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Approach to Burns and Complications of UV Radiation

Developed by Aryan Riahi and Dr. Joseph Lam for PedsCases.com.
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Introduction:

Hello, and welcome to PedsCases!

My name is Aryan Riahi, a senior medical student at the University of British Columbia.

I have the pleasure of recording this podcast today with Dr. Joseph Lam, MD, FRCPC. He is a paediatric dermatologist.

This is a podcast discussing burns in paediatric patients. The skin plays an important role in protecting the body from sunlight and extreme temperatures. Skin barrier functions are lost when external stimuli exceed certain thresholds that result in injury. For example, sunburns, electrical burns, chemical burns, frostbite, and radiation damage are all examples of injuries that impair skin function. Burns are injuries to cutaneous tissue brought on by direct or indirect contact with heat, electricity, radiation (e.g.: ultraviolet radiation resulting in sunburn), or chemicals. All burns are marked by protein denaturation and cell death. Effective identification and management of burns can improve quality of life for patients.

After listening to this podcast, the learner should be able to do the following:

Learning outcomes:

1. Discuss the potential complications, management, and prevention of sunburns.
2. Describe the basic pathophysiology behind thermal burns.
3. Discuss the ambulatory management of burn patients.
4. Determine the amount of fluid administration based on total body surface area and the Parkland formula using the “rule of nines” with modifications for paediatric patients.
5. Compare partial versus full thickness burns.

Now, let’s talk about our first case involving a common chief complaint among patients.

Case One:

History of presenting illness: Marie, an otherwise healthy 11 year old girl presents to your clinic with diffuse redness, swelling, and pain to sun exposed areas after falling asleep for 2 hours on a hot summer day while lying in the back yard of her house.

You examine her arms (shown below). Both upper limbs are warm on palpation.

What is sunburn?

1. Prolonged exposure to the wavelengths produced by sunlight, particularly UVB radiation, can lead to erythema and edema.
2. Sun burns are often first-degree burns, but severe skin burning can lead to second-degree burns.
3. Exposure to ultraviolet (UV) light, whether from direct sunlight exposure or tanning salons, is a potential source of sunburns.
4. Signs and symptoms include erythema, edema, tenderness, blisters and affected areas are hot on palpation. These can occur as soon as 2-6 hours post-exposure and peak at 12-24 hours. In severe cases, blistering can occur locally and chills and fevers can occur systemically.
5. After a few days, skin may start to flake off. Hyper of Hypo - pigmentation can occur and may be permanent.

Which wavelengths of light are involved in sunburns?

1. This is where basic principles about the electromagnetic (light) spectrum come in handy. We have three main types of light in this spectrum which can be separated based on wavelength. There is infrared (over 760 nm), visible (400-760 nm), and ultraviolet (under 400 nm) light.
2. We can divide UV light further into UV-A (320-400 nm), UV-B (290-320 nm), and UV-C (under 290 nm) light.
3. The ozone layer in the outer atmosphere filters out or absorbs UV-C radiation. This leaves UV-A and UV-B radiation as the culprits for sunburns.
4. UV-A is less potent than UV-B radiation and therefore causes less erythema. But 90% of the wavelength that reaches earth is UV-A, so it is more plentiful than UV-B radiation.
5. UV-A penetrates the dermis and subcutaneous layers of the skin. Since stem cells reside in the dermis of the skin, the result of long term UV-A exposure is aging skin. Everyone's skin ages, but UV-A speeds up the process.
6. UV-B is more potent than UV-A radiation. The epidermis absorbs most of it. Long term exposure to UV-A and UV-B, specifically wavelengths of 300-400 nm, can also lead to aging skin.
7. As a result of absorbing UV-B radiation, the epidermis releases inflammatory mediators that lead to swelling and erythema, both of which are early signs of a sunburn.

What are the long-term consequences of sunburns?

1. Long term UV exposure, whether through the sun or other sources such as tanning salons have significant consequences.
2. Relatively benign consequences include skin aging, wrinkles, and freckles (lentigines).
3. More serious consequences include the development of precancerous lesions such as actinic keratosis. Skin cancers including basal cell carcinoma, squamous cell carcinoma, and melanoma are strongly associated with UV exposure as well.

How do we treat sunburns?

1. Basic treatment for sunburns includes cold compresses. If blistering is present, the sunburns are more severe and warrant the same treatment as thermal burns. Blistering indicates a second degree sun burn. Advise patients to leave the blister in-tact as it promotes healing and is a barrier against infection.
2. Recommend relief of discomfort through analgesics such as Tylenol and NSAIDs, aloe vera lotions, and frequent moisturizing of the affected site.

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3. Taking frequent cool baths or showers can also relieve pain.
4. After the bath or shower, the patient should be advised to gently pat themselves and then apply moisturizer. This helps trap water in the skin.
5. Staying hydrated by drinking plenty of water prevents dehydration. While it does not stop the processes of vasodilation and erythema of the sunburn from drawing fluid from the skin, it helps rehydrate the affected individual.
6. While the sunburned skin heals, the patient should wear clothing that covers the entirety of their skin while outdoors. Good clothing to protect from UV radiation is occlusive. If you hold the clothing up in light, it should not visibly allow light to come through.
7. In reality, sunburns are best prevented rather than treated.

How do we prevent sunburns from occurring in the first place? How do we protect ourselves from the damaging effects of UV-A and UV-B radiation?

1. Avoid sun exposure particularly between 10 AM to 2 PM when the amount of UV radiation is at its highest.
2. Utilize protective clothing such as sunglasses, wide-brimmed hats, and long-sleeved clothing.
3. Apply sunscreen frequently with a sun protection factor (SPF) of 50 or greater.
4. SPF is a standard used to measure how effective sunscreens are. An SPF of 15 increases protection against sun, meaning it takes 15 times the time to burn the skin. Note that SPF is a measure of UV-B protection. Unless stated on the product label, UV-A protection is not guaranteed.

Our next case will involve a patient with a thermal burn, which results from infrared radiation.

Case two:

History of presenting illness: Mike is a previously healthy 4 year old boy who presents to the emergency department with his mother. He comes in crying with both hands bandaged. While the mother was not present during the inciting event, she believes that Mike accidentally tipped over the electric kettle that was boiling with hot water.

On examination, he is mildly tachycardic and tachypneic.

Head and neck, cardiac, respiratory, and abdominal exams were unremarkable. However, you notice the following when assessing his legs.

You examine the legs. Capillary refill is under 2 seconds in all digits. There is full active range of motion of the patient's lower limbs bilaterally. Lower extremity reflexes are 3/5 bilaterally. Pedal pulses are normal. Sensation of lower extremities is normal bilaterally.

What causes thermal burns? What conditions can the damage lead to?

1. High temperatures particularly above 44°C damage the skin barrier. When burns are severe, the damaged tissue releases histamine and cytokines which promote vascular permeability. This causes loss of plasma proteins from the intravascular space, which results in fluid to leave the extracellular compartment. The end result can be shock secondary to hypovolemia from the burn.
2. Due to damage caused by burns to the epithelium of the skin, the healing process may be complicated by hypertrophic scarring which may result in contractures if they occur on joint surfaces. Skin cancer such as squamous cell carcinoma may also develop from the extensive epithelial damage.
3. One of the skin barrier functions lost with burns is the immune response. Burns may be prone to infections, leading to sepsis.
4. The consequences of burns span beyond the skin. When the body begins to move fluid to the wrong compartments, pulmonary edema, disseminated intravascular coagulation (DIC), and multiple organ failure are possible complications.

5. If the patient breathed in hot soot from a fire, then airway compromise may occur secondary to tracheal edema. These patients may need immediate airway management and potential intubation.
6. The stomach needs a constant flow of mucus and fluid to protect the mucosa from acid. A Curling's ulcer is a peptic ulcer secondary to burns due to hypovolemia.

How are burns classified?

1. Burns are classified according to their depth and clinical features.
2. First degree burns, called "epidermal burns" present with painful erythema and swelling. Since the stem cells in the stratum basale layer of the epidermis are preserved, these tend to heal without scars.
3. The hallmark feature separating a first and second degree burn is the presence of blisters which are present in the latter.
4. Second degree burns, called "dermal burns" present with intense burning sensation and erythema. Blistering follows after several hours.
5. We separate second degree burns into superficial dermal burns and deep dermal burns. While superficial dermal burns heal without scarring in 2 weeks, deep dermal burns tend to heal with a scar in 4 weeks. Deep dermal burns are often white and present with decreased sensation. They often develop into third degree burns.
6. Third degree burns occur when all cutaneous layers of the skin are damaged. There is no blistering and they appear grayish white. These are the burns where we are concerned about tissue necrosis and eschar formation. Since there are little to no fibroblasts left over to heal the damage, a skin graft may be necessary.
7. Sometimes, it is hard to tell between second and third degree burns. Since third degree burns are often painless, a needle can be gently be stuck into the skin of the affected area to assess for pain. Pain elicited with the needle is consistent with a second degree burn. No pain is consistent with a third degree burn.
8. Another physical exam technique is to gently pull on hair in the affected area. In third degree or deep dermal second degree burns, the hair follicles have been extensively damaged. Therefore, hairs will come out with gentle pulling.

When is a burn classified as severe?

1. When total body surface involvement with second degree burns amounts to 10% or greater in children and 15% or more in adults, consider treatment for severe burns.

How are burns treated?

1. It is important to remember that management for most burns, regardless of the type, has four goals in mind. Carefully monitor the wound, keep it clean, prevent drying out, and treat secondary infections.
2. Most burns should be cooled with running water for 30 minutes. This serves to decrease pain, edema, and inflammation.
3. Look for other injuries with a full assessment of Airway, Breathing, and Circulation (ABC's). This is why one must perform a respiratory and cardiac exam and check peripheral perfusion.
4. Since burns are considered contaminated, clean the wound gently with soap and cold water.
5. Like any other contaminated wound, a tetanus booster should be provided if one has not been received in the last 5 years.
6. Infections can occur in second and third degree burns due to the skin's compromised barrier function. Apply antibiotics and ointments that promote the growth of new tissue. We choose these treatments based on skin condition. Examples include topical silver sulfadiazine and mafenide acetate.
7. Skin grafts may be needed. For deep dermal and third degree burns, the skin involved is removed.
8. Depth is a determinant of surgery. Burn depth is clearly determined after 2 weeks from the initial incident.

In addition to the above, what are some extra considerations for patients with severe burns?

1. Adults with burns covering over 20% Total Body Surface Area (TBSA) or children with burns covering 10% TBSA require IV fluid resuscitation in order to prevent complications from hypovolemia.
2. When fluids are provided, consider Ringers Lactate over Normal Saline to reduce the chance of hyperchloremic acidosis.
3. Escharotomy is reserved for severe burns where the edema is so significant that blood flow is impeded to the extremities. In this procedure, the eschar, which is compromising blood flow, is removed.
4. While a first degree burn is managed with basic topical anesthetics, NSAIDs, and aloe vera gels, a second degree burn requires clean dressings.
5. Dressings should be applied to protect the wound, decrease pain, reduce heat loss, and absorb any exudate from the wound.
6. When choosing a dressing, occlusive ones such as saran wrap can be used to trap heat, serve as a barrier, and to inspect the wound without removing the dressing. In cases with significant exudate coming from the wound, consider non-occlusive dressings that are changed daily.

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Why do we give fluids to burn victims?

1. Burn patients may die from hypovolemic shock or acute kidney injuries.
2. Shock may occur from inflammatory signals from destroyed tissue leading to increased vascular permeability. This results in extravasation of blood from the intravascular space to other compartments. The end result is lack of end organ perfusion.
3. For patients with smaller burns, oral fluids are often sufficient. But patients with severe burns require IV fluids to make up for losses in intravascular volume.

How do we calculate how much fluid to give?

1. The Parkland formula determines the amount of Ringer's Lactate to administer.
2. Parkland formula = Total Body Surface Area (%) X weight (kilograms) X 4 milliliters (ml). This is the amount of fluid to give over 24 hours, with half of it given within the first 8 hours and the rest over the next 16 hours.
3. In adult patients, the head is counted as 9% TBSA, each upper limb is 9% TBSA, each lower limb is 18% TBSA, the trunk is 18% TBSA anteriorly and 18% TBSA posteriorly, and the perineum is counted as 1% TBSA.
4. In pediatric patients, the head increases to 18% TBSA and lower extremities decreases to 14% TBSA.

Our next case will cover yet another type of burn. Can you think of any types of burns that we have yet to cover?

Case three:

History of presenting illness: Mina is an otherwise healthy 12 year old girl who comes in with her mother to your clinic complaining of pain and redness at the distal aspect of her right thumb (D1). She told her mother that she was reaching for an item on the shelf in her garage and accidentally poured her father's rust cleaner (a fluoride-containing solution) on her thumb. She denies systemic symptoms such as shortness of breath, chest pain, weakness, headache, or muscle spasms.

On examination of her thumb, you notice the formation of eschar (black dead skin). Capillary refill is under 2 seconds in all upper extremity digits. Upper extremity reflexes are 3/5 bilaterally. Pulses are normal. There is full active range of motion of the affected limb. Motor and sensation testing for upper extremities is normal.

What is a chemical burn?

1. Acidic or alkaline chemicals damage cutaneous tissue.
2. Acid promotes coagulative necrosis. It presents with crusting tinged with the color of the respective acid. For example, sulfuric acid is brown and hydrochloric acid is yellow.
3. Alkaline chemicals such as plaster, mortar, drain cleaners, fertilizers can penetrate and cause damage to deeper layers of tissue.

How are chemical burns treated?

1. Flush the affected area with water promptly.
2. Neutralizing agents, such as the weak acid, 5% acetic acid (household vinegar), can cause the release of heat when applied on an alkaline burn. This can cause a thermal burn on the affected area. For this reason, they are not applied for acidic or alkaline chemical burns.
3. Some chemical agents have antidotes to counteract them. For example, hydrofluoric acid burns are treated with calcium gluconate gel to be applied every 15 minutes.
4. Following the above treatment, apply the same treatment as thermal burns.

Summary:

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1. Informing patients on ways to protect themselves from ultraviolet rays can help decrease complications such as skin cancer.
2. Burns are divided by depth into first, second, and third degree burns.
3. First degree burns are limited to the epidermis and are characterized by pain and erythema.
4. Second degree or partial thickness burns are subdivided into superficial versus deep burns. Superficial burns involve the papillary dermis, while deep ones also involve the reticular dermis. It is important to tell them apart because deeper burns will take longer than 2-3 weeks to heal and may lead to scarring.
5. Third degree burns are full thickness burns that appear white with a charred appearance. They are not painful.
6. Burn size is measured by the "rule of nines" which has been modified to apply to pediatric patients. Children have larger heads and their extremities are proportionately smaller than adults. Generally, the amount of IV fluids to administer depends on percent body surface area involvement with second and third degree burns and the patient's weight.
7. Basic treatment for burns includes cooling. Severe cases require escharotomy to preserve blood flow. Look for other injuries and perform a full assessment of ABC's (Airway, Breathing, and Circulation).

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We would like to acknowledge the following sources from which pictures and/or statistics were drawn for this PedsCases podcast. The visual references were solely used for educational purposes.

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