Assessment and classification of burn injury

AUTHORS: Phillip L Rice, Jr, MD, Dennis P Orgill, MD, PhD
SECTION EDITOR: Marc G Jeschke, MD, PhD
DEPUTY EDITOR: Kathryn A Collins, MD, PhD, FACS

All topics are updated as new evidence becomes available and our peer review process is complete.

Literature review current through: **Mar 2024.**
This topic last updated: **Feb 20, 2023.**

INTRODUCTION

Burns are commonly thought of as injury to the skin caused by excessive heat. More broadly, burns result from traumatic injuries to the skin or other tissues primarily caused by thermal or other acute exposures. Burns occur when some or all of the cells in the skin or other tissues are destroyed by heat, electrical discharge, friction, chemicals, or radiation. Burns are acute wounds caused by an isolated, non-recurring insult, and healing ideally progresses rapidly through an orderly series of steps [1].

The mechanisms that result in burns and their classification will be reviewed here. The clinical assessment and management of burns in adults and children are discussed elsewhere. (See "Treatment of minor thermal burns" and "Treatment of superficial burns requiring hospital admission" and "Overview of the management of the severely burned patient" and "Treatment of deep burn injury".)

BURN MECHANISMS

Heat — The depth of the thermal injury is related to contact temperature, duration of contact with the external heat source, and the thickness of the skin. Because the thermal conductivity of skin is low, most thermal burns involve the epidermis and part of the dermis [2]. The most common thermal burns are associated with flames, hot liquids, hot solid objects, and steam.

Electrical discharge — Electrical energy is transformed into heat as the current passes through poorly conducting body tissues. Electroporation (injury to cell membranes) disrupts membrane potential and function. The magnitude of the injury depends on the pathway of the current, the resistance to the current flow through the tissues, and the strength and duration of the current flow. (See "Electrical injuries and lightning strikes: Evaluation and management".)

Friction — Injury from friction can occur due to a combination of mechanical disruption of tissues and heat generated by friction.

Chemicals — A wide range of caustic reactions, including alteration of pH, disruption of cellular membranes, and direct toxic effects on metabolic processes, causes injury. In addition to the duration of exposure, the nature of the agent will determine injury severity. Contact with acid causes coagulation necrosis of the tissue, while alkaline burns generate liquefaction necrosis. Systemic absorption of some chemicals is life-threatening, and local damage can include the full thickness of skin and underlying tissues. (See "Topical chemical burns: Initial evaluation and management".)

Radiation — Radiofrequency energy or ionizing radiation can cause damage to skin and tissues. The most common type of radiation burn is sunburn. Radiation burns are most commonly seen today following therapeutic radiation therapy and are also seen in patients who receive excessive radiation from diagnostic procedures. (See "Clinical manifestations, evaluation, and diagnosis of acute radiation exposure".)

Radiation burns can be seen in individuals who work in the nuclear industry. Radiation burns are often associated with cancer due to the ability of ionizing radiation to interact with and damage DNA. The clinical results of ionizing radiation depend on the dose, time of exposure, and type of particle that determines the depth of exposure. Depending on the photon energy, radiation can cause very deep internal burns.

CLASSIFICATION BY DEPTH

Cutaneous burns are classified according to the depth of tissue injury. The depth of the burn largely determines the healing potential and the need for surgical grafting.

General considerations — The traditional classification of burns as first, second, third, or fourth degree was replaced by a system reflecting the need for surgical intervention. Current designations of burn depth are superficial, superficial partial-thickness, deep partial-thickness, and full-thickness (table 1 and figure 1) [3]. The term fourth degree is still used to describe the most severe burns, burns that extend beyond the skin into the subcutaneous soft tissue and can involve underlying vessels, nerves, muscle, bone, and joints.

Burn wounds are not usually uniform in depth, and many have a mixture of deep and superficial components. A precise assessment of the depth of the burn wound may be difficult initially as burn wounds are dynamic and can progress as well as convert to deeper wounds, which may require several days for a final determination [3,4]. Thin skin, particularly on the volar surfaces of the forearms, medial thighs, perineum, and ears, sustains deeper burn injuries than suggested by initial appearance [4]. It is best to assume there are no shallow burns in these areas [5]. Children under five years and adults over 55 are also more susceptible to deeper burns because of thinner skin [4-6].

Appropriate burn wound care may necessitate multiple treatment modalities for different parts of a burn wound depending on the burn depth of each injured part.

The American Burn Association (ABA) has published an educational resource that reviewed the classification and management of the burn wound. The classification system below is largely in agreement [1].

Superficial — Superficial or epidermal burns involve only the epidermal layer of skin. They do not blister but are painful, dry, red, and blanch with pressure (picture 1). Over the next two to three days the pain and erythema subside, and by approximately day 4, the injured epithelium peels away from the newly healed epidermis. Such injuries are generally healed in six days without scarring. This process is commonly seen with sunburns.

Partial-thickness — Partial-thickness burns involve the epidermis and portions of the dermis. They are characterized as either superficial or deep.

- **Superficial partial thickness –** These burns characteristically form blisters within 24 hours between the epidermis and dermis. They are painful, red, weep, and blanch with pressure (picture 2). Burns that initially appear to be only epidermal in depth may be determined to be partial thickness 12 to 24 hours later. These burns generally heal in 7 to 21 days; scarring is unusual, although pigment changes may occur. A layer of fibrinous exudates and necrotic debris may accumulate on the surface, which may predispose the burn wound to heavy bacterial colonization and delayed healing. These burns typically heal without functional impairment or hypertrophic scarring.

- **Deep partial thickness –** These burns extend into the deeper dermis and are characteristically different from superficial partial-thickness burns. Deep burns damage hair follicles and glandular tissue. They are painful to pressure only, almost always blister (easily unroofed), are wet or waxy dry, and have variable mottled colorization from patchy cheesy white to red (picture 3). They do not blanch with pressure. If infection is prevented and wounds are allowed to heal spontaneously without grafting, they will heal in two to nine weeks. These burns invariably cause hypertrophic scarring. If they involve a joint, joint dysfunction is expected even with aggressive physical therapy. A deep partial-thickness burn that fails to heal in two weeks is functionally and cosmetically equivalent to a full-thickness burn. Differentiation from full-thickness burns is often difficult.

Full-thickness — These burns extend through and destroy all layers of the dermis and often injure the underlying subcutaneous tissue. Burn eschar, the dead and denatured dermis, is usually intact. The eschar can compromise the viability of a limb or torso if circumferential.

Full-thickness burns are usually anesthetic or hypo-aesthetic. Skin appearance can vary from waxy white to leathery gray to charred and black. The skin is dry and inelastic and does not blanch with pressure (picture 4). Hairs can easily be pulled from hair follicles. Vesicles and blisters do not develop.

Pale full-thickness burns may simulate normal skin except that the skin does not blanch with pressure. Features that differentiate partial-thickness from full-thickness burns may take some time to develop.

The eschar eventually separates from the underlying tissue and reveals an unhealed bed of granulation tissue. Without surgery, these wounds heal by wound contracture with epithelialization around the wound edges. Scarring is severe with contractures; complete spontaneous healing is not possible.

Extension to deep tissues — Fourth-degree burns are deep and potentially life-threatening injuries that extend through the skin into underlying soft tissue and can involve muscle and/or bone.

EXTENT OF BURN INJURY

A thorough and accurate estimation of burn size is essential to guide therapy and to determine when to transfer a patient to a burn center. Using one of the methods described below, the extent of burns is estimated and expressed as the total percentage of body surface area (ie, TBSA). Superficial (first-degree) burns are **not** included in percentage TBSA burn assessment.

The locations of partial-thickness and full-thickness burned areas are recorded on a burn diagram (figure 2). Burns with an appearance compatible with either deep partial-thickness or full-thickness are presumed to be full-thickness until accurate differentiation is possible.

Methods of estimation — The two commonly used methods of assessing percentage TBSA in adults are the Lund-Browder chart and "Rule of Nines." The Lund-Browder chart is the recommended method in children because it considers the relative percentage of body surface area affected by growth [3,7,8]. If the burn is irregular and/or patchy, the palm method may be more useful.

Superficial (first-degree) burns are **not** included in percentage TBSA burn assessment.

- **Lund-Browder** – The Lund-Browder chart (figure 2) is the most accurate method for estimating TBSA for both adults and children. Children have proportionally larger heads and smaller lower extremities, so the percentage TBSA is more accurately estimated using the Lund-Browder chart (table 2 and figure 2).

- **Rule of Nines** – For adult assessment, the most expeditious method to estimate TBSA in adults is the "Rule of Nines" [9,10]:

  - The head represents 9 percent TBSA
  - Each arm represents 9 percent TBSA
  - Each leg represents 18 percent TBSA
  - The anterior and posterior trunk each represent 18 percent TBSA

- **Palm method** – Small or patchy burns can be approximated by using the surface area of the patient's palm. The palm of the patient's hand, excluding the fingers, is approximately 0.5 percent of total body surface area, and the entire palmar surface including fingers is 1 percent in children and adults [11-13].

Accuracy of percentage TBSA estimates — In several observational reports comparing the estimation of burn size at the referring hospital with the estimation at the receiving burn center, the size of larger burns was underestimated. This resulted in under-resuscitation at the referring hospital [14-16]. Early transfer to a burn center should be arranged when injuries meet the criteria for major burns (table 3). (See "Emergency care of moderate and severe thermal burns in adults", section on 'Initial assessment and treatment'.)

The percentage TBSA burned may be underestimated in women with large breasts who have burns of the anterior trunk. A table based on the cup size of a brassiere is intended to complement the Lund-Browder chart for burn estimation in adults. In a review of 60 volunteers to determine the difference in percentage TBSA of the anterior trunk between males and females, large-breasted women (cup size D and greater) were found to have a significantly greater amount of percentage TBSA on the anterior chest compared with men (16 versus 11 percent) [17]. This additional percentage TBSA is concentrated on the pectoral region and represents 10 percent of TBSA as compared with 5 percent for men and 7 percent for women with smaller breasts. There was an equal distribution of anterior and posterior trunk TBSA in men but a 1.6:1 ratio in large-breasted women. For every increase in cup size, the TBSA of a woman's anterior trunk increases by a factor of 0.1, relative to the posterior trunk (figure 3).

In addition, a study in patients with obesity suggested that both the Rule of Nines and Lund-Browder diagrams underestimate the extent of burns involving the torso and overestimate the percentage of burns involving the extremities in the patients with obesity [18]. In this study, the patient's primary shape (android versus gynecoid) was important for determining the percentage TBSA in comparison to body mass index (BMI) and sex.

Assessment of indeterminate burn depth — Clinical assessment is the most common technique to assess the depth of a burn wound; however, it is accurate in only 60 to 75 percent of the cases, even when carried out by an experienced burn surgeon [19,20]. Making assessments of burn depth is difficult because there are both spatial and temporal changes in perfusion in actual burn patients as most burn patients have burns of various depths caused by their injury.

A variety of methods that aim to improve burn depth assessment are in development or in early clinical use. Experimentally, optical methods can predict burn depth with over 90 percent accuracy. Additional studies will help provide a better understanding as to which technologies will be of greatest clinical use. Examples of such technologies include the following [21-33]:

- Laser Doppler analysis assays the velocity of blood cells in the superficial dermis. This is reported as an index and correlated with blood perfusion.
- Indocyanine green is a dye that can be injected intravenously and can be imaged by the application of ultraviolet light showing both an arterial and venous phase. Cameras are available in most large hospitals, and these systems are commonly used to monitor skin perfusion in skin flaps.
- Thermography also provides an index of perfusion based on the temperature of the tissue. This provides two-dimensional images of perfusion in large areas.
- A number of dermoscopy techniques have also been reported to correlate nicely with burn depth.
- Hyperspectral imaging uses multiple light frequencies to image deoxy and oxyhemoglobin in tissues and has been shown in animal models to accurately correlate with burn depth.

Additional tools that have been evaluated include a single-sided planar magnetic resonance (MR) imaging probe, a unilateral MR imaging sensor equipped with a 2D gradient coil system, novel uses of lasers (eg, optimal coherence tomography), spatial frequency domain imaging alone and in combination with laser speckle imaging, and videomicroscopy.

ANATOMIC LOCATION OF BURN INJURY

The location of a burn often directs treatment. Burns on the face, hands, feet, and genitalia as well as large burns in other areas of the body and those associated with inhalational injury are often referred to burn centers for specialized expertise (table 3).

- Head and neck – (See "Principles of burn reconstruction: Face, scalp, and neck".)
- Extremities – (See "Principles of burn reconstruction: Extremities and regional nodal basins" and "Primary operative management of hand burns".)
- Trunk – (See "Principles of burn management: The breast" and "Principles of burn reconstruction: Perineum and genitalia".)
- Respiratory tract – Superheated gases can cause burns to the respiratory system. More commonly, injury occurs from smoke exerting its effects through local chemical irritation. In addition, chemicals such as carbon monoxide or cyanide can lead to systemic toxicity. Direct thermal injury from hot smoke usually burns only the pharynx while steam can also burn the airway below the glottis. (See "Inhalation injury from heat, smoke, or chemical irritants".)

OVERALL SEVERITY OF BURN INJURY

A combination of the burn mechanism, burn depth, extent, and anatomic location determine the overall severity of the burn injury, which provides general guidance for the preferred disposition and care of these patients (table 3).

Minor or mild burn injury — Minor or mild burns are those that can be treated in a physician's office or in an emergency department as an outpatient. (See "Treatment of minor thermal burns".)

Moderate burn injury — Moderate burns would be those that require admission to a hospital but not to a burn center. These include superficial burns or deeper burns of limited extent. (See "Emergency care of moderate and severe thermal burns in adults" and "Treatment of superficial burns requiring hospital admission".)

Severe burn injury — Severe burn injury can be defined as burns that should be referred to, and treated at, a designated burn center (table 3). (See "Emergency care of moderate and severe thermal burns in adults" and "Overview of the management of the severely burned patient" and "Treatment of deep burn injury".)

SOCIETY GUIDELINE LINKS

Links to society and government-sponsored guidelines from selected countries and regions around the world are provided separately. (See "Society guideline links: Care of the patient with burn injury".)

SUMMARY

- **Burn definition –** A burn is defined as a traumatic injury to the skin or other organic tissue primarily caused by heat or exposure to electrical discharge, friction, chemicals, and radiation. (See 'Introduction' above and 'Burn mechanisms' above.)

- **Classification by burn depth –** Cutaneous burns are classified according to the depth of tissue injury (table 1 and figure 1). The depth of the burn largely determines the healing potential and the need for surgical grafting. (See 'Classification by depth' above.)

  - Superficial or epidermal burns involve only the epidermal layer of skin.
  - Partial-thickness burns involve the epidermis and portions of the dermis.
  - Full-thickness burns extend through and destroy all layers of the dermis.
  - Deeper (fourth-degree) burns extend through the skin into underlying soft tissues such as fascia, muscle, and/or bone.

- **Extent of burn injury –** A thorough estimation of burn size is essential to guide therapy. The extent of the burn injury is expressed as a percentage of the patient's total body surface area (TBSA). Superficial (first-degree) burns are **not** included in percentage TBSA burn assessment. This estimation can be facilitated using a Lund-Browder chart, the Rule of Nines, or the palm method. The most accurate method of assessment of TBSA burn in children and adults is the Lund-Browder chart. The extent of large TBSA burns is often underestimated, and factors such as sex, body shape, and obesity can affect the assessment. (See 'Extent of burn injury' above.)

- **Anatomic location –** The anatomic location of a burn often directs treatment. Burns on the face, hands, feet, and genitalia as well as large burns in other areas of the body are often referred to burn centers for specialized expertise. (See 'Anatomic location of burn injury' above.)

- **Overall burn severity –** A combination of the burn mechanism, burn depth, extent, and anatomic location helps determine the overall severity of the burn injury (minor, moderate, severe), which provides general guidance for the preferred disposition and care of these patients. (See 'Overall severity of burn injury' above.)

REFERENCES

1. American Burn Association White Paper. Surgical management of the burn wound and use of skin substitutes. Copyright 2009. www.ameriburn.or (Accessed on January 04, 2010).
2. Orgill DP, Solari MG, Barlow MS, O'Connor NE. A finite-element model predicts thermal damage in cutaneous contact burns. J Burn Care Rehabil 1998; 19:203.
3. Mertens DM, Jenkins ME, Warden GD. Outpatient burn management. Nurs Clin North Am 1997; 32:343.
4. Baxter CR. Management of burn wounds. Dermatol Clin 1993; 11:709.
5. Pham, TN, Girban, et al. Evaluation of the burn wound: Management decisions. In: Total Burn Care, 3rd edition, Herndon, D (Eds), Saunders Elsevier, Philadelphia 2007. p.119.
6. Orgill DP. Excision and skin grafting of thermal burns. N Engl J Med 2009; 360:893.
7. Woodson LC, Sherwood ER, Aarsland A, et al. Anesthesia for burned patients. In: Total Burn Care, 3rd edition, Herndon DN (Ed), Saunders Elsevier, Philadelphia 2007. p.196.
8. Lund CC, Browder NC. The estimation of areas of burns. Surg Gynecol Obstet 1944; 79:352.
9. Monafo WW. Initial management of burns. N Engl J Med 1996; 335:1581.
10. Wachtel TL, Berry CC, Wachtel EE, Frank HA. The inter-rater reliability of estimating the size of burns from various burn area chart drawings. Burns 2000; 26:156.
11. Perry RJ, Moore CA, Morgan BD, Plummer DL. Determining the approximate area of a burn: an inconsistency investigated and re-evaluated. BMJ 1996; 312:1338.
12. Sheridan RL, Petras L, Basha G, et al. Planimetry study of the percent of body surface represented by the hand and palm: sizing irregular burns is more accurately done with the palm. J Burn Care Rehabil 1995; 16:605.
13. Nagel TR, Schunk JE. Using the hand to estimate the surface area of a burn in children. Pediatr Emerg Care 1997; 13:254.
14. Collis N, Smith G, Fenton OM. Accuracy of burn size estimation and subsequent fluid resuscitation prior to arrival at the Yorkshire Regional Burns Unit. A three year retrospective study. Burns 1999; 25:345.
15. Hagstrom M, Wirth GA, Evans GR, Ikeda CJ. A review of emergency department fluid resuscitation of burn patients transferred to a regional, verified burn center. Ann Plast Surg 2003; 51:173.
16. Freiburg C, Igneri P, Sartorelli K, Rogers F. Effects of differences in percent total body surface area estimation on fluid resuscitation of transferred burn patients. J Burn Care Res 2007; 28:42.

17. Hidvegi N, Nduka C, Myers S, Dziewulski P. Estimation of breast burn size. Plast Reconstr Surg 2004; 113:1591.
18. Williams RY, Wohlgemuth SD. Does the "rule of nines" apply to morbidly obese burn victims? J Burn Care Res 2013; 34:447.
19. Monstrey S, Hoeksema H, Verbelen J, et al. Assessment of burn depth and burn wound healing potential. Burns 2008; 34:761.
20. Serrano C, Boloix-Tortosa R, Gómez-Cía T, Acha B. Features identification for automatic burn classification. Burns 2015; 41:1883.
21. Shin JY, Yi HS. Diagnostic accuracy of laser Doppler imaging in burn depth assessment: Systematic review and meta-analysis. Burns 2016; 42:1369.
22. Hoeksema H, Van de Sijpe K, Tondu T, et al. Accuracy of early burn depth assessment by laser Doppler imaging on different days post burn. Burns 2009; 35:36.
23. Lotter O, Held M, Schiefer J, et al. Utilization of laser Doppler flowmetry and tissue spectrophotometry for burn depth assessment using a miniature swine model. Wound Repair Regen 2015; 23:132.
24. Pape SA, Skouras CA, Byrne PO. An audit of the use of laser Doppler imaging (LDI) in the assessment of burns of intermediate depth. Burns 2001; 27:233.
25. McGill DJ, Sørensen K, MacKay IR, et al. Assessment of burn depth: a prospective, blinded comparison of laser Doppler imaging and videomicroscopy. Burns 2007; 33:833.
26. Jeng JC, Bridgeman A, Shivnan L, et al. Laser Doppler imaging determines need for excision and grafting in advance of clinical judgment: a prospective blinded trial. Burns 2003; 29:665.
27. Crouzet C, Nguyen JQ, Ponticorvo A, et al. Acute discrimination between superficial-partial and deep-partial thickness burns in a preclinical model with laser speckle imaging. Burns 2015; 41:1058.
28. Burke-Smith A, Collier J, Jones I. A comparison of non-invasive imaging modalities: Infrared thermography, spectrophotometric intracutaneous analysis and laser Doppler imaging for the assessment of adult burns. Burns 2015; 41:1695.
29. Wongkietkachorn A, Surakunprapha P, Winaikosol K, et al. Indocyanine green dye angiography as an adjunct to assess indeterminate burn wounds: A prospective, multicentered, triple-blinded study. J Trauma Acute Care Surg 2019; 86:823.
30. Xue EY, Chandler LK, Viviano SL, Keith JD. Use of FLIR ONE Smartphone Thermography in Burn Wound Assessment. Ann Plast Surg 2018; 80:S236.
31. Simmons JD, Kahn SA, Vickers AL, et al. Early Assessment of Burn Depth with Far Infrared Time-Lapse Thermography. J Am Coll Surg 2018; 226:687.

32. Mihara K, Nomiyama T, Masuda K, et al. Dermoscopic insight into skin microcirculation--Burn depth assessment. Burns 2015; 41:1708.
33. Chin MS, Babchenko O, Lujan-Hernandez J, et al. Hyperspectral Imaging for Burn Depth Assessment in an Animal Model. Plast Reconstr Surg Glob Open 2015; 3:e591.

Topic 819 Version 25.0

Contributor Disclosures

Phillip L Rice, Jr, MD No relevant financial relationship(s) with ineligible companies to disclose. **Dennis P Orgill, MD, PhD** Grant/Research/Clinical Trial Support: Acelity [Wound healing]; Integra LifeSciences [Wound healing]; Musculoskeletal Transplant Foundation [Wound healing]. Consultant/Advisory Boards: Acelity [Wound healing]; Integra LifeSciences [Wound healing]; Musculoskeletal Research Foundation [Wound healing]; Professional Education and Research Institute (PERI) [Wound healing]; Quthero [Wound healing]; Urgo Medical [Wound healing]. All of the relevant financial relationships listed have been mitigated. **Marc G Jeschke, MD, PhD** Patent Holder: MyScarTape [Scars]. Consultant/Advisory Boards: Integra LifeSciences [Wound healing]; SeaStar Medical [Renal replacement]. All of the relevant financial relationships listed have been mitigated. **Kathryn A Collins, MD, PhD, FACS** No relevant financial relationship(s) with ineligible companies to disclose.

Contributor disclosures are reviewed for conflicts of interest by the editorial group. When found, these are addressed by vetting through a multi-level review process, and through requirements for references to be provided to support the content. Appropriately referenced content is required of all authors and must conform to UpToDate standards of evidence.

Conflict of interest policy

→