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Special Considerations in Pediatric Burn Patients Regarding Drug Dosage and Administration

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Abstract

Pediatric burn patients are a high-risk patient population to treat. These patients have altered physiologic function as a result of the burn injury, in addition to their smaller size and developing bodies. This creates unique challenges during treatment. Accommodations for these patients are made through unique drug dosages and routes of administration. When treating pediatric burn patients, properly assessing and treating pain promptly and effectively is of utmost importance. Nurses who utilize accurate and appropriate pain assessment scales will provide the best treatment of pain. Proper assessment allows the patient to receive the correct analgesic regime, ensuring a faster and more comfortable recovery process.

Key Terms

Analgesics; Antibiotics; Burns; Child; Pain; Pediatrics

Introduction

In burn patients, many physiologic functions are altered which require unique dosing, routes of administration and intensive care regarding treatment. Due to the significant amount of skin loss, patients are at an increased risk of infection and should be treated with preventive antibiotics.¹ Upon admission into the hospital, burn wounds will be cleansed and dead tissue will be surgically removed before antibiotics are started. If the burn covers a large area, skin grafting may be necessary to help cover the wound and protect it from infection.² Stress hormones are also released as a part of the inflammatory response, which induces a hypermetabolic state. This leads to an increased need for nutritional therapy, typically given through the parenteral route. Respiratory airways may be obstructed due to chemical irritants released from fire accidents and thermal injury from the inhalation of hot vapor or liquids. One of the most significant effects related to burn patients is edema, which may affect localized tissues, the pulmonary airway, brain or liver. Edema leads to decreased cardiac output, initially, as stroke volume decreases. This leads to a decrease in the glomerular filtration rate; renal drug clearance is impaired and dosing needs to be adjusted accordingly. In addition to hepatic edema, albumin and other hepatic protein production is decreased, so hepatic dosing adjustments need to be made. The body readjusts to maintain homeostasis and increase cardiac output, leading to reperfusion.¹

Most medications are modified for the pediatric population due to their smaller body mass and developing physiology. In pediatric burn patients, additional variables need to be taken into account to select the best treatment. Pediatric patients have about three times the body surface area (BSA) of adults,

and more of their weight is water based.³ Therefore, it is crucial to accurately calculate BSA as a percentage of body burned to correctly dose medications and fluids. In a study conducted in 71 pediatric burn patients, 79 percent of BSAs were overestimated or underestimated, highlighting the prevalence of faulty initial assessment.⁴ Substantial capillary damage is also sustained, leading to increased fluid losses and tissue perfusion that needs intense fluid and electrolyte resuscitation. Children are also more susceptible to hypothermia because of their larger BSA to water ratio. For those under the age of two, skin is thinner, attenuating the risk of hyperthermia and increasing metabolic needs because of excessive shivering in an attempt to return to thermal homeostasis.^{3,5}

Using Antibiotics to Prevent Infection in Pediatric Burn Patients

In first degree burn patients, topical antibiotics are not typically used because the burn resides in the epidermal level. These treatments are reserved for second and third degree burns when infection risk is high. Topical antibiotics should be used instead of intravenous forms for preventive use and in early admittance to the hospital when the bacterial organism has not yet been identified. In second degree burns, ointments are preferred because they are occlusive and better tolerated by pediatric patients. For third degree burns, creams should be used for their ability to penetrate to deeper layers of skin, spread over a large surface area, ease of application and soothing effect. Patients with third degree burns may undergo skin grafting, in which case liquid forms of topical antibiotics should be used. Ointment and cream forms will impede skin graft healing, while liquids can be used to irrigate and hydrate the burned area.²

Nursing Roles in Assessing and Controlling Pain

According to Williams, pain that children experience related to burn injuries can be extremely severe.⁶ Furthermore, Vincent and Denyes explain that severe pain that goes untreated can lead to slower recoveries and delayed wound healing in children.⁹ As a result, it is extremely important to accurately assess and control pediatric patients' pain when they are suffering and recovering from burn injuries. Nurses are at the forefront of patient pain assessment, therefore utilizing appropriate assessment tools specifically for a pediatric patient allows for effective pain management throughout treatment. Pain in pediatric burn patients needs to be assessed accurately in order to treat the patient correctly, so these assessment tools are of utmost importance to the nurse, as well as to the prescriber and pharmacist. According to Wong and Baker, quantitatively assessing pain in children is the only way to determine how to appropriately treat and man-

Table 1. Common Topical Antibiotics Used to Treat Pediatric Burn Patients.^{2,6,7}

Antibiotic	Degree of Burn Treated	Pathogen Targeted	Adverse Effects	Important to Note
Bacitracin	Second	Gram positive	Anaphylaxis (rare)	-----
Neomycin	Second	Gram positive & negative	Cutaneous Hypersensitivity, Ototoxicity, Nephrotoxicity	Can be used with bacitracin to minimize adverse effects
Silver Sulfadiazine	Second & Third	Gram positive & negative, Yeast	Pain, Burning, Pruritis, Anemia	Contraindicated in patients with sulfur allergies, increases wound healing time, leaves white residue on skin
Mafenide acetate	Third & Post-Skin Graft	Gram positive & negative	Cutaneous Rash, Metabolic Acidosis	Can be used with nystatin to decrease fungal infection, increases wound healing time, decreases inflammatory response
Silver nitrate	Post-Skin Graft	Staph, pseudomonas, yeasts	Burning, Irritation	Can be used in patients with sulfur allergies, monitor electrolytes, stains black
Neomycin & Polymixin B	Post-Skin Graft	Gram positive & negative, Exception for pseudomonas	Dermatitis, Ototoxicity, Nephrotoxicity	Not for large areas

age their pain. Wong and Baker researched and compared the effectiveness and preference of six different pain assessment scales to be utilized by nurses for children aged 3 to 18 years.¹⁰

The pain assessment tools that Wong and Baker studied included the simple descriptive scale, numeric scale, faces scale, glasses scale, chips scale and color scale.¹⁰ Comparing each of these pain assessment scales, the authors determined that the faces scale, which uses facial expressions coordinated with numerical values to reflect severity of a patient's pain, was the preferred method for children to report their pain to nurses. Wong and Baker also found that the reliability and validity did not differ significantly from scale to scale. Therefore, all pain assessment methods are equally effective in monitoring children's pain. In addition, the researchers concluded that the older the children, the more reliable and valid the pain assessment scales became. The only significantly different portion of data in the study was the children's preference of the pain assessment scale, which illustrates that different assessment scales work better for different children.¹⁰ As a result, when caring for pediatric patients, nurses need to try different pain assessment scales and determine which one works best for each child. This will help nurses and other health care professionals to decide what the most appropriate intervention is for pain management.

Administering Pain Medication

Not only is the nurse's assessment of pain an important part of the treatment of pediatric burn patients, but the nurse's administration of appropriate analgesic medications is also crucial to effective pain management. Administering analgesic medications in pediatric burn patients can treat the pain

caused from the initial burn injury or treat pain prophylactically during a wound dressing change. In a study conducted by Vincent and Denyes, nurses' administration of pain medication was compared to the pain rating that children verbalized to the nurse.⁹ The authors found that nurses were more likely to administer analgesic medications in children reporting both experiencing pain and showing physical signs of pain, such as increased heart rate or painful facial expressions. If pediatric patients reported pain without any physical signs of pain, the nurses were less likely to administer analgesics. This becomes an issue because the experience of pain is very individualized and subjective. A child may be experiencing pain without physically appearing to be in pain, so accurately assessing and treating this pain is imperative. Vincent and Denyes further explain that 26 percent of children who reported pain received no analgesia, and only 51 percent of children who reported a moderate or high level of pain received analgesic medication. The authors emphasize that one of the significant contributing factors to undertreated pain in children is the inaccurate assessment of pain by nurses.⁹ Determining the appropriate pain assessment scale for each child will help nurses to precisely identify pain as well as manage pain in the correct administration of analgesics.

There are many different routes by which analgesic medications can be administered. Some of the common routes used in the pediatric population comprise oral (including nasogastric tubing), intravenous and transcutaneous administrations. According to Dyer et al., oral medication administration in pediatrics is the most common route and usually takes the form of tablet or suspension.¹¹ When giving a medication through a nasogastric (NG) tube, typically the oral tablet is crushed and/or dissolved into solution for

administration. Oral medications (tablet or gelatin capsule) that are designed to be fast-acting and absorbed quickly can be crushed and dissolved in solution. Sustained action or any dosage form that is designed to extend the drug delivery period cannot be crushed or dissolved because it risks toxicity or gastrointestinal upset. Thick liquids can be diluted to make them easier and safer to administer. Buccal and sublingual drugs are ineffective if crushed or dissolved and can still be given by the typical route if there is no oral mucosa damage. To ease administration, liquids are the dosage form of choice when NG tube administration is necessary. Typically NG tubes are also the means of administration for nutritional feedings, so it must be verified that medication administration will not interact with feeding and vice versa. For drugs that require an empty stomach, the feed should be stopped for at least 30 minutes before and after drug administration.¹² Patients who are in pain related to burns, especially young children, may find it easier to swallow an analgesic suspension. The authors emphasize that when nurses administer oral suspensions, it is important to mix the solution well and accurately measure the prescribed amount of medication so that the child's pain can be managed as well as possible.¹¹

Dyer et al. also discuss the intravenous route of medication administration which is used in more critical situations, including pediatric patients who experience significant burn injuries.¹¹ Intravenous medication administration is beneficial in the treatment of pain because the analgesics take effect rapidly and maintain therapeutic levels in the body more easily. Large bore intravenous (IV) catheters should be used for burn patients so that rapid fluid resuscitation and analgesic infusion can occur. Oftentimes, the antecubital area is used to initiate IV therapy in burn patients. It is important for

nurses to dilute the medication if indicated, flush the IV line to determine line patency, and to identify the compatibility of IV injections and infusions if analgesics are being administered along with replacement fluids, as is often seen with burn patients.¹ This route of medication administration is extremely effective in pediatric patients who suffer from a high level of pain due to significant burn injuries.

Finally, another common route of analgesic administration in children is the transcutaneous route, which is often delivered through a dermal patch. Dyer et al. explain that the rate of transcutaneous absorption is significantly faster in children compared to that of adults.¹¹ The researchers point out that nurses need to wear gloves when administering this form of medication so that the analgesic does not get absorbed by their own skin. Furthermore, it is important for nurses to rotate skin sites on the patient when using topical medications to prevent irritation and to remove old patches when placing new patches on the skin to prevent analgesic overdose. The severity of the injury, as well as the child's pain rating, often determines the route of analgesic administration in pediatric burn patients. Nurses are responsible for accurately assessing pain and correctly administering analgesic medications. Accuracy will help decrease pediatric patients' pain and, in turn, will promote a more rapid recovery and healing process. The table below highlights common analgesics utilized.

Study Evaluation

After a patient has been acutely treated for a burn injury, the painful healing process begins. A burn patient experiences two types of pain: background and procedure associated pain. The injured tissue inflammation and healing processes

Table 2. Common Analgesics Used in Pediatric Burn Patients.¹³⁻¹⁹

Analgesic	Degree of Burn Treated	Adverse Effects	Important to Note
Acetaminophen	First	Nausea, Vomiting, Constipation, Pruritis, Atelectasis	Can be used with opioids
NSAIDs	First & Second	Nausea, Vomiting, Pruritis, Urinary Retention	Can be used with opioids
Morphine	Second & Third	Nausea, Vomiting, Pruritis, Urinary Retention, Sedation	Common Patient Controlled Analgesia use ≥ 5 years of age
Hydromorphone	Second & Third	Nausea, Vomiting, Pruritis, Urinary Retention, Hypertension	Equivalent to morphine
Fentanyl	Second & Third	Nausea, Vomiting, Pruritis, Urinary Retention, Hypotension, Bradycardia	Equivalent to morphine but with faster onset time; Can be used in renal impairment
Pethidine	Second & Third	Nausea, Vomiting, Pruritis, Urinary Retention, Anxiety, Seizures	Contraindicated in renal impairment
Methadone	Second & Third	Nausea, Vomiting, Pruritis, Dizziness, Arrhythmias, Seizures	For chronic pain management
Ketamine	Second & Third	Nausea, Vomiting, Pruritis, Arrhythmias, Respiratory Depression	Can be used with opioids

cause background pain, while procedural pain is an increase in discomfort experienced by the patient when undergoing necessary therapy associated with burn treatment. Typically more analgesia is required due to increased pain experienced by the patient as a result of procedural pain.¹³ Each type of pain needs to be evaluated and appropriately treated for pain management. This course can provoke anxiety and is especially difficult in children who do not understand that painful adjunct procedures, such as dressing or tube changes, will reduce infection risk, limit scarring and decrease the healing time.^{13,20} During this distressing time, a child can develop insomnia, depression, anxiety, academic problems, longer healing times and an overall decrease in quality of life. To limit these side effects, it is imperative for the patient's pain to be properly treated.^{21,22} The analgesia regime is individualized for each patient and is chosen at the discretion of the medical team. The decision is made from multiple factors regarding the pain symptoms such as severity, length, type, ease of transition between intravenous and by mouth administration and patient specific factors including discharge versus inpatient care, daily activities, history of adverse reaction and patient goals in pain management.²³

From Table 2, it is easy to conclude that there are many medication options available for the treatment of pain in pediatric burn patients, and there is not a consensus about which agent is superior. "For the pediatric population the optimal analgesic is one that is easy to administer, well-tolerated, [with a] rapid-onset of analgesia effects, limited sedation and short duration of action."¹³ Two options that can be used are fentanyl and morphine. A study conducted by Rhonda et al. was designed to assess the analgesic effectiveness between oral transmucosal fentanyl citrate and oral morphine in pediatric burn patients when dressings or tubing were changed.²⁴ Patients assessed in the study were above 10 kg, were able to describe their pain using the Face Pain Rating Scale and had a wound that required a 30 minute or longer tubing procedure. Those under 3 years of age, over 18 years of age and with any previous diagnosis of physical or mental illness were excluded from the study. Those with a past adverse reaction with either of the two agents or that had taken a monoamine oxidase inhibitor containing agent in the last 14 days were also excluded.²⁴ The study was double-blinded, reverse crossover, time randomized and placebo-controlled. The study participants were randomly split into two treatment groups and they only differed in the sequence in

which they received the medications. The dosing sequence between the two groups was as follows: The medications for each group were given 30 to 40 minutes prior to the tubing procedure. Both a self and nurse assessment of the patient's pain level, associated anxiety, cooperation and sedation were assessed before, during and after the procedure.²⁴ The anxiety and cooperation ratings were included because secondary outcomes of proper pain management are a decrease in patient anxiety level and increased cooperation in painful procedures. Pain assessment was completed using the Face Pain Rating Scale with a 0 to 5 rating scale. Anxiety was measured by the Fear Thermometer on a scale from 0 to 4. Patient pain and anxiety were recorded at medication administration, every 15 minutes until the procedure concluded and three and a half hours after the procedure.²⁴ If a patient complained of pain with a Face Pain Rating of greater than 4, they were given a rescue dose of 0.4 mg/kg of morphine for increased analgesia. Side effects and level of sedation were also documented.²⁴ The study concluded that fentanyl was superior to morphine in managing the pain and anxiety associated with procedures of pediatric burn patients. The fentanyl treatment was also found to decrease anxiety levels in those patients suffering from comorbid anxiety. Neither medication had any significant side effects reported, and sedation levels between the two medications were roughly equivalent. A limitation of this study was the small sample size, with a total of just eight patients participating. More research in pediatric burn pain management is needed to make better clinical decisions.²⁴

Implications in Pharmacy and Nursing Practice

Pain management in pediatric burn patients is an imperative process. If addressed properly, the patient will recover more quickly and experience less pain anxiety during recovery. Assessing a patient's pain is complicated because every person feels pain differently, and patients are often unable to adequately explain the type and severity of pain that they are experiencing. This is especially true in the pediatric patient population where nonverbal cues are a key component in communication. Using pain scales that include a nonverbal factor helps the medical team better assess the patient's pain status. This leads to proper medication selection without overtreatment or undertreatment of a patient's pain symptoms. Overtreatment of pain medications can cause serious side effects such as increased sedation or respiratory depression. Pediatric patients are more susceptible to this side effect.

Table 3. Dosing Strategy Between Patient Groups.²⁴

Dosing Strategy	Patient Group 1	Patient Group 2
Day 1	Fentanyl and placebo morphine	Morphine and placebo fentanyl
Day 2	Morphine and placebo fentanyl	Fentanyl and placebo morphine
Dosing Levels (Therapeutic Equivalent)	Fentanyl citrate dose: 10 µg/kg	Morphine: 0.6 mg/kg

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Undertreatment may cause increased anxiety leading to problems such as insomnia, academic issues and a longer healing time. The key to pain management is proper assessment. If the patient is properly assessed, they are more likely to receive the correct medication for their pain and will have a greater chance of achieving positive outcomes than those that do not have their pain properly managed.

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