Module 1
Burn
Objectives

1. Describe the function of the skin (Workbook 1-5 to 1-7)

2. Describe the structure of the skin (Workbook 1-8 to 1-11).

3. Identify the layers of the epidermis and describe the features of each layer (Workbook 1-11).

4. Define shock. As part of your definition, discuss 4 different types of shock, describe symptoms of shock, and discuss treatment for shock (Workbook 1-14, Burn Case Study pg. 1).

5. Differentiate between 1st, 2nd, and 3rd degree burns (Workbook 1-15, Burn Case Study pg. 2).

6. Be able to determine the total body surface area burned using the Rule of Nines (Workbook 1-16, Burn Case Study pg. 2).
7. Describe the systemic effects of a major burn to include the inflammatory response, sympathetic nervous system response and the basal metabolic response. Describe the effects of a major burn on the immune system, the kidneys, and the respiratory system (Workbook 1-18, 1-19).

8. Describe the application of the use of stem cell therapy for burn patients. As part of your description (Workbook 1-20, 1-21):

   1) Define stem cells.
   2) Differentiate between pluripotent, multipotent, and unipotent stem cells.
   3) List advantages and disadvantages of bone marrow stem cells, hair follicle stem cells, and adipose stem cells for skin transplants.
9. Describe tests used to assess the condition of the burn patient to include (Burn Case Study pgs. 2, 4):
   
   A. Vital signs. Describe how core temperature, blood pressure, pulse, and respiration are affected in a burn patient.

   B. Laboratory tests:
      1. CBC: Describe how WBCs, RBCs, and the Hct are affected by the major burn of this patient.
      2. Chemistry panel: Describe how the glucose level, creatine kinase, BUN, and protein levels are affected from the major burn.
      3. Describe what carboxyhemoglobin is and how it might be affected by smoke inhalation.

10. Describe treatment methods used for this burn patient to include (Burn Case Study pages 3-5):
    
    A. Lactated Ringer’s
    B. Mechanical Ventilation and endotracheal intubation
    C. Foley Catheter
    D. Chest X-ray
    E. Debridement
    F. Skin Grafting
    G. Transfusion of Packed RBCs

    Use the questions throughout the case to guide your study of the treatment methods.
11. Discuss the nutritional requirements of a burn patient (Burn Case Study pg. 4).

12. Define the following medical words (Workbook pgs. 1-18 to 1-19; Burn Case Study pgs. 2-5):
   - From the case: tachypnea, tachycardia, stridor, edema, sepsis, nasogastric tube, contractures.
   - From “The Systemic Effects of Major Burns on the Body” (Workbook 1-18 to 1-19): hypotension, oliguria.

13. Describe the roles of the following health care professionals in the case (Case Study pgs. 1-5, Case Study Summary, Case Study Professionals):
   - Emergency Medical Technicians (EMTs) and Paramedics
   - Nurses
   - Physician
   - Respiratory Therapist
   - Dietician
   - Physical Therapist
   - Occupational Therapist
   - Psychiatrist
   - Plastic Surgeon
A body system is a group of organs and accessory structures that work together for a common function. If you were asked to name an organ you might think of the heart, lungs, or kidneys. The skin is also an organ although we often don’t think of it as such. In fact, it’s the largest organ in the body weighing 4.5-5 kg (10-11 lb) and covering about 2 square meters (22 square feet). The integumentary system is made up of the skin and accessory structures including oil and sweat glands, hair, sensory nerves, and nails.
Functions of the skin can be largely put into three main categories: protection, regulation, and sensation.

**Protection:** If you were asked to name a function of the skin, the first thing that may come to your mind is **protection.** It is true that the skin forms a great barrier to the outside world. In fact, the only organisms that can penetrate unbroken skin are hookworm larvae and threadworm (*Strongyloides*) larvae. These larvae can burrow into bare skin in warm tropical countries. Make sure to wear your shoes if you’re traveling in the tropics!

As we will learn shortly, the outer layer of the skin is made up 25-30 layers of dead keratinocytes (skin cells). This is why you can exfoliate your skin without pain; you’re simply getting rid of dead skin cells. **Keratin,** a protein made by skin cells called keratinocytes, helps in protection from microbes, abrasions, heat and chemicals. **Lipids** help make our skin waterproof. A pigment called **melanin** not only gives skin its color but also absorbs UV light so that it does not pass, and damage other cells. The skin also can repair most superficial cuts and scrapes so that underlying tissue is not damaged. Pretty remarkable, right?
**Regulation:** The skin aids in maintaining homeostasis, a condition of balance in the body. When the body does not maintain homeostasis, disease occurs. The skin is a key player in regulating body temperature. Blood vessels that lie close to the skin’s surface vasodilate to cool body temperatures. When you’re working out you may get red and flushed. This is due to the dilation of surface blood vessels giving off heat. When temperatures are cool, blood vessels close to the surface of the skin constrict, shunting blood to vital core organs. This is why fingers and toes may turn blue in the cold. The skin also regulates body temperature through sweat glands. Every day about 400 ml of water evaporates from the skin.

**Sensation:** The skin has many types of nerve receptors that detect sensations from the outside environment. These sensations include pain, touch, pressure, vibration, and even tickling. In Georgia, a rare disorder occurred in a young girl who was born without pain receptors (NY Times Magazine, 2012). Sounds great, right? The problem is those receptors warn us of injury, so you remove your hand from the hot stove instead of letting it cool.

The skin also makes vitamin D from ultraviolet rays from the sun. In addition the skin can absorb fat soluble vitamins, A, D, E, and K.
Structure of the Skin

The skin is made up of two true layers, the superficial thin epidermis and the dermis, a thick layer of connective tissue deep to the epidermis. Deep to the dermis is the subcutaneous layer. This layer is composed primarily of adipocytes (fat cells). Adipocytes help insulate the skin and store fat for energy. You may have heard of a subcutaneous (SC, SQ, sub-cu or subcut) injection. This injection is given with a short needle beneath the skin into the subcutaneous layer. Insulin is an example of a medication given subcutaneously. Because the subcutaneous layer has fewer blood vessels, drugs are absorbed slower than intra-muscular injections.
The dermis sits just deep to the epidermis. The dermis contains blood vessels that provide oxygen and nutrients to the epidermal layer. The dermis contains elastic fibers that provide elasticity to the skin. It also contains strong collagen fibers. You might have a pair of leather shoes, a belt, or wallet. Leather is made from the dried dermis from animals.

The dermis is comprised of a superficial papillary region (about 1/5 of the dermis) and a deeper reticular region (4/5 of the dermal region). The papillary region contains capillary loops of blood vessels and nerve receptors for touch, temperature, pain, and even tickling and itching. Within the reticular region are hair follicles, nerves, sebaceous (oil) glands and sudoriferous (sweat glands). Tattoo ink is placed with a needle into the dermal region of the skin. Because this region is stable (compared to epidermal cells) tattoos are permanent, although they can be removed by lasers.
The **epidermis** is the most superficial layer of the skin. It consists of five layers of stratified squamous epithelium. The primary cells of the epidermis are keratinocytes. These cells produce keratin, a tough protective protein. They also produce lamellar granules which helps make the skin waterproof.

Cells in the epidermis arise from stem cells in the deep basale layer. Over a period of about four weeks, the cells travel superficially through the epidermis, undergoing changes that eventually lead to cell death or apoptosis. Cells in the most superficial layer, (stratum corneum), are sloughed off as dead skin cells. If you’ve ever exfoliated cells, it is this top layer of dead skin cells that are removed.
The layers of the epidermis, from deep to superficial, are listed below.

**Stratum basale:** This layer contains a single row of keratinocytes, along with stem cells discussed above.

**Stratum spinosum:** Superficial to the stratum basale, this layer contains keratinocytes that look spiny under the microscope; hence the name spinosum. Eight to ten layers of these spiky keratinocytes make up this layer.

**Stratum granulosum:** Keratinocytes begin apoptosis in the granulosum. These cells appear flattened as the nucleus begins to disintegrate. The granulosum is made up of three to five layers of these cells.

**Stratum lucidum:** This layer of the epidermis is only found in thick skin and provides extra protection. Thick skin is found in the fingertips, palms, and soles of the feet. This layer consists of three-five layers of flattened, dead keratinocytes.

**Stratum corneum:** The most superficial layer of the epidermis consists of 25-30 layers of dead keratinocytes. These cells contain mainly keratin (providing strength and protection). Between the cells are many lamellar granules that provide waterproofing.

The following acronym may help you remember the layers of the epidermis, from deep to superficial: **Boys Seek Good Looking Chicks** (basale, spinosum, granulosum, lucidum, corneum).
To complete this activity access the Wiley Plus Interactions software from the link on the Canvas modules page. From the Interactions home page:
1. Select “Disease Resistance”
2. On the red menu bar select “Contents”
3. Under Contents select “Disease Resistance”
4. Select “Anatomy Overview:
5. Select “The Integument and Disease Resistance.”
Answers can be found on the Interactions Software

The Integumentary System

To complete this worksheet, select:

Module: Foundations
Activity: Anatomy Overviews
Title: The Integumentary System

1. Describe integumentary system functions. __________________________
   __________________________
   __________________________

2. Click on Skin and Associated Glands to investigate the following:
   a. Name five specific skin and associated gland functions. __________________________
   __________________________
   __________________________
   __________________________
   __________________________

   b. Identify each of the following:
   Epidermis
   Free nerve ending
   Dermis
   Sweat gland
   Blood vessels
   Subcutaneous layer (hypodermis)

[Diagram of skin layers and structures]
Label the layers of the integument

1. ________________
2. ________________
3. ________________

Label the layers of the epidermis

1. ________________
2. ________________
3. ________________
4. ________________
5. ________________
Shock

Shock occurs when the cardiovascular system cannot deliver enough oxygen to the tissues. If shock is not treated, cells and tissue may die from lack of oxygen. Shock can be classified into four types:

1. **Hypovolemic shock:**
   This type of shock is caused by low blood volume. Often this is caused by hemorrhaging from trauma or rupture of a large blood vessel such as the aorta. A loss of large amounts of fluid other than blood can also lead to this type of shock. In burn patients, loss of large amounts of fluid from damage to the protective barrier of the skin, leads to shock.

2. **Cardiogenic shock:**
   This type of shock is caused by failure of the heart. This may be due to a myocardial infarction (heart attack), heart valve defects, or abnormal heart rhythms (arrhythmias).

3. **Neurogenic shock:**
   Nerves control vasoconstriction (narrowing) or vasodilation (expansion) of blood vessels. With nerve damage, blood vessels may remain vasodilated. While the amount of blood remains the same, the blood vessels dilate so there is not enough blood to fill them. Imagine running a cup of water through a large irrigation channel. The water wouldn’t get very far. If you took that same cup of water and poured it through a drinking straw, it would run easily through the straw. The blood vessels need to be small enough in diameter so that blood has enough pressure to get where it needs to go.

4. **Sepsis or Anaphylactic shock:**
   Sepsis occurs from a complication of infection causing widespread inflammation throughout the body. Sepsis may also cause vasodilation and capillary permeability (blood vessels are leaky leading to a loss of fluid), which may then lead to shock. Anaphylaxis is caused by a serious allergic reaction. It also causes widespread inflammation, vasodilation of blood vessels, and capillary permeability.
Assessing the Severity of a Burn

Burns can be caused by heat, electricity, chemicals, electricity, sunlight, or radiation. Burns cause tissue damage and are graded by their severity.

- **1st degree burn**: A sunburn is a classic example of a first degree burn. These burns cause mild pain and redness (erythema) but there is no blistering. These burns may flake or peel as they heal, but generally do not require medical intervention. The skin will typically heal within three to six days. Healing may be accompanied by flaking or peeling.

- **2nd degree burn**: A burn that blisters is typically a second degree burn which destroys the epidermis and part of the dermis. These are painful burns. In addition to blisters there is redness and edema. These burns typically take three to four weeks to heal and skin grafts are usually not required. There may be scarring.

  First and second degree burns may also be called partial-thickness burns.

- **3rd degree burn**: Strangely a third degree burn is not painful because skin nerves are destroyed along with most skin function. This burn is also called a full-thickness burn because it destroys the epidermis, dermis, and subcutaneous layer. The color of these burns varies but often look black or charred. They may also look marble-white or mahogany in color.
Rule of Nines

The rule of nines is a quick means for estimating the surface area in an adult affected by a burn.

1. Count 9% for both the anterior and posterior head and neck.
2. Count 9% for both the anterior and posterior surfaces of each upper limb.
3. Count 36% (4 x 9) for both the anterior and posterior surfaces of the trunk, including the buttocks.
4. Count 9% for the anterior and 9% for the posterior surfaces of each lower limb. Count 1% for the perineum.

A major burn includes third-degree burns over 10% of the body; or second-degree burns over 25% of the body; or any third-degree burns on the face, hands, feet or perineum. If the burn area exceeds 70%, more than half the victims die.
Burn Assessment
Review Questions

1. A victim of a fire is admitted to the emergency room. You observe considerable damage to the epidermis and dermis of the anterior and posterior right and left arms and the anterior and posterior portions of the trunk. You also note patches of charred skin and insensitivity to touch. What type of burn is indicated by these characteristics? Approximately what percentage of the body is burned?

2. A scald burn causes blistering and redness to the anterior portion of one arm and the anterior trunk. What type of burn is indicated and approximately what percentage of the body is burned?

3. A patient is brought to the emergency room with trauma from a car rollover and subsequent explosion. The patient’s arms have large blisters from the burn on the anterior and posterior sections. The torso and back appear marble white. She complains about severe pain in her arms but does not complain of pain in her torso and back. What is your initial assessment of the burns and what percentage of the body is burned?
The Systemic Effects of Major Burns on the Body

In 2016 there were 486,000 burn injuries in the US requiring treatment, with 40,000 requiring hospitalizations (with 30,000 admissions to burn centers). There were 3,275 deaths from fire and smoke inhalation; however, the survival rate from those admitted to burn centers was 96.8%. (American Burn Association, 2016). Worldwide burn incidence is about 11 million people and ranks fourth in all injuries (Peck, 2004). There is an estimated 180,000 deaths from burns worldwide with the majority occurring in low and middle income countries (World Health Organization, 2017). Fire and burn injuries account for the majority of burns in the US (44%) followed by scald injuries (33%), contact with hot objects (9%), electrical burns (4%), chemical burns (3%), and 7% miscellaneous causes (Culleiton and Simko, 2013).

Burns are expensive to treat. A burn that covers 30% of total body surface can cost as much as $200,000 in just initial hospitalization costs. There can be additional major expenses if reconstructive surgery or rehabilitation is needed. The very young and the very old or at the greatest risk for mortality from burns with children under the age of four and adults over the age of sixty-five at greatest risk of death from a major burn (Culleiton and Simko, 2013).

Major burns cause problems throughout the body affecting every body system. This response includes:

1. **Inflammatory Response.** Mast cells are large cells full of granules that play a key role in the inflammatory response. One of the major granules that mast cells contain is histamine. Not only does histamine cause things like hives, and itching with allergies, it also causes the blood vessels to get leaky. This increased permeability of the vessels allows fluid to leak out along with proteins. This fluid accumulates in the tissues causing edema (swelling). The loss of blood proteins leads to hypotension (low blood pressure), oliguria (diminished urine output), and shock. The heart speeds up to compensate (tachycardia) and respirations increase (tachypnea).

2. **Sympathetic nervous system** is stimulated. The sympathetic nervous system puts the body in a fight or flight mode. You may have experienced this when you go take an exam or give a speech. Your heart rate speeds up, respirations increase, and saliva dries up. This response releases glycogen stores from the liver and elevates blood glucose. If you’re running away from a mountain lion, your muscles will need all of the energy they can get.
3. The body’s **basal metabolic rate increases**. It’s the same as adding a lot of logs on the fire when you’re camping. If you’re sitting near the fire, you warm up. With a major burn, the body’s core temperature is turned up and the body consumes oxygen and glucose at a very high rate. This leads to greatly increased nutritional demands as discussed in the case.

4. **Suppression of the immune system.** Cortisol, a hormone produced in the adrenal cortex, is released as part of the sympathetic nervous system. If you’ve ever had a cortisone shot, you know that it’s given to reduce inflammation. In the body, cortisol also suppresses the immune system. So a big problem exists. The major barrier to the outside world, the skin, has been damaged allowing an open door for microorganisms to cause infection. The body’s defense mechanisms are suppressed. The most common complications in burns are due to infections and/or respiratory problems from smoke inhalation.

5. The **kidneys** have to filter out large amounts of myoglobin, an oxygen carrying molecule from muscle, and also hemoglobin, the oxygen carrying molecule from red blood cells. This can lead to acute renal failure.

6. The **respiratory system** may be affected because of carbon monoxide poisoning and inhalation of toxins from the smoke. This can lead to fluid in the lungs (pulmonary edema) and diminished oxygen to the body.

7. **Cardiovascular system:** Because of the loss of fluids, blood pressure decreases, which can lead to a hypovolemic shock. The heart may have difficulty contracting (this should improve 24-30 hours after the initial burn injury. If the patient has an electrical burn, the patient may experience a myocardial infarction (heart attack) and/or changes in the electrical conduction of the heart leading to abnormal heart rhythms including ventricular fibrillation where the pumping chambers of the heart quiver and can’t pump blood to the lungs or the body. This is a life threatening arrhythmia.

There are many other complications that may occur with a major burn but you may be overwhelmed by now. So is the body with a major burn! Think about it; the body needs tons of oxygen to heal. In a burn, even more is needed because of the increased basal metabolic rate. With red blood cell destruction and lung damage, the oxygen is just not there. It’s not surprising that the mortality rate from major burns is so high.
Stem Cell Therapy for Burn Patients

In major burns, it is often difficult to obtain enough skin tissue from the patient for autologous skin grafting. It is advantageous to close the wound as soon as possible. The use of stem cells to regenerate skin tissue not only has the advantage of creating more tissue, but the wounds tend to heal faster. The use of embryonic stem cells is controversial. Researchers are now looking at alternative methods for growing new skin, experimenting with stem cells from the bone marrow, adipose tissue, and hair follicles (Lewis, 2013).

Stem cells are undifferentiated cells that can differentiate into one or more cell lines (one of the body’s more than 200 cell types). Cells that are pluripotent may differentiate into any of the embryonic layers from which adult cells are derived. Embryonic cells are true pluripotent cells. Multipotent cells can differentiate into a limited number of cell types while unipotent cells can only differentiate into one cell type. Stem cells from the bone marrow and fat are multipotent, those from hair follicles are unipotent. The advantages and disadvantages of each in regenerating tissue in burn patients are listed below.

Bone Marrow Stem Cells are typically harvested from the iliac crest. These cells have been demonstrated to differentiate into keratinocytes and fibroblasts (cells that lay down new protein fibers). They also aid in the growth of new blood vessels (angiogenesis) and have anti-inflammatory properties. Disadvantages of these cells include the following: 1) the procedure to harvest them is painful, 2) the yield of stem cells is low, and 3) the number declines with age.
Stem Cell Therapy for Burn Patients

**Adipose Stem Cells:**
Adipose (fat) tissue is plentiful, easily isolated, and rich in multipotent stem cells. With current trends for cosmetic surgeries such as liposuction, there is no shortage of adipose tissue. These cells divide rapidly and produce anti-inflammatory cytokines. A disadvantage of these cells is that the isolation procedure is complex.

Both bone marrow and adipose stem cells release anti-inflammatory cytokines (cellular messengers). Infusions of these stem cells may help reduce the widespread inflammation present in burn patients. Studies have demonstrated that stem cells will migrate to the site of the wound and begin healing. This is true not only of the skin but also the lungs which may undergo significant damage from smoke inhalation.

Stem cells have been demonstrated to speed up the healing of partial-thickness burns, closing wounds in as quickly as three weeks. The use of non-embryonic stem cells looks promising in the future of skin grafting and healing of major burns.

**Hair Follicle Stem Cells:** The bulb of the hair follicle contains epithelial and melanocyte stem cells. Stem cells from hair follicles can migrate and assist in healing the wound. These cells are readily available from anywhere that there is hair in the body. Disadvantages include that they are unipotent and the harvesting yield is low.
References


Case Questions

1. Define shock.

2. What are physiological causes of shock?

3. List 4 symptoms of compensated shock, and 1 symptom of decompensated shock.

4. When is shock irreversible?

5. List 4 main types of shock.


7. What is a Lactated Ringer’s Solution?

8. How does administration of Lactated Ringer's help with a burn patient?

9. Once the severity of a burn has been assessed, can the degree of the burn change?
Case Questions

10. What percentage of the body is burned when there is a significant mortality risk?

11. Burns on what part of the body may cause swelling and obstruction of the airway?

12. What is the danger of a large burn around the chest wall?

13. List two other types of burns besides thermal burns.

14. What is the best treatment for minor burns?

15. What causes stridor?

16. What is a mechanical ventilator and how is a patient connected to the ventilator?

17. What are some of the risks of mechanical ventilation?

18. Why is this patient being intubated?

19. Why is a rapid sequence intubation being performed?

20. What type of energy do x-rays use to create ionizing radiation in order to see pictures of the inside of the body?
Case Questions

21. What structures in the chest cavity absorb radiation and appear light on an x-ray? Structures that are filled with air appear to be what color on a chest x-ray?

22. Structure that are filled with air appear to be what color on a chest x-ray?

23. If an adult has a burn covering 25% of their body surface area, how much does their metabolic rate increase?

24. How much weight might an adult patient lose with a surface burn of 40%, without adequate nutritional support?

25. If possible, when should enteral feedings begin and what type of enteral diet is recommended?

26. What is debridement?

27. What methods can be used for debridement?

28. What is skin grafting?

29. What are the three classifications of skin grafts?

30. What are packed RBC’s and why are they transfused instead of whole blood?
Discussion Questions

1. Stem cells are being studied as a possible treatment option for skin grafting in burn patients and as possible options for regeneration of many other types of tissue. Stem cell research has been a controversial political issue. In your opinion, should stem cell research be allowed in the United States? If so, should there be limitations on this research?

2. Mechanical ventilators and other medical equipment can artificially prolong a patient’s life. Terri Schiavo was kept on life support for 15 years. She had a cardiac arrest in 1990. After 2 1/2 months in a coma, her condition was changed to a vegetative state. She demonstrated no brain activity but her heart was still beating. After a prolonged legal battle between her husband and her parents, tube feedings were discontinued. Terri died 13 days later. In your opinion, are there conditions when a patient should be kept on life support? At what point should life support be removed and the patient be allowed to die? When the family disagrees about discontinuing life support, who should make the final decision?