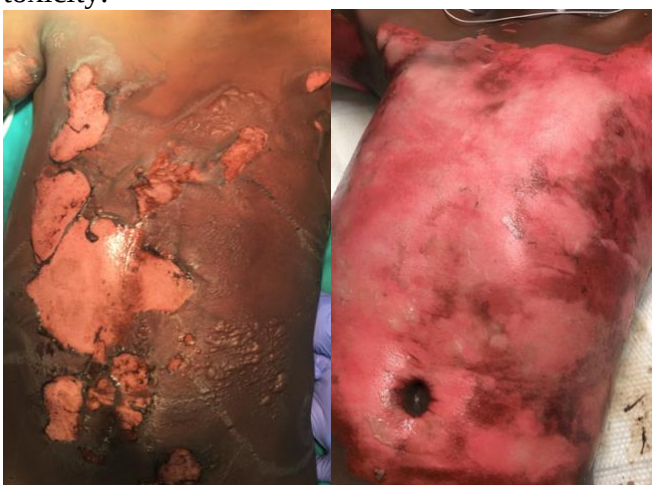
In addition to fluids, tube feeds via a nasogastric or orogastric tube should be initiated on admission if resources allow. Early (within 24-48 hours) passive gut feeding has decreased burn mortality rates in children and adults.

After the initial evaluation and stabilization of the patient, the wounds need to be cleaned and dressed. Wound care is painful, and if the patient is not experiencing much pain, it suggests that the wounds may be full thickness and the cutaneous nerve endings may be compromised. Ensure that adequate analgesia is administered prior to beginning wound care (e.g. fentanyl, morphine, ketamine) and adjuvant medications are scheduled throughout wound care period (e.g. muscle relaxants, gabapentin, non-steroidal anti-inflammatories, paracetamol, etc)

Studies have investigated leaving blisters intact versus unroofing them. Unless the blisters are small and intact, they are normally unroofed and dressed due to the increased risk of wound infection from delayed violation of blisters as well as wound conversion that can occur under a blister. If supplies are limited, an alternative to partial thickness wounds is to open the blister and allow the fluid to escape, permitting the wall of the blister to serve as a dressing. A drawback to this approach is that the wound bed cannot be seen and a deep partial thickness injury or even progression to full thickness injury may occur unseen.

The wounds are cleansed with gentle washing. Soap and water is generally effective and the use of saline or antiseptics is not necessary. Once the wounds are cleaned and non-viable tissue is debrided, the wounds should be dressed with a moist cytoprotective dressing. Commonly, this includes a thick layer of an antibiotic ointment (neomycin or bacitracin), or moistened gauze with saline or Dakin's solution, followed by dry dressings to hold them in place. Silver sulfadiazine ("SSD") is also

available in many settings. These dressings should be changed one-two times daily or more frequently if they become soiled, to decrease the bacterial burden at the base of the wound. If the burn requires surgical excision, the dressings post-operatively can be similar or are determined by the skin substitute or graft used. The burn wound will need dressings until re-epithelialization occurs. Bear in mind that topical antibiotics such as neomycin applied to a large wound may be systemically absorbed, leading to toxicity.



Before and after initial debridement. This patient received a Cyanokit (hydroxocobalamin) which has altered the appearance of the wound bed.

Circumferential or near circumferential full-thickness burns of the extremities, with eschar that compromise the underlying tissue or circulation, require escharotomy. Similarly, circumferential or near circumferential eschar to the neck and torso will need escharotomy if ventilation is compromised. Escharotomy to an extremity should be done within eight hours of injury and ideally well before evidence of impaired perfusion develops. It is rarely needed after resuscitation has been completed, i.e. after 48-72 hrs. Escharotomy is incision of the burn, down to the subcutaneous fat, parallel to the limb, torso, or neck, in such a way that the circumferential nature of the burn does not constrict the tissue underneath.

Escharotomy involves incision through burned tissue down to subcutaneous fat, in areas where the burn is circumferential and inhibits circulation (in the extremities) or ventilation in the trunk, as shown here.) Source: Greenwood JE *https://doi.org/10.1177/0310057X19895523*

Capillary refill of the nail beds, pulses, doppler signals of the arteries, temperature, compartment pressures, and whether the compartment "feels" full and tight are used to assess if escharotomy is needed. However, if you are uncertain whether or not to perform escharotomy, the recommendation is to perform it. The risk of complications of performing an unnecessary escharotomy are much lower than the potential loss of limb that may result from failure to perform or performing a delayed escharotomy.

Decision Making:

Burn care is resource intense, requiring a team approach to provide care that can last months or even longer. In the evaluation of these patients, it is important to know if the hospital has the needed resources, and if it is possible and better to refer these patients to another hospital. In many resource-limited settings, an entire country may be served by a single burn center, which may be hundreds of kilometers away. An understanding of your country's resources can help tremendously in a discussion with the patient and the family.

Goals of burn care are multifaceted and patient autonomy should be respected throughout their care. In general, the goal is to get the burn wounds to heal as quickly as possible, prevent infection, and minimize the complications associated with hypertrophic scar formation. Achieving these goals can be an extensive undertaking, requiring

critical care support, wound care, operative intervention, nutritional support, treatment of infections, and rehabilitation. There are times when a large TBSA burn may not be survivable, especially in a resource limited setting, and an approach focusing on patient comfort and support may be the appropriate option. Keeping wounds covered with dressings can help control pain and keep the patient comfortable. The decision to palliate rather than treat an extensive burn can be very difficult, and should be made in consultation with experienced clinicians who know what is possible in your setting.

If resources permit, patients with deep partial and full thickness burns will best be treated by early excision and grafting (within 2-5 days of injury). A plan should be devised for each major burn patient, and is dependent upon the extent of burn, its location and depth, and resources available. This approach makes intensive use of operating theater time, blood products, and other resources, though it ultimately results in faster healing and a shorter hospital stay. See Tangential Excision of Burns.

In resource limited settings, a longer wound-care focused approach may be more realistic. Dressing changes are performed until the eschar has sloughed off and granulation tissue has established on the wound bed. At this point the wound bed is prepared and skin grafted where needed. If this approach is taken, it is important that the patient receives attentive care, and undergoes ongoing physical therapy, splinting, nutritional support, and regular revaluation for wound infection development. The eschar will slough by bacterial activity. As this method involves leaving a wound open for some time, it is prone to invasive infection. Close monitoring and frequent wound care is crucial.

Bear in mind also that this approach is painful for the patient. We have seen, in extreme circumstances, patients develop tolerance to anesthetic medications because of frequent debridements.

Initial appearance of a burn caused by exposure to a "space heater" while unconscious. It is impossible to tell how much of this wound is full thickness at this time. It is reasonable to defer judgment until after the initial debridement.

The same burn, after debridement and serial dressing changes for a few days. It is now quite clear that the brown and white areas in the center of the wound are full thickness and must be excised. The surrounding pink area may or may not contain viable epidermal cells. It would be reasonable to debride this area gently with a scalpel and if it bleeds, apply a meshed split thickness skin graft to the whole area.

An option for large areas of burns is to perform staged excisions to limit blood loss during each operation. For patients undergoing excision and grafting, there are several questions to think about prior to going to the operating room.

1. Will the burns be excised in a single stage or would the patient be better served by sequential excisions every few days until the burn is completely excised? Often, this is dependent upon the TBSA and resources available, including donor skin. It may also depend on whether the donor site will be re-harvested for multiple grafts in a patient with a high TBSA burn. It is necessary to plan for ample healing of donor site in between harvests.
2. Will the patient be immediately grafted or is a skin substitute needed and available for

placement? This depends on the physiologic status of the patient, the quality of the wound bed, the resources available, and what percentage of graft loss may be acceptable.

3. Are the wounds appropriate for tangential excision or is fascial excision needed? Ideally, wounds are treated with tangential excision which preserves viable dermis and/or fat, improving functional and cosmetic outcomes. However, burns extending into the subcutaneous tissue and beyond will best be treated by fascial excision. Massive burns will often need full fascial excision because the hemodynamic insult of tangential excision may be beyond the physiologic reserve of the patient.
4. How will blood loss be reduced during the operation, and is blood available if a transfusion is needed? A major limitation of burn wound excision is blood loss. However, this can be limited through various techniques. We describe these techniques in the chapter, Tangential Excision of Burns.
5. Are materials in place for post-operative splinting and rehabilitation? Will a limb be splinted or do fingers need to be immobilized with K-wires? Ensuring that you have a plan for post-operative rehabilitation and mobilization will serve the patient well.
6. Would the patient be better served by an amputation? Although many patients are reluctant at first, a prolonged treatment course that bankrupts the extended family and takes months or years may not be the best course of action.
7. What social factors will affect this patient's ability to follow the post-treatment plan? Two specific considerations are adequate nutrition, and ability to access wound care near their home.

Case Study #1:

A 14-month-old girl was brought to the clinic after putting her hand into hot tea. A dressing consisting of toothpaste, maize flour and cooking oil had already been applied by the family. With the home remedy applied, the depth of the burn could not be assessed.

The wound was cleaned gently and found to be erythematous and sensate throughout. Thick adherent skin on the palm of the hand was not debrided. A moist, petroleum jelly ("Vaseline") based ointment, covered by a protective dressing was applied. The mother was instructed to leave the dressing in place and to return to the clinic every other day, except weekends, for continued care.

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Two days later, the patient was seen again. The dressing was dirty on the outside but the wound was still clean and moist. The dressing was changed and the wound was gently cleaned. The wound appeared clean and healthy. No new sites of apparent necrosis were seen.

Three days later the patient was seen again. The wound was progressing nicely and beginning to heal.

After another three days, the wound was clearly progressing well. It was less "wet" in appearance. The patient was treated and bandaged again in the clinic, but areas of the healed upper arm were left open, and the mother was instructed to apply Vaseline at home.

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The patient returned 2 days later. The wound was clearly all dry, and the thick skin on the palm had completely fallen off. Function and range of motion were completely normal.

The final photos, shown below, were taken 11 months after the initial injury. The hand was completely functional. The discoloration on the volar surface of the hand had also resolved completely.

Wound care by E. Meyerhoff, RAE Clinic, Baringo, Kenya

Comment: This is a very common presentation in low-resource settings. The history and initial examination suggest a benign course with proper wound care. Immersion in hot cooking oil or exposure to flames would be more likely to result in a full thickness burn. Frequent clinician review of the wound, careful mobilization of the fingers, and maintenance of a moist healing environment are all key to assuring a good outcome. It is important to assess the conditions at home: a single parent caring for multiple children will not be able to apply dressings themselves: the child will need to be brought to the clinic for review at least every 2 days, or admitted if this is difficult.

Case Study #2:

A 12-month-old girl was brought to the clinic after sustaining burns, possibly with hot porridge.

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She was left alone near a metal pot of porridge cooking over an open fire. A neighbor heard her crying and found her covered in hot porridge, lying next to the overturned pot. On referral to the clinic, a home dressing consisting of raw egg had already been applied.

All wounds appeared sensate except the center of the left flank burn. This area appeared pale and did not blanch when gentle finger pressure was applied. The wounds were cleaned and gently irrigated. A moist Vaseline-based treatment was applied, and bandaged with a non-stick dressing for protection.

The patient was treated at the clinic every other day three times a week. Eight days later most of the wound was clearly sensate, healthy, and starting to dry. The area in the center of the flank burn remained concerning, as it appeared white, firm, and "leathery" in appearance, in contrast with the pink healing tissue surrounding it.

The same wound care regimen was continued and no determination about the suspected full-thickness portion of the burn was made at that time.

Three weeks later it was clear that there were no living epidermal cells within the center of the wound. Whereas the rest of the wound was dry and even returning to its normal skin color, the center of the flank wound had only granulation tissue.

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The family was unable to access a higher level of care due to financial concerns. The granulation tissue was kept moist, with the patient treated at the clinic 2 or 3 times a week, whenever the parents could bring her.

During the next several weeks and months the non-healing portion of the wound was kept moist, and dressed at the clinic. The following two photos were taken 10 weeks apart:

At this time the family's national health insurance was mature enough and the clinic was able to arrange a skin graft. The final result was complete healing of the wound:

Wound care by E. Meyerhoff, RAE Clinic, Baringo, Kenya

Comment: Unfortunately, the un-witnessed child burn with a somewhat vague history is also very common in low-resource settings. In this case, it was not known how long the child was unattended for, or how much oil was in the porridge, which would have raised its temperature significantly. Similarly, the child may have come in contact with the cooking pot, hot coals or flames. A full-thickness wound was suspected as described. In any case, it is almost always impossible to unravel what truly happened in our setting.

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When the central part of the wound failed to heal with supportive care, it quickly became apparent that there were no living epidermal cells within it. It got smaller in the only way that such wounds can: by the contraction of myofibroblasts pulling the wound edges together.

If this wound had been in the axilla or across another joint, it would have led to contracture, a much harder problem to treat. Wounds in areas that can not completely heal by contraction remain as they are, granulation tissue. Eventually they may be at risk for malignant transformation, also known as Marjolin's ulcer.

There were no viable epidermal cells in this child's antecubital fossa after he sustained a burn: the only way the wound could heal was by contraction of the wound edges, leading to a contracture deformity.

A wound that is not able to heal by contraction of its edges, as here on the lateral scalp, will remain unhealed. (Note that as it attempted to contract, the wound pulled on the upper eyelid and exposed and desiccated the eye.) Over time, usually years, that chronic wound may undergo malignant transformation into an aggressive form of Squamous Cell carcinoma known as Marjolin's ulcer.

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Resource-Rich Settings

For massive burns, wound coverage is often achieved with Cultured Epidermal Autograft, in which two cm full thickness skin biopsies are taken and sheets of skin are cultured in the lab. For patients without adequate donor sites, this allows the wound to be covered. Newer technology like cell suspension (ReCell) is improving the cosmetic appearance of wounds after care.