A Retrospective Chart Review: Are Gastrointestinal Complications Associated With Formula Brand and Rate Changes Outside of the Standard Protocol in a Random Sample of Pediatric Burn and Trauma Patients?

THESIS

Presented in Partial Fulfillment of the Requirements for the Degree Master of Science in the Graduate School of The Ohio State University

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2012

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Abstract

Adequate provision of nutrition support, based on recommendations from a registered dietitian (RD), is a crucial component of care of the critically ill pediatric patient. The goal of this study was to compare current enteral nutrition (EN) practices at a Midwestern children’s hospital to RD recommendations, and to explore the possible relationship between these variations with the occurrence of gastrointestinal (GI) complications and length of stay (LOS).

This retrospective review included pediatric burn and trauma patients who were admitted to a Midwestern children’s hospital between October 2008 and July 2010, and required EN at any time during their hospital stay. Differences between RD recommendations for EN and actual practices were analyzed, and the relationship between these differences and the occurrence of GI complications and LOS was explored. Descriptive statistics, chi-square analysis, and linear regression analysis using SPSS were used for data analyses.

Sixty patients were included in this retrospective review. The number of patients who received an RD consult within 24 hours of admission was 30/60 (50%). Recorded daily volume intakes were both over and under volumes recommended by the RD. There was no significant association between the occurrence of diarrhea or vomiting and rapid EN rate advancements ($p > .05$). There was a significant association between the occurrence of abdominal distention or excessive gastric residuals and rapid EN rate
advancements ($p < .05$). There was no significant relationship between the occurrences of GI complications and the number of EN formula changes ($p > .05$). There was a significant relationship ($R^2 = .733$) between increased GI complications and increased hospital LOS ($p < .05$).

Variation exists between RD recommendations for nutrition support and actual practice in pediatric burn and trauma patients. GI complications may increase as a result of this variation. Adherence to feeding protocols may help reduce unwanted GI complications while providing adequate nutrition therapy to improve patient outcomes in critically ill children.
Acknowledgments

I first would like to offer thanks to my Lord and Savior, Jesus Christ for giving me strength, patience, and grace throughout this process. I would not have been able to complete this thesis without your unconditional love and guidance.

I would like to express my gratitude to my advisor Dr. Marcia Nahikian-Nelms, for her help, guidance, patience, time, and support throughout the writing of this thesis. Her expertise was essential, and I am grateful to have had the opportunity to learn from her extensive knowledge and skill in the field of dietetics.

I would also like to thank Dr. Colleen Spees, and Terri Capello for their guidance and support. I want to thank Dr. Spees for her research expertise which pushed me to write and perform at a higher level. I want to thank Terri for having the patience to assist me in completing the data collection by providing me with anything I needed. I also want to thank her for keeping a sense of humor when we hit roadblocks along the way. I would also like to acknowledge Dr. Susan White, whose statistical analysis expertise was vital to helping me complete the data organization and analysis for this thesis. I would also like to express gratitude to Matthew Gorr for taking the time to help edit my document.

Finally, I would like to acknowledge my husband Greg for his unconditional love and support which helped me to continue when things seemed difficult. I am excited to begin the next chapter of our lives as we become parents very soon.
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Chapter 1: Introduction

Background and Significance

Children that experience burn injuries, trauma, and critical illness often have poor health outcomes. Appropriate nutrition therapy is required to improve both morbidity and mortality in the critically ill pediatric population. Burn injuries are the 10th most common cause of accidental death in children and adults and each year about 11,000 children and adults are hospitalized for burns [1]. Children with severe burn injuries have higher rates of mortality when compared to adults with similar injuries [2].

When the body experiences a trauma, such as a burn injury, several physiological changes occur. The stress on the body leads to an increase in catabolic processes with subsequent loss of lean body mass [3]. In addition, the body responds to a trauma by increasing stress hormones such as endogenous catecholamines, cortisol, other glucocorticoids, epinephrine and norepinephrine [1]. In burn patients, hypermetabolism occurs as a result of increased inflammation and evaporative heat loss from the burned tissue [1]. Other physiological changes that occur include: increased heart rate, increased blood pressure, increased glucagon release from the liver, increased lipolysis, increased thermogenesis, increased levels of hemoglobin and plasma proteins, decreased coagulation time, relaxation of gastrointestinal (GI) smooth muscle, increased protein breakdown for gluconeogenesis, and decreased antioxidant defenses [1]. These changes
contribute to increased morbidity and mortality and require adequate nutrition therapy to support metabolic requirements and to blunt the stress response.

While children and adults experience similar physiological changes in response to trauma or burn injuries, additional factors contribute to specific pediatric needs. During burn injuries, children not only have increased metabolism but are also still growing and developing. Children also have a GI system that is not fully developed and includes a smaller stomach which holds less than the stomach of an adult [4]. The pediatric population also has limited body stores of protein [4]. In addition, toddlers and infants have higher fluid maintenance needs per unit of weight than older children and adults and experience fluid deficits much more quickly [5]. The mortality rate is greater in children largely due to the immaturity of the immune system and its inability to respond well to the stress of the injury [5]. Nutritional demands differ between children and adults as well with children having: increased energy and protein requirements for wound healing, a higher basal metabolic rate per kilogram of body weight, increased body surface area in relation to body weight, decreased energy and protein reserves, additional consideration for growth and development, negative nitrogen balance occurring even on burns of smaller size, and a greater risk for cerebral growth retardation in infants [6]. With burn patients, it is also important to note that children have a thinner dermis which can lead to greater heat loss and a higher risk of becoming hypothermic [1]. The catabolic processes and muscle breakdown that occur in burn and trauma patients can lead to cessation of growth in a child until wound healing is complete and adequate nutrition therapy is provided for the years following the injury [7].
Nutrition therapy is necessary in these critically ill patients because malnutrition often occurs as a result of the metabolic response to the injury [8]. Lack of nutrition support can exaggerate existing nutrient deficiencies and influence the outcome of the illness [8]. Appropriate nutrition therapy can modulate the stress response in the short-term and minimize complications in the long-term [8]. Early feeding has been shown to preserve GI function, restore cell-mediated immunity, reduce bacterial translocation, decrease the hypermetabolic response, decrease weight loss, improve nitrogen retention, increase intestinal blood flow, stimulate secretion of GI trophic hormones, and in general, reduce morbidity and mortality [9].

Despite the importance of nutrition therapy, both underfeeding and overfeeding can lead to complications in a critically ill child. Overfeeding can cause an increased production of carbon dioxide, increased risk of hepatic steatosis, hyperglycemia, and osmotic diuresis [10]. On the other hand, underfeeding can lead to weight loss, poor healing, and increased hospital length of stay. Registered dietitians (RDs) have the expertise to recommend effective feeding protocols in critically ill children to help minimize over- or underfeeding. Enteral nutrition (EN) can also lead to GI complications such as diarrhea, vomiting, abdominal distention, and increased gastric residual volumes. The overall goal of nutrition therapy during critical illness is to reduce these complications while providing adequate nutrition for healing, and therefore, improving patient outcomes.

Utilizing the expertise of an RD when prescribing EN can ensure appropriate volumes and infusion rates are provided to patients. RDs follow feeding protocols which
are necessary to promote consistent progression and transition of nutrition support. Without these protocols, patients may be over- or underfed or experience GI complications which lead to poorer patient outcomes such as increased hospital length of stay, as well as increased morbidity and mortality. Further research is needed to ensure that feeding protocols, that are safe and effective in the critically ill child, are consistently followed in practice.

**Objectives**

The 5 primary objectives of this study were the following:

1. To define and describe the differences between RD recommendations for EN (including the brand and type of formula, daily volume intake, and rate advancement recommendations) and the recorded actual EN intake in a random sample of pediatric burn and trauma patients admitted October 2008 through July 2010.

2. To determine the incidence of GI complications including diarrhea, vomiting, increased gastric residuals, or abdominal distention as documented in the medical record for a random sample of pediatric burn and trauma patients admitted October 2008 through July 2010.

3. To determine if there is a higher rate of documented GI complications including diarrhea, vomiting, increased gastric residuals, or abdominal distention in a random sample of pediatric burn and trauma patients when given rapid EN rate advancements, as measured by rate increases exceeding what was recommended by the RD.
4. To determine if there is a higher rate of documented GI complications including diarrhea, vomiting, increased gastric residuals, or abdominal distention in a random sample of pediatric burn and trauma patients when they receive formula changes during their hospital stay, with change defined as a switch in the brand or type (adult or pediatric) of formula.

5. To determine if there is an increased hospital length of stay in a random sample of pediatric burn and trauma patients who experience GI complications compared to patients who do not experience GI complications.

**Research Questions**

1. What percentage of patients of the sample received a dietitian consult for nutrition support within 24 hours of admission?

2. What is the difference between the daily volume of enteral feeding recorded on intake/output records compared to the daily volume of enteral feeding prescribed by the registered dietitian?

3. Is there an association between intolerance, as measured by diarrhea, vomiting, abdominal distention and excessive residuals, and enteral nutrition feeding rate increases that are greater than recommendations from the registered dietitian?

4. Is there a correlation between intolerance, as measured by diarrhea, vomiting, abdominal distention and excessive residuals, and the number of formula changes, with change defined as a switch in the brand or type (adult or pediatric) of formula?

5. Do pediatric burn and trauma patients with GI complications have a greater hospital length of stay when compared to patients without GI complications?
**Research Approach**

This study was a retrospective medical record review. It focused on pediatric and adolescent patients admitted to and discharged from the Pediatric Intensive Care Unit (PICU) or Burn/Trauma Units at a Midwestern children’s hospital from October 2008 through July 2010. The medical records were reviewed for EN recommendations from the RD and whether or not enteral feedings were prescribed and advanced per those recommendations.
Glossary of Terms

**Burn Injury:** Damage to the body's tissues caused by heat, chemicals, electricity, sunlight or radiation covering any percentage of the body.

**Calorie:** Equivalent to 1000 calories or 1 kilocalorie (kcal). Is the amount of heat energy required to raise or lower 1 kg of pure liquid water by 1°C. In nutrition, is used to express energy content of food.

**Catabolism:** Metabolic processes which breakdown organic molecules in the body to release energy.

**Critical Illness:** Life-threatening conditions requiring organ support and invasive monitoring. Patients admitted to the intensive care unit, burn unit, or trauma unit.

**Energy:** Required to sustain the body’s various functions by oxidation (primarily carbohydrates, fats, and amino acids), yielding the chemical energy needed to sustain metabolism, nerve transmission, respiration, and physical work.

**Enteral Nutrition:** Feeding provided through the GI tract via a tube, catheter, or stoma that delivers nutrients distal to the oral cavity.

**Hypermetabolism:** Physiological state of increased rate of metabolic activity.

**Malnutrition:** A subacute or chronic state of nutrition, in which a combination of varying degrees of overnutrition or undernutrition and inflammatory activity has led to a change in body composition and diminished function.

**Medical Nutrition Therapy:** Assessment of the nutrition status of the patient, and treatment which includes diet therapy, counseling, or use of specialized nutrition supplements.
Morbidity: The presence of illness or disease.

Mortality: Rate of death in a specific group or specific time.

Nutrition Assessment: A comprehensive approach to diagnosing a nutrition problem that employs a combination of the following: medical, nutrition, and medication histories; physical examination; anthropometric measurements; and laboratory data.

Nutrition Care: Interventions, monitoring, and evaluation designed to facilitate appropriate nutrient intake based upon the integration of information from the nutrition assessment.

Nutrition Care Plan: A formal statement of the nutrition goals and interventions prescribed for an individual using the data obtained from a nutrition assessment. The plan should include statements of nutrition goals and monitoring/evaluation parameters, the most appropriate route of administration of nutrition therapy, method of nutrition access, anticipated duration of therapy, and training and counseling goals and methods.

Nutrition Screening: A process to identify an individual who may be malnourished or at risk for malnutrition to determine if a detailed nutrition assessment is indicated.

Nutrition Support Service (or Team): An interdisciplinary group which may include physicians, nurses, dietitians, pharmacists, and/or other healthcare professionals with expertise in nutrition who manage the provision of nutrition support therapy.

Nutrition Support: Parenteral and/or enteral nutrition.

Outcome: The measured result of the performance of nutrition therapy.

Oral Nutrition: Nutrients taken by mouth.
**Parenteral Nutrition:** The intravenous administration of nutrients. Central: Parenteral nutrition delivered into a large-diameter vein, usually the superior vena cava adjacent to the right atrium. Peripheral: Parenteral nutrition delivered into a peripheral vein, usually of the hand or forearm.

**Pediatrics:** Includes the growth, development, and health of the child and therefore begins in the period before birth when conception is apparent. It continues through childhood and adolescence when the growth and developmental processes are generally completed. Includes ages 0-18 years.

**Weight/Body Weight:** Actual, measured body weight of an individual.
Chapter 2: Review of Literature

Normal Nutrition for Children

Due to the rapid growth and development children experience from birth through adolescence, nutritional recommendations differ at each developmental stage. Starting with the infant stage, feeding recommendations include breast milk or iron-fortified formula for the first 12 months of life [11]. Solid foods should be incorporated incrementally as shown in Table 2.1 below.

<table>
<thead>
<tr>
<th>Age (Months)</th>
<th>Food (Portion Size)</th>
<th>Feedings Per Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4</td>
<td>Breast milk or infant formula (2-4 oz)</td>
<td>8-12</td>
</tr>
<tr>
<td>4-6</td>
<td>Breast milk or infant formula (6-8 oz)</td>
<td>4-6</td>
</tr>
<tr>
<td></td>
<td>Infant cereal (1-2 Tbsp)</td>
<td>1-2</td>
</tr>
<tr>
<td>6-8</td>
<td>Breast milk or infant formula (6-8 oz)</td>
<td>3-5</td>
</tr>
<tr>
<td></td>
<td>Infant cereal (2-4 Tbsp)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Crackers (2), bread (½ slice)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Juice (0-3 oz)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Fruit or vegetable (2-3 Tbsp)</td>
<td>1-2</td>
</tr>
<tr>
<td>8-12</td>
<td>Breast milk or infant formula (6-8 oz)</td>
<td>3-4</td>
</tr>
<tr>
<td></td>
<td>Cheese (½ oz) or yogurt (½ cup)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Infant cereal (2-4 Tbsp), bread (½ slice), crackers (2), or pasta (3-4 Tbsp)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Juice (3 oz)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Fruit or vegetable (3-4 Tbsp)</td>
<td>2-3</td>
</tr>
<tr>
<td></td>
<td>Meat (3-4 Tbsp) or beans (¼ cup)</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 2.1: Typical Portion Sizes and Daily Intakes for Infants [12]
As children enter the toddler stage (1-3 years of age), more specific energy and protein recommendations have been established. The average energy needs of a toddler are 90-102 kcal/kg per day [12]. The protein requirement for toddlers is approximately 13 g/day or 1.1 g/kg per day [13]. Lipid requirements vary during these years, with younger children requiring more dietary fat to continue brain and nerve development [12]. Current guidelines recommend refraining from excessively restricting fat intake in toddlers in order to meet these nutritional needs [14].

Children in the preschool stage (4-5 years of age) require an average caloric intake of 1,300-1,600 kcal/day, which is approximately 90-102 kcal/kg per day [13]. Appetite varies with children of this age so it is more important to look at weekly average intake instead of daily intake when performing a dietary assessment. Recommendations for protein are 13-19 g/day or .95 g/kg per day [13]. At the preschool stage, children should gradually begin to consume a diet with no more than 30 percent of total calories from fat, and no more than 10 percent of total calories from saturated fat [14].

School-age children (5-11 years of age) require 70-90 kcal/kg per day to meet their energy needs [13]. In addition, protein requirements are 19-34 g/day, equivalent to approximately .95 g/kg per day [13]. Activity level, size, and growth rate all determine the level of energy and protein required in children at this stage.

Once a child enters adolescence, it becomes more difficult to determine his or her nutrient needs because these needs are influenced by the process of puberty, age, gender, and level of physical activity. Estimated energy requirement tables have been developed based on the USDA’s Dietary Reference Intakes (DRIs) to account for these factors in
children at the adolescent stage of growth and development [12]. Protein needs for adolescents are highest during growth spurts, which usually occur between ages 11-14 years for females and ages 15-18 years for males. Protein needs on average are .85 g/kg per day or 46-52 g of protein per day [13].

Children in all stages of development are able to receive the necessary vitamins and minerals to stay healthy by eating a variety of foods. Multivitamin use is only suggested if a child’s eating is inconsistent or if a child is ill or on certain medications for an extended period of time [12].

**Physiological Challenges of Providing Nutrition Support in Pediatrics**

Nutritional recommendations differ for children when compared to adults due to several physiological issues. Children have an increased metabolism during critical illness and injury much like adults. However, they are also in the process of growth and development which has an impact on their nutrient needs. Their gastrointestinal (GI) tract is not completely developed and smaller children obviously have smaller stomach sizes which limits the volume of food that can be consumed. Children also have limited body stores of protein which further increases the need to provide adequate dietary protein during injury [4]. They also have a higher basal metabolic rate (BMR) per kilogram of body weight, increased body surface area in relation to body weight, and decreased endogenous energy reserves [6].

Children are at a higher risk of undesirable outcomes following a severe trauma or critical illness when compared to adults. Infants are at a greater risk for cerebral growth retardation following critical illness [15]. In addition, children have an immature immune
system which does not respond well to stress following a severe trauma and thus contributes to higher rates of mortality [10].

Even within children, energy requirements vary greatly for different ages and stages of development. Formulas for estimating energy needs are often developed and tested on older children but not on very young children [16]. Treating children at various stages of development can be challenging due to the wide range of nutritional recommendations.

Nutrition support is often required in critically ill children because their nutrient requirements cannot be met with an oral diet alone [4]. Many times, an adult formula must be used to provide the appropriate nutrient density without providing too large of a volume. However, the very young child has an immature GI tract and renal system which may not be able to tolerate these high levels of dietary protein and other nutrients [4]. Therefore, nutrition support recommendations must consider the physiological differences between children and adults.

**A.S.P.E.N. Clinical Guidelines for Critically Ill Children**

Nutrition support is often implemented in critically ill patients due to increased nutrient needs as well as an inability to meet these needs through an oral diet alone. Current nutrition support guidelines aim to modulate the short-term stress response and minimize potential long-term complications [8]. Providing medical nutrition therapy for critically ill children is challenging but vital to improving outcomes. Stress, inflammation, and illness cause the body to experience physiological changes which have an impact on metabolism. Malnutrition commonly occurs in critically ill patients as a
result of a prolonged period of catabolism. In addition, lack of nutrition support can further exaggerate existing nutrient deficiencies. Current practice demonstrates that under- and overfeeding are prevalent in pediatric intensive care units (PICU) at many hospitals [17]. It is important to have effective nutrition guidelines for registered dietitians (RDs) because malnutrition and increased GI complications negatively affect the outcomes of critical illness and injury.

In order to provide accurate nutritional recommendations, screening and assessment must occur first. Current American Society for Parenteral and Enteral Nutrition (ASPEN) clinical guidelines state that all children admitted with critical illness must undergo nutrition screening to identify those with existing malnutrition or those who are at nutritional risk [8]. In patients at nutritional risk, a full nutrition assessment should be performed and a nutrition care plan should be developed by an RD. Nutrition screening and assessment are needed to treat and prevent malnutrition which consequently affects hospital length of stay, illness course, and patient morbidity and mortality [8].

Once the nutrition care plan has been determined, current guidelines state that energy expenditure should be assessed throughout the course of the illness. Standard equations often used to estimate pediatric energy expenditure are often unreliable [8]. Guidelines further state that indirect calorimetry should be performed to determine energy expenditure in patients who have suspected metabolic alterations or malnutrition. Patients who are admitted to the PICU, have suffered from severe burns, or are on mechanical ventilation experience varying levels of hypermetabolism. As a result, failure
to provide adequate energy in these patients can result in loss of lean body mass [8].
While it is important to provide adequate nutrition for healing and growth, overfeeding a critically ill child can lead to complications such as increased production of carbon dioxide, prolonged need for mechanical ventilation support, impaired liver function (hepatic steatosis or cholestasis), hyperglycemia, and osmotic diuresis [8, 10]. RDs must follow feeding protocols and monitor the patient closely to minimize over- or underfeeding and decrease the incidence of GI complications.

There is insufficient data to make evidence-based guidelines for macronutrient intake in critically ill children [8]. Clinical judgment should be used in this area when providing nutritional care. Increased protein catabolism occurs when the body experiences critical illness so sufficient protein must be provided to slow or prevent lean muscle wasting, weight loss, and immune dysfunction [8]. In addition, sufficient protein is needed to modulate the inflammatory response and increase wound healing [8]. Critically ill children also experience hyperglycemia and increased lipid turnover, which can have an impact on carbohydrate and lipid needs.

Enteral nutrition (EN) support is the preferred mode of nutrient provision assuming the patient has a functioning GI tract and no other contraindications [8]. There is insufficient data to recommend a specific site of nutrient infusion (gastric or post-pyloric) for critically ill children [8]. However, post-pyloric feedings are often considered for children at high risk for aspiration. EN is preferred over parenteral nutrition (PN) because it is more cost-effective and has a lower risk of nosocomial infection [18]. In addition, EN better maintains GI function, minimizes bacterial translocation, suppresses
hypermetabolic response to stress, enhances protein accrual, and is associated with decreased septic morbidity, metabolic derangements, reduced hospital length-of-stay, and higher survival rates [19-26].

Based on available data, the use of immune-enhancing formulas in critically ill children has not been shown to improve outcomes [8]. Further research is needed to determine safety and efficacy of these formulas.

ASPEN clinical guidelines also recommend use of a specialized nutrition support team in the PICU to implement aggressive feeding protocols. This approach may enhance the overall delivery of nutrition, result in a shorter time to goal nutrition rate, increase the delivery of EN, and decrease the delivery of PN [8].

**Burn Pathophysiology and Impact on Nutrition**

A burn injury is categorized by several physiological changes that are divided up into stages including: acute phase (comprised of ebb and flow phases), rehabilitation, and convalescence. The ebb phase occurs immediately after injury and is characterized by hypovolemia, tissue hypoxia, and poor cardiac output [3]. The ebb phase is followed by the flow phase which occurs 12-24 hours after the injury and is characterized by increased glucose production as well as fatty-acid oxidation [27].

Regarding nutrition, it is important to note that a body experiences catabolic processes during the acute phase of a burn injury and preservation of lean body mass should be the main priority. While in the acute phase, many patients have greatly increased energy requirements that can even double in patients who have greater than 50 percent total body surface area (TBSA) burned [28]. Nutrition support is often indicated
in severely burned patients due to increased energy needs as well as the potential need for mechanical ventilation support as a result of smoke inhalation injuries.

The rehabilitative phase follows the acute phase of a burn injury and is characterized by wound closure and the beginning of physical therapy. While patients in this stage no longer require special care in the intensive care unit, they still have high energy and protein needs. Nutrition therapy during this phase involves promoting weight gain, supporting growth and development, transitioning to an oral diet in place of nutrition support, and treating bone disease and hypovitaminosis D [12].

As the rehabilitative phase ends, the convalescent phase begins. Patients leave the hospital during this phase but are still seen frequently for treatment. For healing, growth and development, patients in this stage still need adequate energy, protein, vitamins, minerals, and electrolytes [12].

Patients with a burn injury experience an increase in endogenous catecholamines, cortisol, and other glucocorticoids that are a result of a stress response to trauma. Epinephrine and norepinephrine increase 10-fold in burns that cover 30-40 percent of TBSA [29]. The physiological response to a burn injury involves increased heart rate, increased blood pressure, glucagon release from the liver, increased lipolysis, increased thermogenesis, increased hemoglobin levels, increased plasma protein levels, decreased coagulation time, relaxation of GI tract smooth muscle, increased protein breakdown for gluconeogenesis, increased levels of oxygen free radicals, and decreased antioxidant defenses [1]. The increase in metabolism, resulting from inflammation and evaporative heat loss, can last 9-12 months post-injury [30].
Rutan et al. [31] discussed the growth delays children often experience following a burn injury. A cessation of growth can occur while the body recovers from the injury. During the acute phase, hair, nail, and bone growth are slowed. Protein and fat depletion can also lead to weight loss, muscle loss, decreased immune response, and poor wound healing. They also found that children showed decreased growth in linear height for up to three years post-burn [31]. Muscle breakdown has been observed for up to 9 months following a severe burn injury [7]. These growth delays make adequate nutrition therapy vital during all phases of a burn injury in order to provide for catch-up growth, and eventually, a return to normal growth.

Adults and children have different outcomes following a severe burn injury. Fluid resuscitation problems in children ages 0-48 months led to higher mortality when compared to adults with similar sized burn injuries [2]. Similarly, children ages 0-12 years with large burns had higher mortality than adults with similar sized burns [2]. In addition, the study researchers found that children younger than 4 years old with burns greater than 30 percent TBSA had higher mortality rates than older children and adults with similar sized burns [2]. Sheridan et al. [32] also determined that infants and young children have the highest rates of death from burn injuries.

Several factors can lead to increased morbidity and mortality in children who experience burns when compared to adults. One factor is that infants and toddlers have higher fluid maintenance needs following a burn injury compared to older children and adults. Also, negative nitrogen balance occurs in smaller burns in children but is not common in smaller burns in adults [10]. Following a burn injury, children experience
greater heat loss than adults and have a higher risk of becoming hypothermic [1]. As a result of these challenges, children have increased nutrient requirements to heal a burn injury and to provide for growth and development.

**Nutrition Assessment for Burn Patients**

Clinicians need to understand that physiological changes in burn patients can have an impact on nutrition assessment. Considerations should be made regarding impaired immunity from surgery and infection, the effects of wound losses, the effects of transfusions on serum proteins, changes in the rates of muscle protein breakdown, and rapid physical changes in extracellular volume which can decrease body weight [33, 34]. During nutrition assessment RDs should determine the current metabolic status of a patient and assess the extent of the burn injury. They should also determine pre-injury nutrition status, age of the patient, presence of inhalation injury, and any organ dysfunction [35]. A thorough nutrition assessment also includes pre-injury weight, height, plotting of growth charts, biochemical lab measures, diet history, medications, supplements, respiratory status, and a GI assessment (bowel history, nausea or vomiting, gastric residuals) [12]. Current protocol at a Midwestern children’s hospital recommends that serum prealbumin and C-reactive protein be drawn upon admission and weekly thereafter, in addition to measuring insulin-like growth factor-1 (IGF-1) as needed.

Determination of nitrogen balance is the most common clinical method for assessing a patient’s protein status [36]. Nitrogen balance estimates nitrogen intake (found in amino acids in proteins) and then compares this to nitrogen excretion. Nitrogen excretion is estimated from urine urea nitrogen (UUN) and an estimate of cutaneous or
GI losses. Manning et al. [36] stated that nitrogen balance calculations and improvement over time in response to nutrition therapy are the most consistent nutrition variable associated with improved outcomes in critically ill patients.

Curreri et al. [37] analyzed survival and hospitalization time for 937 patients who had burn injuries and found that hospital length of stay is primarily based on injury size, age, and regional problems of post-hospital placement into rehabilitation programs. Therefore, proper assessment is needed to help RDs identify patients who may be at a high risk for a long hospital length of stay.

**Nutrition Recommendations for Burn Patients**

A nutrition plan must first determine the necessary energy requirements of a patient. In patients with a burn injury, energy needs are partially determined by the size of the burn. Indirect calorimetry is the best method for getting an accurate resting energy expenditure (REE) because formulas that are commonly used tend to over- or underestimate REE [38]. After measuring REE with indirect calorimetry, a patient’s caloric goal should be set at 120-130 percent of the measured REE [1]. Clinical judgment can also lead to a higher or lower caloric goal based on the presence of sepsis, wound infection, surgeries, pain, or the presence of multiple injuries. Current practice at a Midwestern children’s hospital involves utilizing Solomon’s formula in order to estimate energy needs in pediatric burn patients. Solomon’s formula estimates energy needs as: RDA for age + 30 kcal/1% TBSA burned [39]. Solomon’s formula also makes adjustments in infants and young children by recommending half of the additional
calories in infants weighing up to 9 kg, and two-thirds of the additional calories in children weighing 10-13 kg [39].

There is currently insufficient data to make evidence-based guidelines on lipid and carbohydrate requirements in burn patients [1]. However, burn patients often experience hyperglycemia and increased lipolysis, which should influence recommendations for carbohydrate and lipid amounts. Protein needs are increased in burn patients due to increased gluconeogenesis, the need for wound healing, and increased losses in urine and wounds [1]. Current recommendations suggest a protein goal of 2.5-4 g/kg per day [40]. RDs can determine whether to choose the higher or lower end of the range based on renal sufficiency, fluid balance, and size of the wound.

Meyer et al. [41] reviewed changes in amino acid needs in burn patients and suggest that arginine can become conditionally essential following a burn injury. Furthermore, leucine, isoleucine, and valine may be helpful in patients with a burn injury but more research needs to be done before guidelines are established [42]. Sheridan et al. [43] studied the effects of providing glutamine to burned children to encourage protein accretion but found that short-term supplementation did not have an effect. It may be necessary to provide several days of glutamine supplementation to restore plasma glutamine levels and stimulate protein synthesis [43].

Compared to pre-injury needs, vitamin and mineral requirements increase in a burn patient but evidence-based guidelines have not yet been determined [1]. Requirements for vitamins A, C, and D are increased following a burn injury. Vitamin C allows for collagen synthesis, increased immunity, and antioxidant function. Vitamin A is
necessary for antioxidant function and increased immunity. Vitamin D and calcium are both needed for bone health due to the reduced bone formation that occurs following a burn [44]. Zinc and copper deficiencies have been observed in burn patients so supplementation may be necessary [1]. Additional antioxidant defenses can be provided with vitamin E and glutathione supplementation (along with vitamins A and C) to decrease mortality in burn patients [45]. Prelak et al. [35] suggest pediatric burn patients ages 3 years and older require supplementation of zinc, copper, selenium, and vitamin C in addition to a children’s multivitamin. Current protocol at a Midwestern children’s hospital recommends vitamin supplementation as listed in Table 2.2 below.

<table>
<thead>
<tr>
<th>Age/Weight</th>
<th>Vitamin/Mineral Supplement</th>
<th>Amount Recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥3 years old or ≥18kg</td>
<td>Multivitamin/mineral</td>
<td>1 children’s vitamin daily</td>
</tr>
<tr>
<td></td>
<td>Zinc</td>
<td>1mg/kg daily</td>
</tr>
<tr>
<td></td>
<td>Vitamin C</td>
<td>250mg twice daily</td>
</tr>
<tr>
<td>&lt;3 years old or &lt;18kg</td>
<td>Multivitamin/mineral</td>
<td>1 children’s vitamin daily</td>
</tr>
<tr>
<td></td>
<td>Zinc</td>
<td>1mg/kg daily</td>
</tr>
<tr>
<td></td>
<td>Vitamin C</td>
<td>100mg twice daily</td>
</tr>
</tbody>
</table>

Table 2.2: Vitamin & Mineral Supplementation for Pediatric Burn Patients

Pham et al. [46] studied the effect of tight glycemic control in severely burned children and found that insulin therapy used to regulate blood glucose is safe and effective in the pediatric population, and can lower infection rates as well as improve survival rates.
**Nutrition Support for Burn Patients**

Burn injuries commonly result in several metabolic abnormalities contributing to malnourishment, increased risk of infection, decreased wound healing, and altered cell function. Research has determined that a combination of early initiation of nutrition support and wound treatment can blunt the catabolic processes occurring in the body of a burn patient [3, 19]. Also, initiating EN within 12 hours of injury led to higher levels of serum albumin and total protein when compared to feedings that began 72 hours or later post-injury [19]. In addition, animal studies have demonstrated that delaying enteral feedings in critically ill patients led to a loss of nearly 50 percent of the mucosal weight of the jejunum of the small intestine while immediate feeding did not have this loss [47]. Venter et al. [48] also concluded that providing enteral feedings within 12 hours post-injury is both safe and effective and enteral feeding rates can be increased in volumes within 2-3 days post-injury. Enzi et al. [49] found that waiting greater than 18 hours to initiate nutrition support often led to higher rates of gastroparesis and other complications. Scott et al. [9] stated that the benefits of early EN include a decrease in the hypercatabolic response, a decrease in the release of stress hormones, reduced weight loss, improved caloric intake, increased insulin secretion, improved protein retention, and a shortened hospital length of stay in burn patients. Therefore, data from several studies support the early initiation of EN in burn patients. RDs should be consulted and EN should be initiated in pediatric burn patients within 24 hours of admission.

Once EN has been initiated, guidelines indicate that continuous feedings are better tolerated than bolus feeds in the pediatric population [12]. When implementing
continuous feedings, a gradual advancement to goal rate is recommended to minimize GI complications [12]. Though more research is needed to determine appropriate EN advancement rates for pediatric burn patients, current protocol at a Midwestern children’s hospital recommends initiating feeds at 1-2ml/kg/hr with gradual advancement of 0.5-1.0ml/kg/hr every 8-24 hours until goal rate is attained. This feeding protocol is recommended by RDs to provide adequate nutrition therapy while minimizing GI complications that often lead to poorer outcomes.

As previously stated, nutrition support can lead to GI complications in children with critical illness or burn injuries. Patients on mechanical ventilation or treated with drugs that reduce gastric motility often have poor tolerance to oral or nasogastric enteral feedings [50]. Lopez-Herce et al. [51] found that GI complications occurred more often in patients receiving epinephrine, sedatives, and muscle relaxants. They also saw an increase in enteral feeding GI complications in patients suffering from shock and patients receiving continuous renal replacement therapy for acute renal failure [51]. Skillman et al. [52] also found increased GI complications from EN in patients with hypokalemia or hypophosphatemia. Post-pyloric EN demonstrated a reduction in some GI complications and allowed for the volume of the feedings to be increased rapidly within 48 hours [51]. In fact, EN was suspended due to GI complications in only 2.1 percent of the patients in the study [51]. Mortality in children with complications related to nutrition support is higher than patients who tolerate enteral feedings [51]. As a result, RDs must implement a care plan that minimizes GI complications while still providing adequate nutrition.
Besides GI complications, EN can also be associated with mechanical or infectious problems. Pneumonia is a common infectious complication related to EN aspiration [52]. Microbial contamination of the feeding tube or nutrition formula can also occur during nutrition support. In infants, microbial contamination during EN can increase the risk for necrotizing enterocolitis (NEC) [53]. Mechanical issues often include occlusion of the feeding tube or tube placement errors. While research has established the benefit of nutrition support in critically ill patients, there can be unintended complications that need to be addressed.

**Nutrition Monitoring/Evaluation for Burn Patients**

Once the nutrition plan is in place, it is necessary to monitor markers of nutrition status and assess clinical condition as needed so that nutrition support can be adjusted. Since most burn patients require nutrition support, the RD should monitor EN tolerance, volume received, formula received, and rate of infusion. Anthropometric and biochemical measurements that should be monitored differ depending on what phase of the burn the patient is experiencing. Table 2.3 below reviews the suggested monitoring schedule in each of the phases of a burn injury.
<table>
<thead>
<tr>
<th>Elements of Nutrition Assessment</th>
<th>Acute Phase</th>
<th>Rehabilitative Phase</th>
<th>Convalescent Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>Biweekly</td>
<td>Weekly</td>
<td>At scheduled visits</td>
</tr>
<tr>
<td>Calorie &amp; Protein Intakes</td>
<td>Daily</td>
<td>Daily</td>
<td>If nutrition status is a concern</td>
</tr>
<tr>
<td>Prealbumin &amp; C-Reactive Protein</td>
<td>Biweekly</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Urine Urea Nitrogen</td>
<td>Weekly</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Albumin</td>
<td>None</td>
<td>Monthly</td>
<td>If nutrition status is a concern</td>
</tr>
<tr>
<td>Indirect Calorimetry</td>
<td>Weekly</td>
<td>If weight gain cannot be achieved</td>
<td>None</td>
</tr>
</tbody>
</table>

Table 2.3: Monitoring Throughout Burn Injury Care (Modified from [35])

**Critical Illness Impact on Nutrition**

Energy needs vary greatly from patient to patient, with high-stress injuries and surgeries increasing REE more than low-stress injuries and surgeries. Canete *et al.* [54] found that infants had a measured REE of 39.4 kcal/kg with a low-stress injury while infants with a high-stress injury had a measured REE of 58.0 kcal/kg. REE changed for both groups 8 days later with an increase to 66.4 kcal/kg in the low-stress infants and a decrease to 50.7 kcal/kg in the high-stress infants [54]. The rise in REE measured in the low-stress group was likely a result of catch-up growth causing increased energy needs [54].

In critically ill children, protein breakdown exceeds protein synthesis which leads to negative nitrogen balance. Protein losses from lean body mass continue until the stress...
response has resolved. Critically ill children also have an elevated rate of fat oxidation compared to children with little to no stress.

In order to effectively treat critically ill children, it is necessary to first define the level of severity in these patients. Trauma alert activation criteria for a Midwestern children’s hospital assigns severity of injury to either level 1 or level 2. Level 1 criteria are listed below:

- Airway or respiratory compromise; airway or breathing maintained by maneuvers, adjuncts or ETT; pneumothorax; facial or neck injury with potential for airway or cervical spine injury
- Tachycardia with poor perfusion; hypotension; need for more than 2 fluid boluses or 40 ml/kg fluid resuscitation from time of injury; patients who have received and/or are receiving blood products
- Neurologic compromise; paralysis
- Smoke inhalation with any of the above criteria
- 2\textsuperscript{nd} and 3\textsuperscript{rd} degree burns with >30\% TBSA burnt
- Penetrating wounds to the head, neck, torso, abdomen, thigh, buttocks, or 2 proximal upper extremities
- Limb-threatening injuries as evidenced by: amputation, near amputation, degloving injury (any of these to more than fingers or toes); signs of decreased perfusion including absent pulse, dusksiness/cyanosis, coolness, delayed capillary refill, paralysis
- Consider high-risk mechanisms of injury, including: ejection from vehicle and/or death of occupant in the same vehicle
- Any other reason the surgical trauma attending, ED attending, TNL, ED charge nurse or EMS providers believe the patient requires resources of a level 1 trauma alert

Criteria for a level 2 trauma are listed below:

- Neurologic injury, as evidenced by: combative, disorientation, or confusion
- Blunt abdominal trauma with suspicion for intra-abdominal injury: abdominal pain and/or tenderness, or abdominal bruising or seat-belt marks
- Penetrating wounds through 2 or more distal extremities other than fingers and toes
- 2\textsuperscript{nd} and 3\textsuperscript{rd} degree burns with 15-30\% TBSA burnt
- Suspected or confirmed femur fracture with high risk mechanism of injury (see below)
• Transfer patients with high-risk injuries, including but not limited to: Head injury (open or depressed skull fracture, intracranial bleed), thoracic injury (pulmonary contusion), abdominal injury (known or suspected intra-abdominal injury), orthopedic injury, complex pelvic fractures
• Consider trauma alert for high-risk mechanisms of injury, such as:
  o Struck, dragged, or run over by a vehicle
  o Motor vehicle collision (MVC) with high speed impact or rollover of vehicle
  o Falls > 20 feet in height
  o Motorized cycle/dirt bike/bicycle
  o ATV (all-terrain vehicle)
• Any other reason the ED attending, TNL, ED charge nurse, or EMS providers believe the patient requires resources of a level 2 trauma alert

Critically ill children admitted to the PICU or burn/trauma units are assigned a trauma level based on the above criteria.

**Nutrition Assessment for Critically Ill Children**

Nutrition assessment is the first thing that must occur in order for an RD to develop an appropriate intervention and monitoring plan. A thorough nutrition assessment includes analysis of laboratory values, which may be difficult to interpret in patients experiencing a metabolic response to stress and injury. Albumin is a poor indicator of nutrition status because there is a shift in hepatic synthesis compared to normal function [12]. Prealbumin is only a useful indicator of nutrition status if it is analyzed in comparison to C-reactive protein (CRP). For example, if a patient has a low level of prealbumin and an elevated level of CRP, it indicates a stress response and is not related to nutrition status [12]. When CRP is normal and prealbumin is low, this could indicate that current nutrition therapy is insufficient [12]. Assessment should also include other lab values including electrolytes, blood urea nitrogen (BUN), creatinine, and blood glucose.
Client history is the next important component of a thorough nutrition assessment. Past medical history could include birth weight and length, prematurity, history of chronic disease, medical history, nutrition history (malnutrition, obesity, or use of nutrition support), surgical history, and social history. A food and nutrition-related history is often included in an assessment of a critically ill patient. In infants, RDs must assess the type, frequency, and amount of breast or formula feedings. Food allergies or sensitivities, use of supplements, or use of alternative therapies should also be documented. If the patient is on home EN, information must be gathered on the patient’s regimen. A detailed diet history should be obtained in children with severe malnutrition, obesity, or growth problems at admission.

Anthropometric measurements should be taken during assessment. Body composition changes occur rapidly during critical illness and the related stress response. Measurements including weight, height, and head circumference should occur soon after admission to assess baseline nutrition status [12]. While interpreting anthropometric measurements, it is important to note that fluid shifts are common during a stress response [12].

**Nutrition Recommendations for Critically Ill Children**

After the thorough nutrition assessment is completed, a nutrition care plan can be developed. Nutrition interventions first need to target the nutrition diagnosis of the highest priority. For example, if a patient has had little to no nutritional intake for several days, the nutrition plan must include recommendations for energy and protein needs and a plan to initiate enteral or parenteral nutrition support. Other nutrition interventions
could include recommending indirect calorimetry, reducing or increasing an enteral feeding rate, documenting energy balance and comparing intake to recommendations.

Nutrition intervention goals can keep the nutrition care plan on track and direct the monitoring plan. General goals for PICU patients include timely delivery of nutrition, proper route of nutrition support, improved disease outcomes, minimized complications of over- or underfeeding, and recurrent reassessment [12].

Energy requirements can be determined by using predictive equations like the Schofield or World Health Organization (WHO) formulas or indirect calorimetry [12]. Indirect calorimetry functions by measuring oxygen concentration of each inspired breath and carbon dioxide concentration of each expired breath. Then, a regression equation is used to calculate a 24-hour energy expenditure measurement. The measured REE is based on the clinical condition of the patient (such as mechanically ventilated, sedated, and so on) and if the patient’s status changes, the results are no longer valid [12].

Current predictive equations commonly used in a critically ill child often lead to over- or underfeeding [55]. Despite knowledge that these equations are often inaccurate, indirect calorimetry is rarely used in practice. This is likely due to limitations including: the difficulty of timing the procedure, inaccurate results due to air leaks that commonly occur in intubated patients, body weight minimum requirements in order for the metabolic cart to be accurate, the need for the patient to be stable and on continuous feedings for at least 12 hours prior to testing (enteral feedings are often interrupted in the PICU), limited resources of some hospital departments, time needed to calibrate the metabolic cart, time required for testing (30 minutes), and the need for trained staff to
perform and interpret the results [55]. Despite these limitations, Burritt et al. [55] recommend routine use of indirect calorimetry in the PICU to measure REE, especially if metabolic derangements are suspected. Using case studies, they found that commonly used predictive equations for REE in this population led to measurements that were far different from measurements taken using indirect calorimetry [55]. The variation in REE measurements using various equations and indirect calorimetry for a case study are located in table 2.4 below.

<table>
<thead>
<tr>
<th>Predictive Equations</th>
<th>Measured REE/Recommended kcal per day</th>
<th>% of Measured REE</th>
</tr>
</thead>
<tbody>
<tr>
<td>World Health Organization (WHO)</td>
<td>2016</td>
<td>166%</td>
</tr>
<tr>
<td>Schofield</td>
<td>1996</td>
<td>164%</td>
</tr>
<tr>
<td>Recommended Dietary Allowance (RDA)</td>
<td>3510</td>
<td>289%</td>
</tr>
<tr>
<td>Total Energy Expenditure (TEE)</td>
<td>2672</td>
<td>220%</td>
</tr>
<tr>
<td>16.1kcal/cm height</td>
<td>2496</td>
<td>205%</td>
</tr>
<tr>
<td>Indirect Calorimetry</td>
<td>1216</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 2.4: Predictive Equations and Indirect Calorimetry (Modified from [55])

Once REE has been measured by indirect calorimetry or estimated using predictive equations, total energy requirements should be determined. Physical activity contributions should be considered in healthy children, but more research is needed to determine physical activity effects in a critically ill child [12]. Increased energy expenditure can occur in patients with greater lean body mass, presence of fever, increased movement, certain medications, or use of bolus feeds [12]. Reduced energy
expenditure can occur in patients with greater fat mass, on mechanical ventilation, certain medications, deep sedation, decreased movement, or growth cessation [12].

Once energy needs have been calculated, macronutrient distribution can then be determined. As previously mentioned, protein needs are higher in a critically ill child. During a catabolic state, the goal of nutrition therapy is to decrease the amount of protein losses until the body resumes the processes of anabolism. Evidence-based data are insufficient to provide specific protein recommendations in a critically ill child [12]. Suggested guidelines are as follows: 2-3 g/kg per day in children ages 0-2 years, 1.5-2 g/kg per day in children ages 2-13 years, and 1.5 g/kg per day for children ages 13-18 years [35].

After protein recommendations are determined, the remaining energy needs are met with carbohydrates and lipids. Carbohydrates should be provided in amounts that reduce muscle catabolism while avoiding hyperglycemia and liver dysfunction [12]. Current research recommends providing glucose at a rate of 5-6 mg/kg/minute or providing 60 percent of non-protein energy as glucose [56, 57]. Lipid requirements are based on preventing an essential fatty acid deficiency which can be accomplished by providing as little as 5 percent of total energy as lipids. Current guidelines recommend providing 40 percent of non-protein energy as fat [12].

The final component of nutrient needs that must be considered is the provision of vitamins and minerals. Research is limited in this area so micronutrient demands in critically ill children are difficult to predict, but are necessary to prevent poor outcomes. During a stress response, rapid cellular turnover increases the demand for several
vitamins including antioxidants. Current recommendations suggest that patients with high stress illness or injury or a lengthy stay in intensive care should be monitored for development of vitamin or mineral deficiencies and be supplemented as needed [52].

RDs must determine fluid and electrolyte requirements in a critically ill child as well. Fluid requirements are based on size, diagnosis, and treatment of a patient. Critically ill children usually do not have normal rates of water evaporation and do not have the same maintenance fluid requirements [12]. Fluid maintenance calculations are as follows:

- <1kg: weight (kg) x 125 mL/kg/day
- 1-10kg: weight (kg) x 100 mL/kg/day
- 11-20kg: 50 mL/kg/day for each kg over 10 kg + 1,000 mL
- >20kg: 20 mL/kg/day for each kg over 20 kg + 1,500 mL

Electrolytes fluctuate rapidly in critically ill children so management is usually done best by intravenous fluids. The requirement for sodium, potassium, and chloride in children younger than 3 years of age is 3-5 mEq/kg per day, and for children older than 3 years of age is 2-5 mEq/kg per day [12].

**Nutrition Support for Critically Ill Children**

A majority of children in the PICU require nutrition support to meet energy and nutrient needs in place of an oral diet. After nutrition assessment has been performed, the first step in implementing a care plan that involves nutrition support is determining the appropriate type. Current guidelines recommend EN over PN if there is a functioning GI tract [8, 53]. Indications for EN include a functioning GI tract, the need to supplement an oral diet, prolonged NPO (nothing by mouth) status, oromotor dysfunction, altered neurological status, or respiratory failure [12]. Contraindications to EN include GI...
obstruction, prolonged ileus, peritonitis, severe vomiting or diarrhea, enterocutaneous fistula, or hemodynamic instability [12]. Nutrition support in the PICU is often interrupted due to medical testing, fluid restrictions, and perceived intolerances, so it is important for nutrition practitioners to monitor energy balance and communicate with the health care team.

After deciding to implement EN, the next step in intervention is to decide which route (gastric or post-pyloric) is most appropriate. There is currently little data to support one route over the other in critically ill children [12]. However, children with EN via a post-pyloric feeding tube are often able to achieve and maintain target goal rates sooner [58]. Meert et al. [59] found that children on mechanical ventilation fed via the post-pyloric route were able to achieve a greater percentage of their caloric goal. Unfortunately, there were still complications from the feedings such as aspiration, vomiting, diarrhea, and abdominal distention [59]. Therefore, further research is needed to determine if one approach is better than the other.

Once route is chosen, early nutrition support initiation is recommended. Early initiation of EN is considered safe and well tolerated and can even improve patient outcomes. Many PICU departments begin EN within 48-72 hours following admission [12]. Delaying nutrition support can lead to significant energy imbalance. As a result, RDs should be consulted and EN initiated within 24 hours of admission in critically ill pediatric patients.

After determining type, route, and deciding to initiate early, the type of formula must be determined. A majority of children tolerate a polymeric, age-appropriate formula
The use of adult formulas in pediatric patients is not typically recommended due to the higher energy and protein concentration per liter, and the resultant high renal solute loads and osmolality (see Appendix A) [12]. The higher osmolality and renal solute load of adult formulas may be poorly tolerated by a child and result in increased complications and inadequate energy intake. However, the use of adult formulas may be considered for critically ill children who are ages 10 years and older to provide adequate energy during periods of volume restriction [12]. RDs recommend the brand of EN formula that will best serve the individual patient’s needs while minimizing GI complications. There is insufficient data to determine if specialized formulas with increased antioxidants and omega-3 fatty acids are beneficial to the pediatric population [54]. Limited data support the use of glutamine supplementation in patients requiring long-term nutrition support to help prevent GI mucosal atrophy but more research is needed to make an evidence-based guideline [54].

Decisions must also be made on whether to provide bolus or continuous feeds. Some children tolerate bolus feeds but a continuous drip infusion is preferred in patients with complications such as vomiting or gastric distention. Current guidelines suggest that enteral feedings should be started at a rate of 0.5-1 ml/kg/hr, and advanced by 0.5-1 ml/kg/hr every 4 to 24 hours, but RDs can modify this based on the needs of each individual child [12]. Further research is needed on determining appropriate EN rate advancement guidelines in critically ill children.

Despite the creation of care plans that include EN regimens based on nutrient and energy needs, it is common for EN to be interrupted in critically ill patients. Feedings can
be stopped for elective procedures, unplanned interventions, or diagnostic tests that require a fasting state in a patient. Avoidable EN interruptions include suboptimal prescription, failure to initiate EN early, or perceived feeding intolerance [60]. Mehta et al. [60] found that more than half of all EN interruptions were considered avoidable either because there was an unnecessarily long duration of fasting or the reasons for stopping the feeding were unclear. Furthermore, patients with avoidable interruptions required a longer period of time to reach caloric goals, and were three times more likely to be started on PN [60]. They also found that 43 percent of patients with post-pyloric feedings had interruptions due to tube malposition, obstruction, and placement failure [60]. These patients ended up having a longer length of stay in critical care as a result [60]. In this study, perceived intolerance based on diarrhea, gastric residual volumes, or abdominal distention, was the number one reason the health care team stopped EN [60].

Despite the importance of implementing nutrition therapy, complications can occur with both enteral and parenteral nutrition in the critically ill patient. EN can produce gastric complications including increased gastric residual volumes, diarrhea, nausea, vomiting, and abdominal distention. PN may have complications such as increased risk of atrophy of intestinal mucosa, liver abnormalities, hyperglycemia, and risk of infection [53]. Placement of EN is typically in the stomach because it is most similar to the natural physiology of the human body. However, nasogastric enteral feeds may not be tolerated as well as post-pyloric enteral feeds because patients often have decreased gastric motility related to the use of drugs while in critical care [61]. This can lead to increased gastric residual volumes and a higher risk of aspiration pneumonia.
Therefore, further research is needed to determine enteral feeding protocols that best reduce complications in pediatric patients.

**Nutrition Monitoring/Evaluation for Critically Ill Children**

Reassessment must occur regularly to ensure that nutrition goals are being met and the nutrition care plan is adequate. Outcomes can be measured in biochemical data from lab tests such as prealbumin, CRP, and electrolytes. Anthropometric measurements such as weight and height can also be used to assess adequacy of nutrition therapy. RDs must use these measurements and evaluate the nutrition interventions and goals to determine if a change must be made in the care plan.

**Summary**

Research has led to the development of the current EN protocol for pediatric patients. Current evidence has established that early initiation of nutrition support leads to improved outcomes, indirect calorimetry is the most accurate method of estimating energy requirements, and EN is preferred over PN in critically ill pediatric patients [3, 4, 8, 9, 19-27, 38, 47-49, 55, 58]. Studies have been conducted on determining the appropriate formula, route of feeding (gastric or post-pyloric), and potential causes of GI complications related to nutrition support, but evidence-based guidelines have not yet been determined in these areas [8, 18, 42, 43, 45, 46, 50, 51, 53, 58-61]. Furthermore, research has not yet determined if enteral feeding rate advancements or volumes have an impact on the incidence of GI complications in pediatric patients. Therefore, this study was conducted to focus on these areas and also to describe the difference between RD
recommendations and actual implementation during the provision of nutrition support in pediatric burn and trauma patients.
Chapter 3: Methodology

Background

Nutrition therapy for pediatric patients who have experienced a severe burn or trauma should provide adequate energy and protein for the body to heal while simultaneously minimizing undesirable gastrointestinal (GI) complications. Registered dietitians (RDs) prescribe enteral nutrition (EN) based on feeding protocols established through evidence-based research. Feeding protocols include guidelines that address route of nutrition support, estimation of nutrient needs, preferred enteral formulas, timing of EN initiation, and EN rate advancement recommendations. The main purpose of this study was to determine if EN practices outside of protocol led to increased GI complications.

Pediatric patients are not fully developed and have several physiological differences compared to adult patients. The immature GI system of children must be considered when RDs determine the prescription for EN and the rate advancement schedule for these feedings. GI complications may occur if the feeding volume is too large or is increased too rapidly. There is limited research on what constitutes an excessive feeding volume or rapid rate advancement in critically ill pediatric patients. This study focused on current enteral feeding practices, whether they were outside of feeding protocols recommended by RDs, and whether these practices resulted in GI complications.
complications. Qualitative analysis of information gathered from medical charts was performed for this study.

**Research Questions**

1. What percentage of patients of the sample received a dietitian consult for nutrition support within 24 hours of admission?

2. What is the difference between the daily volume of enteral feeding recorded on intake/output records compared to the daily volume of enteral feeding prescribed by the registered dietitian?

3. Is there an association between intolerance, as measured by diarrhea, vomiting, abdominal distention and excessive residuals, and enteral nutrition feeding rate increases that are greater than recommendations from the registered dietitian?

4. Is there a correlation between intolerance, as measured by diarrhea, vomiting, abdominal distention and excessive residuals, and the number of formula changes, with change defined as a switch in the brand or type (adult or pediatric) of formula?

5. Do pediatric burn and trauma patients with GI complications have a greater hospital length of stay when compared to patients without GI complications?

**Research Design**

The design of this study was a retrospective medical record review for a sample of burn and trauma patients admitted to a children’s hospital in Columbus, Ohio. The data for this study was gathered from electronic medical records of patients admitted to the Pediatric Intensive Care Unit (PICU) or Burn/Trauma Unit from October 2008 through July 2010. This study was an exploratory study aimed at investigating whether EN
recommendations from the RD were followed in practice and whether or not actual EN procedures utilized by the medical staff had an impact on GI complications. Although the focus of this study is narrow, its implications may have a greater impact on patient outcomes in critically ill children.

A retrospective study design uses existing data that have been recorded for reasons other than research. In this study, the data being reviewed are medical records used in the hospital for patient care. Retrospective study designs can be useful as pilot studies which can help focus research questions, determine appropriate sample sizes, and identify feasibility issues for a future prospective study. Advantages of this study design include that they are inexpensive, use existing records, and allow for study of rare occurrences [62]. Retrospective studies can be of 3 different types: case report, case series, and case-control. This study is a case series type with the intention of reporting on multiple similar cases.

Limitations

There are limitations in this study because it is an exploratory study using a retrospective chart review design. Also, collecting information on the variables to be analyzed is challenging in the hospital setting because medical staff must keep accurate records or the data is not useful. For example, if a member of the medical team fails to record an incident of diarrhea in a patient’s medical chart, this information would be unavailable for analysis. As a result of this missing information, outcomes of the study may be affected. In addition, some of the patients studied have co-morbid conditions and
socioeconomic factors that may play a role in the variables being investigated. For the purposes of this study, no other conditions and factors were included into the analyses.

Using a retrospective chart review design can also come with limitations. One issue is the need for the investigator to depend on the availability and accuracy of medical records. Also, in a case series approach, selection bias can occur because the cases studied are often self-selected. A retrospective case series also lacks a control. Other potential disadvantages of this research design is that it is difficult to provide randomization or utilize blinding to reduce bias, it may be difficult to access important information due to institutional regulations, it is difficult to establish cause and effect, and the results are usually only able to produce a hypothesis [62]. In this particular study, it is necessary to use a retrospective approach in order to focus research questions and determine a potential design for a prospective study.

**Sample Selection**

The sample consists of patients admitted to the hospital who meet the inclusion criteria for the study. The inclusion criteria are admission to a Midwestern children’s hospital from October 2008 through July 2010, admission to the Burn/Trauma unit or PICU, placed on EN any time during treatment, and survival of the injury. A list of patients admitted during the specified timeframe was generated. The list of patients was numbered and a random number generator was used to determine the order that the patient charts would be investigated. Patients not meeting the inclusion criteria were excluded from the study. Upon review of the medical charts, a sample of 60 patients
composed of 30 burn patients and 30 trauma patients were included in the analysis of this study.

**Data Analysis and Instrumentation**

Data for analysis were collected from each patient’s medical record in the online charting system at a Midwestern children’s hospital. The collected data were organized into a spreadsheet that was created specifically for this study (see Appendix B). Information gathered from the patient medical chart included demographic and descriptive information, RD recommendations for EN, physician EN notes and orders, actual EN intakes, and any notes of GI complications including vomiting, diarrhea, abdominal distention, or increased gastric residual volumes.

Demographic and descriptive information was recorded from the RD’s initial note including: admitting diagnosis, age, past medical history, weight at admission, and percent TBSA. Length of hospital stay was recorded from the patient summary and a row was created for each day to record data throughout the patient’s stay. To record whether the enteral feeding was started within 24 hours of admission, the intakes/outputs section of the chart was reviewed to locate when feeding actually began. The order history was used to determine if an RD was consulted within 24 hours of admission. EN orders and physician notes were reviewed to determine the type of feeding tube used, whether or not PN was utilized during the patient’s stay, and what trauma level the patient was categorized into based on the severity of injury.

The next section of data collected involved reviewing EN orders, physician notes, and RD notes. All EN orders from the medication history section of the chart were
recorded. RD notes were reviewed to copy EN recommendations and changes in those recommendations throughout the patient’s stay. Any recorded weights were also taken from the RD’s note. Physician and resident notes were reviewed to copy recommendations or comments related to EN throughout the patient’s stay.

The final section of the data collection included the actual EN intakes and any GI complications. First, a column was created with recommended volume of EN intake based on the RD’s notes. Then, the intakes/outputs section of the chart was reviewed to record the actual volume intake, enteral feeding infusion rate, and brand/type of formula for each day of the patient’s hospital stay. A column was created to record whether the EN feedings were advanced per RD recommendations or not. This was determined by reviewing the recommendations from the RD on how much to increase the feedings until goal rate is achieved, and comparing this to the actual feeding rate advancements implemented until goal rate was achieved. A column was created to indicate if there was a change in the brand or type of formula during the patient’s hospital stay. Also recorded from the intakes/outputs section were notes of vomiting (noted as emesis in outputs), diarrhea (noted as loose stool in outputs), or gastric residuals (noted in outputs). Gastric residuals were considered high if the feedings were stopped by the medical staff in relation to this observation. There was no established protocol for what to consider excessive gastric residuals in critically ill children in this Midwestern children’s hospital. Abdominal distention was recorded from physician and resident notes. Once information was collected for each patient for each day of their hospital stay, data were collapsed to
ensure that only one row of data existed for each subject to account for differing lengths of stay.

The collected data was then analyzed in order to answer and discuss the proposed research questions. Descriptive statistics using SPSS 20.0 (IBM©, Chicago, IL, 2012) were utilized to determine the number of patients and percentage of the sample who received an RD consult within 24 hours of admission as well as the differences between RD recommended daily volumes and actual daily volume intakes. A chi-square test of independence was utilized to explore the association between EN rate advancement practices and the occurrence of GI complications. Each GI complication was analyzed separately. Linear regression analysis and a chi-square test of independence were utilized to explore the relationship between the number of formula changes and the occurrence of GI complications. Once again, GI complications were analyzed separately. Linear regression analysis was utilized to explore the relationship between the occurrence of GI complications and hospital length of stay.
Chapter 4: Results and Discussion

Introduction

A retrospective chart review of 60 pediatric burn and trauma patients was conducted to determine if there is an association between gastrointestinal (GI) complications and formula brand or rate changes outside of standard protocol. A list of 391 patients was generated between October 2008 through July 2010 and of that list, 30 burn patients and 30 trauma patients were randomly selected to be included in the study.

Data collected included age at admission, length of stay, admitting diagnosis, percent total body surface area (TBSA) in burn patients, trauma level, past medical history, initial recorded weight and any recorded weight during the patient’s stay, whether the enteral feeding began within 24 hours of admission or not, route of enteral nutrition (EN) used, whether the patient received parenteral nutrition (PN) during their hospital stay or not, whether a registered dietitian (RD) was consulted within 24 hours of admission or not, EN orders from the medication history, RD recommendations for EN throughout the patient’s stay, physician notes related to EN throughout the patient’s stay, RD recommended daily volume of EN, recorded daily volume intake, recorded daily feeding rate, recorded daily brand or type of enteral formula, and recorded daily incidents of diarrhea, vomiting, excess gastric residuals, and abdominal distention. These variables were used to provide a description of each patient, a description of RD recommendations,
and information about actual EN intake. These variables were also used to identify any
association between GI complications and EN practices outside of RD recommendations
based on protocol. Table 4.1 below lists characteristics of the sample patients used in the
analysis.

<table>
<thead>
<tr>
<th>Patient Demographics (n = 60)</th>
<th>Mean</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Patient Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (months)</td>
<td>70.9</td>
<td>2.0</td>
<td>261.0</td>
<td>-</td>
</tr>
<tr>
<td>Trauma Level:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not Classified</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>7</td>
</tr>
<tr>
<td>Level Below 1 or 2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>13</td>
</tr>
<tr>
<td>Level 2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>12</td>
</tr>
<tr>
<td>Level 1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>28</td>
</tr>
<tr>
<td>% TBSA (burns only)</td>
<td>17.2%</td>
<td>4.0%</td>
<td>80.0%</td>
<td>-</td>
</tr>
<tr>
<td>Length of Stay (days)</td>
<td>27.3</td>
<td>2.0</td>
<td>121.0</td>
<td></td>
</tr>
<tr>
<td>Duration of EN (days)</td>
<td>19.6</td>
<td>1.0</td>
<td>87.0</td>
<td></td>
</tr>
<tr>
<td>Adm. Weight (kg)</td>
<td>27.0</td>
<td>4.7</td>
<td>93.0</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 4.1: Characteristics of Patient Sample

The primary research questions were:

1. What percentage of patients of the sample received a dietitian consult for nutrition
   support within 24 hours of admission?

2. What is the difference between the daily volume of enteral feeding recorded on
   intake/output records compared to the daily volume of enteral feeding prescribed by
   the registered dietitian?
3. Is there an association between intolerance, as measured by diarrhea, vomiting, abdominal distention and excessive residuals, and enteral nutrition feeding rate increases that are greater than recommendations from the registered dietitian?

4. Is there a correlation between intolerance, as measured by diarrhea, vomiting, abdominal distention and excessive residuals, and the number of formula changes, with change defined as a switch in the brand or type (adult or pediatric) of formula?

5. Do pediatric burn and trauma patients with GI complications have a greater hospital length of stay when compared to patients without GI complications?

**Results**

Descriptive statistics were used to provide an overview of current EN practices in a Midwestern children’s hospital and are listed in table 4.2 below.
### Table 4.2: Description of Current EN Practices

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>% of Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>RD consult within 24 hours of admission?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>30</td>
<td>50.0%</td>
</tr>
<tr>
<td>No</td>
<td>30</td>
<td>50.0%</td>
</tr>
<tr>
<td>EN started within 24 hours of admission?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>22</td>
<td>36.7%</td>
</tr>
<tr>
<td>No</td>
<td>38</td>
<td>63.3%</td>
</tr>
<tr>
<td>Days until first feeding:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-5</td>
<td>54</td>
<td>90.0%</td>
</tr>
<tr>
<td>6-10</td>
<td>4</td>
<td>6.7%</td>
</tr>
<tr>
<td>11-15</td>
<td>1</td>
<td>1.7%</td>
</tr>
<tr>
<td>16-20</td>
<td>1</td>
<td>1.7%</td>
</tr>
<tr>
<td>EN rate advanced per RD recs?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>41</td>
<td>68.3%</td>
</tr>
<tr>
<td>No</td>
<td>19</td>
<td>31.7%</td>
</tr>
<tr>
<td>Number of formula changes:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>39</td>
<td>65.0%</td>
</tr>
<tr>
<td>1-5</td>
<td>19</td>
<td>31.7%</td>
</tr>
<tr>
<td>6-15</td>
<td>2</td>
<td>3.3%</td>
</tr>
</tbody>
</table>

Analysis of variables utilizing descriptive statistics was used to answer research questions 1 and 2. Of the 60 patients in the sample, 30 patients (50%) received a dietitian consult within 24 hours of admission while the other 30 patients did not. Analysis of volume intake for the sample revealed daily intakes that were both over and under volumes recommended by the RD. Provision of daily volumes that exceeded recommendations by the RD occurred in 40 of the 60 patients (66.7%) with a mean duration of 11.91% of hospital length of stay. In patients receiving more than recommended throughout their entire stay (n=6), the mean daily amount above recommendations was 21.43 mL. Provision of daily volumes that were below
recommendations by the RD occurred in 59 of the 60 patients (98.3%) with a mean
duration of 50.3% of hospital length of stay. In patients receiving less than recommended
throughout their entire stay (n=54), the mean daily amount below recommendations was
379.64 mL. These differences can be viewed in table 4.3 below.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily Amount Above Recs (mL) (n=6)</td>
<td>21.43 (± 12.56)</td>
</tr>
<tr>
<td>Number of Days with Volumes Above Recs (n=60)</td>
<td>3.68 (± .74)</td>
</tr>
<tr>
<td>Percentage of Stay with Volumes Above Recs (n=60)</td>
<td>11.91% (± 1.75%)</td>
</tr>
<tr>
<td>Daily Amount Below Recs (mL) (n=54)</td>
<td>379.64 (± 28.80)</td>
</tr>
<tr>
<td>Number of Days with Volumes Below Recs (n=60)</td>
<td>14.17 (± 1.93)</td>
</tr>
<tr>
<td>Percentage of Stay with Volumes Below Recs (n=60)</td>
<td>50.30% (± 2.88%)</td>
</tr>
</tbody>
</table>

Table 4.3: Difference between RD Recommended Daily Volume and Actual Intake
The third research question was answered using a chi-square test of independence to examine the relationship between the occurrence of GI complications in patients who received EN rate advancements per RD recommendations and those who did not. Each GI complication (diarrhea, vomiting, abdominal distention, and excess gastric residuals) was analyzed separately. The relationship between patients who received EN rate advancements per RD recommendations and those who did not, in regards to the occurrence of diarrhea was not significant, $X^2 (1, N = 60) = 2.67, p = .10$. The relationship between the two groups in regards to the occurrence of vomiting was not significant, $X^2 (1, N = 60) = 2.67, p = .10$. The relationship between the two groups in regards to the occurrence of excess residuals was significant, $X^2 (1, N = 60) = 5.89, p = .02$. The relationship between the two groups in regards to the occurrence of abdominal distention was significant, $X^2 (1, N = 60) = 4.45, p = .04$. These results indicate that incidents of both diarrhea and vomiting are unlikely to be related to providing EN rate advancements more rapidly than recommended by the RD. These results also indicate that incidents of both abdominal distention and excess gastric residuals are likely to be related to providing EN rate advancements more rapidly than recommended by the RD. Table 4.4 below combines the contingency tables used for the chi-square analysis for each GI complication.
The fourth research question was analyzed using linear regression analysis to determine if the number of formula changes predicted the occurrence of GI complications. Each GI complication was evaluated separately. The linear regression analysis revealed that the number of formula changes did not predict the occurrence of diarrhea, $r^2=.05$ (adjusted $r^2=.03$), $F(1, 58)=2.76$, $p=.10$, the number of formula changes did not predict the occurrence of vomiting, $r^2=.00$ (adjusted $r^2=-.01$), $F(1, 58)=.21$, $p=.65$, the number of formula changes did not predict the occurrence of excess gastric residuals, $r^2=.01$ (adjusted $r^2=-.01$), $F(1, 58)=.29$, $p=.59$, and the number of formula changes did not predict the occurrence of abdominal distention, $r^2=.00$ (adjusted $r^2=-.02$), $F(1, 58)=.00$. 

<table>
<thead>
<tr>
<th></th>
<th>No</th>
<th>Yes</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diarrhea?</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Follow RD Recs for Rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Advancement?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>3</td>
<td>16</td>
<td>19</td>
</tr>
<tr>
<td>Yes</td>
<td>15</td>
<td>26</td>
<td>41</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>42</td>
<td>60</td>
</tr>
<tr>
<td><strong>Vomiting?</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Follow RD Recs for Rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Advancement?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>3</td>
<td>16</td>
<td>19</td>
</tr>
<tr>
<td>Yes</td>
<td>15</td>
<td>26</td>
<td>41</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>42</td>
<td>60</td>
</tr>
<tr>
<td><strong>Excess Residuals?</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Follow RD Recs for Rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Advancement?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>15</td>
<td>4</td>
<td>19</td>
</tr>
<tr>
<td>Yes</td>
<td>40</td>
<td>1</td>
<td>41</td>
</tr>
<tr>
<td>Total</td>
<td>55</td>
<td>5</td>
<td>60</td>
</tr>
<tr>
<td><strong>Abdominal Distention?</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Follow RD Recs for Rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Advancement?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>13</td>
<td>6</td>
<td>19</td>
</tr>
<tr>
<td>Yes</td>
<td>37</td>
<td>4</td>
<td>41</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>10</td>
<td>60</td>
</tr>
</tbody>
</table>

Table 4.4: Chi-Square Analysis on Rate Advancement and GI Complications
\[ p = .98. \] The results for each GI complication are shown in figure 4.1, figure 4.2, figure 4.3, and figure 4.4 below.

Figure 4.1: Relationship between Formula Changes and Diarrhea
Figure 4.2: Relationship between Formula Changes and Vomiting
Figure 4.3: Relationship between Formula Changes and Excess Residuals
In addition to the linear regression analysis, the fourth research question was also analyzed using a chi-square test of independence to examine the relationship between the number of formula changes (categorized into 3 groups) and the occurrence of GI complications. Each GI complication was analyzed separately. The relationship between the number of formula changes and the occurrence of diarrhea was not significant, \( X^2 (1, N = 60) = 4.10, p = .13 \). The relationship between the number of formula changes and the occurrence of vomiting was not significant, \( X^2 (1, N = 60) = 2.97, p = .23 \). The
relationship between the number of formula changes and the occurrence of excess residuals was not significant, $X^2 (1, N = 60) = .07, p = .97$. The relationship between the number of formula changes and the occurrence of abdominal distention was not significant, $X^2 (1, N = 60) = 5.12, p = .08$. These results indicate that incidents of GI complications are unlikely to be related to the number of formula changes during a patient’s hospital stay. Table 4.5 below combines the contingency tables used for the chi-square analysis for each GI complication.
<table>
<thead>
<tr>
<th>Diarrhea?</th>
<th>No</th>
<th>Yes</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Formula Changes</td>
<td>0</td>
<td>15</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>&gt;1</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>42</td>
<td>60</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vomiting?</th>
<th>No</th>
<th>Yes</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Formula Changes</td>
<td>0</td>
<td>13</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>&gt;1</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>42</td>
<td>60</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Excess Residuals?</th>
<th>No</th>
<th>Yes</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Formula Changes</td>
<td>0</td>
<td>36</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>&gt;1</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>55</td>
<td>5</td>
<td>60</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Abdominal Distention?</th>
<th>No</th>
<th>Yes</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Formula Changes</td>
<td>0</td>
<td>33</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>&gt;1</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>10</td>
<td>60</td>
</tr>
</tbody>
</table>

Table 4.5: Chi-Square Analysis on Formula Changes and GI Complications

The fifth research question was analyzed using linear regression analysis to determine if the occurrence of GI complications predicted a prolonged patient hospital length of stay. The linear regression analysis revealed that the number of days patients experienced any GI complications predicted an increased length of stay, $r^2=.73$ (adjusted $r^2=.73$), $F(1, 58)=159.01$, $p=.01$, but that the percentage of stay patients experienced any
GI complications did not predict an increased length of stay, $r^2=.02$ (adjusted $r^2=.01$), $F(1, 58)=1.41$, $p=.24$. These results are displayed in figure 4.5 and figure 4.6 below.

Figure 4.5: Relationship between GI Complication (Number of Days) and Length of Stay
Discussion and Conclusion

When creating nutrition care plans for pediatric burn and trauma patients, RDs follow feeding protocols that utilize evidence-based guidelines. These guidelines state that early initiation of enteral feeding is both safe and effective in critically ill children. Therefore, feeding protocols at many hospitals recommend beginning EN within 24 hours of admission, and consulting an RD within 24 hours of admission in critically ill children.
Protocols at this hospital state that an RD should be consulted within 24 hours of admission for burn patients and within 72 hours of admission for trauma patients at level 3 nutritional risk. In this study, EN was started within 24 hours of admission in only 22 of the 60 patients and an RD was consulted within 24 hours of admission in 30 of the 60 patients. These results indicate that the feeding protocol at a Midwestern children’s hospital is not being followed consistently for pediatric burn and trauma patients.

In order to promote healing and growth, RDs determine appropriate EN daily volumes for each patient using estimated energy needs. Analysis of volume intake for the sample revealed daily intakes that were both over and under volumes recommended by the RD. The variations in daily recorded intakes reveal that pediatric burn and trauma patients may not be receiving adequate nutrition to promote healing and growth.

A major focus of this study was exploring the relationship between EN rate advancement practices or formula brand/type changes and resultant GI complications. Further research is needed to determine specific EN rate advancement guidelines in this population; however, current protocol recommends gradual advancement to goal rate as tolerated. Furthermore, current guidelines state that an age-appropriate polymeric formula is best tolerated by the pediatric population. In this study, RD recommendations for EN rate advancements were compared to actual recorded EN rate advancements, and results reveal that 19 of the 60 patients received more rapid rate advancements than recommended by the RD. In addition, there was a formula change at least one time in 21 of the 60 patients. These results indicate that RD recommendations are not being consistently followed in practice.
In this study, the occurrence of GI complications was compared between patients who had EN rates advanced per RD recommendations and patients who had EN rates advanced more rapidly. Results indicate that vomiting and diarrhea increased slightly when EN was advanced to goal rate more rapidly. However, this increase was not significant enough to indicate that rapid rate advancements were the only cause of increased vomiting and diarrhea. Results also indicate that abdominal distention and excess residuals increased when EN was advanced to goal rate more rapidly. These results were significant in suggesting that the rapid rate advancements may have been the cause of these GI complications. However, very few patients in the sample experienced excess residuals or abdominal distention at all, so further research is needed before conclusions can be drawn.

In this study, the relationship between GI complications and the number of formula changes was explored. The results indicate that there was no relationship between the number of formula changes and GI complications. However, it remains prudent to keep these patients on one formula throughout the duration of their nutrition support as long as it is tolerated in order to ensure nutrition therapy is adequate and effective.

Due to the daily monitoring of these patients by the RD, rapid rate advancements and inappropriate formula changes were corrected in a timely manner. This monitoring may have led to a reduction in the occurrence of GI complications related to improper EN feeding practices. While this practice is preferred to help improve patient outcomes, it may have had an impact on the results of this study.
Avoidance of GI complications is a major goal of nutrition therapy in pediatric burn and trauma patients. Increased GI complications may delay healing, increase a patient’s hospital length of stay, and therefore, contribute to poorer outcomes. In this study, the relationship between hospital length of stay and occurrence of GI complications was explored. Patients with GI complications tended to have longer hospital stays than patients without GI complications. However, this relationship does not imply cause and effect, as patients may simply have had more GI complications because they were in the hospital for a longer period of time. It is known that patients experiencing GI complications often do not receive adequate nutrition therapy to promote healing and growth, thus contributing to an increased hospital length of stay. As a result, it remains prudent to attempt to minimize GI complications in order to provide adequate nutrition therapy, and therefore, reduce hospital length of stay.

Overall, there is definite variation between RD recommendations for EN and actual practice in a Midwestern children’s hospital. RDs make recommendations from evidence-based guidelines which, according to current research, may improve patient outcomes. As a result, hospitals should implement feeding practices that reflect these guidelines in order to reduce morbidity and mortality. Furthermore, decreased tolerance to EN, as demonstrated by increased GI complications, may be related to improper EN practices in addition to other factors. Minimization of these GI complications should be one of the goals of nutrition therapy in critically ill children, to reduce hospital length of stay, and improve patient outcomes.
Limitations

This study focused primarily on EN practices as they relate to GI complications in the sample population. However, there were other factors in the patients’ medical charts that could have had an influence on GI complications, but were not considered in this study. Factors such as medications, other diagnoses, patient medical history, and weights were not considered in this study. These factors could play a role in the incidence of GI complications in this population. In addition, this study looked at patients of various ages and diagnoses. It is possible that patients of different ages and diagnoses respond differently to nutrition support. This researcher recognizes the need for further studies that include the factors that were not included in this study.

The number of patients included in this study could have been larger and, therefore, sample size is another limitation of this study. Stronger or different results may have been seen if there was a larger population studied. Along with the sample size, the collection of information from the progress notes of RDs and physicians is another limitation of this study. Medical charts are only complete if the medical staff members keep accurate records. For example, gastric residuals were not recorded consistently in the medical charts of these patients. As a result, human error must be considered when viewing the data analysis of this study. As a retrospective chart review, this study was only able to gather information that was at one time collected and documented on each patient. The results, therefore, could have been affected by missing information in the chart.
Future research should be conducted using prospective study methods that control or evaluate additional factors. Prospective studies could improve feeding protocols in pediatric burn and trauma patients by leading to the creation of guidelines that minimize GI complications and improve patient outcomes.
Chapter 5: A Retrospective Chart Review: Are Gastrointestinal Complications Associated With Formula Brand and Rate Changes Outside of the Standard Protocol in a Random Sample of Pediatric Burn and Trauma Patients?

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Abstract

Background: Adequate provision of nutrition support, based on recommendations from a registered dietitian (RD), is a crucial component of care of the critically ill pediatric patient. The goal of this study was to compare current enteral nutrition (EN) practices at a Midwestern children’s hospital to RD recommendations, and to explore the possible relationship between these variations and the occurrence of gastrointestinal (GI) complications. Methods: This retrospective review included pediatric burn and trauma patients who were admitted to a Midwestern children’s hospital between October 2008 and July 2010, and required EN at any time during their hospital stay. Differences between RD recommendations for EN and actual practices were analyzed, and the relationship between these differences and the occurrence of GI complications was explored. Descriptive statistics, chi-square analysis, and linear regression analysis using SPSS were used for data analyses. IRB approval was obtained. Results: 60 patients were included in this retrospective review. The number of patients who received an RD consult within 24 hours of admission was 30/60 (50%). Recorded daily volume intakes were both over and under volumes recommended by the RD. There was no significant association between the occurrence of diarrhea or vomiting and rapid EN rate advancements ($p > .05$). There was a significant association between the occurrence of abdominal distention or excess gastric residuals and rapid EN rate advancements ($p < .05$). There was no significant relationship between the occurrences of GI complications and the number of EN formula changes ($p > .05$). There was a significant relationship ($R^2 = .733$) between increased GI complications and increased hospital length of stay ($p < .05$). Conclusion:
Variation exists between RD recommendations for nutrition support and actual practice in pediatric burn and trauma patients. GI complications may increase as a result of this variation, in addition to other factors. Adherence to feeding protocols may help reduce unwanted GI complications while providing adequate nutrition therapy to improve patient outcomes in critically ill children.
Introduction

Nutritional status is an important determinant of health outcomes in children who have experienced burn or trauma injuries. Appropriate nutrition therapy, implemented by a registered dietitian (RD), is required to improve both morbidity and mortality in these critically ill children. Burn injuries are the 10th most common cause of accidental death in children and adults and each year about 11,000 children and adults are hospitalized for burns [1]. In addition, children with severe burn injuries have higher rates of mortality when compared to adults with similar injuries [2].

Proper nutritional intervention is important to reducing morbidity and mortality in pediatric burn and trauma patients because several physiological changes occur in response to severe injury. The body responds to injury by increasing catabolic processes and releasing stress hormones which can lead to loss of lean body mass [1, 3]. Specifically in patients with a burn injury, a prolonged period of hypermetabolism can occur in response to increased inflammation and evaporative heat loss from the burned tissue [1]. Increased catabolism is particularly problematic in the pediatric population because children are still in a period of growth and development. These physiological changes contribute to increased morbidity and mortality and require adequate nutrition therapy to support metabolic requirements as well as to modulate the stress response.

RDs make feeding recommendations for pediatric burn and trauma patients that are developed into feeding protocols based upon evidence-based guidelines. Current nutrition support guidelines from the American Society for Parenteral and Enteral Nutrition (ASPEN) aim to modulate the short-term stress response and minimize
potential long-term complications [4]. These guidelines state that nutrition assessment and intervention should be performed by an RD in order to treat and prevent malnutrition and minimize gastrointestinal (GI) complications [4]. Nutrition therapy should include adequate provision of energy, protein, vitamins and minerals to help slow or prevent lean muscle wasting, slow or prevent weight loss, promote wound healing, and modulate the inflammatory response [4]. Guidelines further state that enteral nutrition (EN) is the preferred mode of nutrition support during critical illness because it better maintains GI function, minimizes bacterial translocation, suppresses the hypermetabolic response to stress, enhances protein accrual, and is associated with decreased septic morbidity, metabolic derangements, reduced hospital length of stay, and higher survival rates [5-12]. Scott et al. [13] demonstrated that providing EN specifically within 24 hours of admission provided the most benefit. Due to these benefits, many hospitals institute a feeding protocol that requires RDs to be consulted, and EN to be initiated within 24 hours of admission for the critically ill patient.

Once EN has been initiated, guidelines indicate that continuous feedings are better tolerated than bolus feeds in the pediatric population [14]. A gradual advancement to goal rate is recommended to minimize GI complications, though further research is needed to determine specific EN rate advancement guidelines in pediatric burn and trauma patients [14]. Guidelines further state that most children tolerate a standard, age-appropriate, polymeric formula [14]. The use of adult formulas in pediatric patients is not typically recommended due to the higher energy and protein concentration per liter, and the resultant high renal solute loads and osmolality [14]. The higher osmolality and renal
solute load of adult formulas may be poorly tolerated by a child and result in increased complications and inadequate energy intake. RDs recommend the brand of EN formula that will best serve the individual patient’s needs while minimizing GI complications.

While it is important to provide adequate nutrition for healing and growth, overfeeding or providing EN outside of protocol can lead to unwanted complications. Overfeeding can lead to increased production of carbon dioxide, prolonged need for mechanical ventilation support, impaired liver function, hyperglycemia, and osmotic diuresis [4, 15]. Providing nutrition support to pediatric burn and trauma patients outside of standard protocol may lead to increased GI complications such as diarrhea, vomiting, abdominal distention, and increased gastric residual volumes. In addition to EN feeding practices, Lopez-Herce et al. [16] found that GI complications occurred more often in patients receiving epinephrine, sedatives, muscle relaxants, or continuous renal replacement therapy. Skillman et al. [17] further found increased GI complications in patients with hypokalemia or hypophosphatemia. Further research is needed to determine the impact of current EN practices in critically ill children on GI complications.

RDs have the expertise to provide nutrition support recommendations that help minimize the incidence of over- or underfeeding as well as reduce unwanted GI complications. Reducing complications may reduce hospital length of stay and decrease morbidity and mortality. The purpose of this study was to describe current enteral feeding practices in pediatric burn and trauma patients, to determine if these practices are outside of recommendations by an RD, and to determine whether or not these practices resulted in increased GI complications.
Methods

The design of this study was a retrospective medical record review for a randomized sample of burn and trauma patients admitted to a children’s hospital in Columbus, Ohio. The data for this study were gathered from electronic medical records of a sample of patients meeting the inclusion criteria. The inclusion criteria are admission to the Burn/Trauma or Pediatric Intensive Care Unit (PICU) from October 2008 through July 2010, placed on EN support at any time during the hospital stay, and survival of the injury. A list of patients admitted during the specified timeframe was generated and numbered. A random number generator was used to determine the order that the patient charts would be investigated. Patients not meeting the inclusion criteria were excluded from the study. Upon review of the medical charts, a sample of 60 patients composed of 30 burn patients and 30 trauma patients were randomly selected to be included in the analysis of this study. This study was an exploratory study aimed at investigating whether EN recommendations from the RD were followed in practice and whether or not actual EN procedures utilized by the medical staff had an impact on GI complications. Approval for this study was attained from the hospital’s Institutional Review Board (IRB).

Data for analysis was collected from each patient’s medical record in the online charting system at a Midwestern children’s hospital. Information gathered from the patient medical chart included demographic and descriptive information, dietitian EN recommendations and progress notes, physician EN orders, actual EN intakes, and any notes of GI complications including vomiting, diarrhea, abdominal distention, or increased gastric residual volumes. Information recorded from the RD notes included:
admitting diagnosis, age, past medical history, weight at admission, percent total body surface area (TBSA) burn, and EN recommendations throughout the patient’s hospital stay. Length of hospital stay was recorded from the patient summary. Information recorded from the intakes/output record included: whether or not the enteral feeding began within 24 hours of admission or not, actual volume intake, enteral feeding infusion rate, brand/type of formula for each day of the patient’s hospital stay, notes of vomiting (noted as emesis in output), diarrhea (noted as loose stool in output), or gastric residuals (noted in output). The presence of abdominal distention was recorded from physician and resident notes. The order history was reviewed to determine if an RD was consulted within 24 hours of admission, and to record actual EN orders throughout the patient’s stay. EN orders and physician notes were reviewed to determine the type of feeding tube used, whether or not parenteral nutrition was utilized during the patient’s stay, and what trauma level the patient was categorized into based on severity of injury. Physician notes related to EN were recorded as well.

Descriptive statistics using SPSS 20.0 (IBM©, Chicago, IL, 2012) were utilized to determine the number of patients and percentage of the sample who received an RD consult within 24 hours of admission as well as the differences between RD recommended daily volumes and actual intakes. A chi-square test of independence was utilized to explore the association between EN rate advancement practices and the occurrence of GI complications. Each GI complication was analyzed separately. Linear regression analysis and a chi-square test of independence were utilized to explore the relationship between the number of formula changes and the occurrence of GI
complications. Once again, GI complications were analyzed separately. Linear regression analysis was utilized to explore the relationship between the occurrence of GI complications and hospital length of stay.

**Results**

A total of 60 patients were included in this study with 30 patients admitted for a burn injury and 30 patients admitted with a non-burn traumatic injury. Patients ranged in age from 2 months to 21 years. An RD was consulted within 24 hours of admission in 50% (30/60) of the patients. The remaining 30 patients received an RD consult after this time or not at all. EN was started within 24 hours of admission in 36.7% (22/60) of the patients, and started after 24 hours in 63.3% (38/60) of the patients. The EN rate was advanced to goal rate per RD recommendations in 68.3% (41/60) of the patients while the advancement to goal rate was achieved more rapidly in 31.7% (19/60) of the patients. During EN support, the formula brand or type was changed at least once in 35% (21/60) of the patients while 65% (39/60) of the patients remained on the same formula throughout the duration of nutrition support.

Analysis of volume intake for the sample revealed daily intakes that were both over and under volumes recommended by the RD. Provision of daily volumes that exceeded recommendations by the RD occurred in 66.7% (40/60) of the patients with a mean duration of 11.91% of hospital length of stay. Provision of daily volumes that were below recommendations by the RD occurred in 98.3% (59/60) of the patients with a mean duration of 50.3% of hospital length of stay. These results can be viewed in Table 5.1.
GI complications were compared between patients who received EN rate advancements per RD recommendations and patients who did not. Each GI complication (diarrhea, vomiting, abdominal distention, and excess gastric residuals) was analyzed separately. The relationship between patients who received EN rate advancements per RD recommendations and those who did not, in regards to the occurrence of diarrhea was not significant, $X^2 (1, N = 60) = 2.67, p > .05$. The relationship between the two groups in regards to the occurrence of vomiting was not significant, $X^2 (1, N = 60) = 2.67, p > .05$. The relationship between the two groups in regards to the occurrence of excess residuals was significant, $X^2 (1, N = 60) = 5.89, p = .02$. The relationship between the two groups in regards to the occurrence of abdominal distention was significant, $X^2 (1, N = 60) = 4.45, p = .04$. Table 5.2 lists the number of patients falling into each category for the chi-square analysis for each GI complication.

Linear regression analysis was used to determine if the number of formula changes predicted the occurrence of GI complications. Each GI complication was evaluated separately. The linear regression analysis revealed that the number of formula changes did not predict the occurrence of diarrhea, $r^2=.05$ (adjusted $r^2=.03$), $F(1, 58)=2.76, p>.05$, the number of formula changes did not predict the occurrence of vomiting, $r^2=.00$ (adjusted $r^2=-.01$), $F(1, 58)=.21, p>.05$, the number of formula changes did not predict the occurrence of excess gastric residuals, $r^2=.01$ (adjusted $r^2=-.01$), $F(1, 58)=.29, p>.05$, and the number of formula changes did not predict the occurrence of abdominal distention, $r^2=.00$ (adjusted $r^2=-.02$), $F(1, 58)=.00, p>.05$. The results for each GI complication are shown in figure 5.1, figure 5.2, figure 5.3, and figure 5.4.
In addition to the linear regression analysis, a chi-square test of independence was used to examine the relationship between the number of formula changes (categorized into 3 groups) and the occurrence of GI complications. Each GI complication was analyzed separately. The relationship between the number of formula changes and the occurrence of diarrhea was not significant, \(X^2 (1, N = 60) = 4.10, p > .05\). The relationship between the number of formula changes and the occurrence of vomiting was not significant, \(X^2 (1, N = 60) = 2.97, p > .05\). The relationship between the number of formula changes and the occurrence of excess residuals was not significant, \(X^2 (1, N = 60) = .07, p > .05\). The relationship between the number of formula changes and the occurrence of abdominal distention was not significant, \(X^2 (1, N = 60) = 5.12, p > .05\). Table 5.3 combines the contingency tables used for the chi-square analysis for each GI complication.

Linear regression analysis was used to determine if the occurrence of GI complications predicted a prolonged patient hospital length of stay. Results revealed that the number of days patients experienced any GI complications predicted an increased length of stay, \(r^2 = .73\) (adjusted \(r^2 = .73\)), \(F(1, 58) = 159.01, p = .01\), but that the percentage of stay patients experienced any GI complications did not predict an increased length of stay, \(r^2 = .02\) (adjusted \(r^2 = .01\)), \(F(1, 58) = 1.41, p > .05\). These results are displayed in figure 5.5 and figure 5.6.

**Discussion**

When creating nutrition care plans for pediatric burn and trauma patients, RDs follow feeding protocols that utilize evidence-based guidelines. These guidelines state
that early initiation of enteral feeding is both safe and effective in critically ill children. Therefore, feeding protocols at many hospitals recommend beginning EN within 24 hours of admission, and consulting an RD within 24 hours of admission in critically ill children. Protocols at this hospital state that an RD should be consulted within 24 hours of admission for burn patients and within 72 hours of admission for trauma patients at level 3 nutritional risk. In this study, EN was started within 24 hours of admission in only 22 of the 60 patients and an RD was consulted within 24 hours of admission in 30 of the 60 patients. These results indicate that the feeding protocol at a Midwestern children’s hospital is not being followed consistently for pediatric burn and trauma patients.

In order to promote healing and growth, RDs determine appropriate EN daily volumes for each patient using estimated energy needs. In this study, daily volume intakes were both over and under volumes recommended by the RD, which can both lead to poorer patient outcomes. The variations in daily recorded intakes reveal that pediatric burn and trauma patients may not be receiving adequate nutrition to promote healing and growth.

A major focus of this study was exploring the relationship between EN rate advancement practices or formula brand/type changes and resultant GI complications. Further research is needed to determine specific EN rate advancement guidelines in this population; however, current protocol recommends gradual advancement to goal rate as tolerated. Furthermore, current guidelines state that an age-appropriate polymeric formula is best tolerated by the pediatric population. In this study, RD recommendations for EN rate advancements were compared to actual recorded EN rate advancements, and results
reveal that 19 of the 60 patients received more rapid rate advancements than recommended by the RD. In addition, there was a formula change at least one time in 21 of the 60 patients. These results indicate that RD recommendations are not being consistently followed in practice.

In this study, the occurrence of GI complications was compared between patients who had EN rates advanced per RD recommendations and patients who had EN rates advanced more rapidly. Results indicate that vomiting and diarrhea increased slightly when EN was advanced to goal rate more rapidly. However, this increase was not significant enough to indicate that rapid rate advancements were the only cause of increased vomiting and diarrhea. Results also indicate that abdominal distention and excess residuals increased when EN was advanced to goal rate more rapidly. These results were significant in suggesting that the rapid rate advancements may have been the cause of these GI complications. However, very few patients in the sample experienced excess residuals or abdominal distention at all, so further research is needed before conclusions can be drawn.

In this study, the relationship between GI complications and the number of formula changes was explored. The results indicate that there was no relationship between the number of formula changes and GI complications. However, it remains prudent to keep these patients on one formula throughout the duration of their nutrition support as long as it is tolerated in order to ensure nutrition therapy is adequate and effective.
Due to the daily monitoring of these patients by the RD, rapid rate advancements and inappropriate formula changes were corrected in a timely manner. This monitoring may have led to a reduction in the occurrence of GI complications related to improper EN feeding practices. While this practice is preferred to help improve patient outcomes, it may have had an impact on the results of this study.

Avoidance of GI complications is a major goal of nutrition therapy in pediatric burn and trauma patients. Increased GI complications may delay healing, increase a patient’s hospital length of stay, and therefore, contribute to poorer outcomes. In this study, the relationship between hospital length of stay and occurrence of GI complications was explored. Patients with GI complications tended to have longer hospital stays than patients without GI complications. However, this relationship does not imply cause and effect, as patients may simply have had more GI complications because they were in the hospital for a longer period of time. It is known that patients experiencing GI complications often do not receive adequate nutrition therapy to promote healing and growth, thus contributing to an increased hospital length of stay. As a result, it remains prudent to attempt to minimize GI complications in order to provide adequate nutrition therapy, and therefore, reduce hospital length of stay.

**Limitations**

This study has limitations including its retrospective design. Data from the medical charts is only useful if medical staff kept accurate records because any missing information could have an impact on the results of the study. Also, this study included a wide variety of ages, weights, medications, diagnoses and past medical conditions which
may have an impact on the variables being studied. Future studies could consider whether other factors, such as age, contribute to increased GI complications during EN support. In addition, further research utilizing a prospective study design is needed to allow for the creation of evidence-based guidelines in providing EN support to pediatric burn and trauma patients.

Conclusions

Variation exists between RD recommendations for EN and actual practice in pediatric burn and trauma patients. Furthermore, decreased tolerance to EN, as demonstrated by increased GI complications, may be related to improper EN practices in addition to other factors. RDs make recommendations from evidence-based guidelines which, according to current research, may improve patient outcomes. As a result, adherence to feeding protocols may help reduce unwanted GI complications while providing adequate nutrition therapy to reduce morbidity and mortality in critically ill children.
Article References


<table>
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<th>Variable</th>
<th>Mean (SE)</th>
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<td>Daily Amount Above Recs (mL) (n=6)</td>
<td>21.43 (± 12.56)</td>
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<tr>
<td>Number of Days with Volumes Above Recs (n=60)</td>
<td>3.68 (± .74)</td>
</tr>
<tr>
<td>Percentage of Stay with Volumes Above Recs (n=60)</td>
<td>11.91% (± 1.75%)</td>
</tr>
<tr>
<td>Daily Amount Below Recs (mL) (n=54)</td>
<td>379.64 (± 28.80)</td>
</tr>
<tr>
<td>Number of Days with Volumes Below Recs (n=60)</td>
<td>14.17 (± 1.93)</td>
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<tr>
<td>Percentage of Stay with Volumes Below Recs (n=60)</td>
<td>50.30% (± 2.88%)</td>
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Table 5.1: Comparison of RD Recommended Daily Volume and Actual Intake
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<td><strong>Follow RD Recs for Rate</strong></td>
<td>No</td>
<td>Yes</td>
<td>Total</td>
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<td><strong>Advancement?</strong></td>
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<tr>
<td>No</td>
<td>3</td>
<td>16</td>
<td>19</td>
<td>3</td>
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<tr>
<td>Yes</td>
<td>15</td>
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<td>Total</td>
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<td>42</td>
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</table>

Table 5.2. Chi-Square Analysis on Rate Advancement and GI Complications
Figure 5.1: Relationship between Formula Changes and Diarrhea
Figure 5.2: Relationship between Formula Changes and Vomiting
Figure 5.3: Relationship between Formula Changes and Excess Residuals
Figure 5.4: Relationship Formula Changes and Abdominal Distention
### Table 5.3: Chi-Square Analysis on Formula Changes and GI Complications

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<td><strong>Number of Formula Changes</strong></td>
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<tr>
<td><strong>Diarrhea?</strong></td>
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<td>0</td>
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<td>1</td>
<td>2</td>
<td>8</td>
<td>10</td>
<td>4</td>
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<td>&gt;1</td>
<td>1</td>
<td>10</td>
<td>11</td>
<td>1</td>
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<tr>
<td><strong>Total</strong></td>
<td>18</td>
<td>42</td>
<td>60</td>
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Table: Diarrhea? | Vomiting? | Excess Residuals? | Abdominal Distention?
Figure 5.5: Relationship between GI Complication (Number of Days) and Length of Stay
Figure 5.6: Relationship between GI Complications (Percentage of Stay) and Length of Stay
References


Appendix A

Comparison of Osmolality in Pediatric and Adult Enteral Formulas

<table>
<thead>
<tr>
<th>Pediatric Enteral Formula Brand</th>
<th>Osmolality (mOsm/kg water)</th>
<th>Osmolality of Standard Adult Formula [Ensure] (mOsm/kg water)</th>
<th>Difference (mOsm/kg water)</th>
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<tbody>
<tr>
<td>Boost Kid Essentials 1.5 Cal</td>
<td>390</td>
<td>620</td>
<td>230</td>
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<tr>
<td>Elecare</td>
<td>350</td>
<td>620</td>
<td>270</td>
</tr>
<tr>
<td>Enfamil</td>
<td>300</td>
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<td>320</td>
</tr>
<tr>
<td>Nestle Good Start Supreme</td>
<td>265</td>
<td>620</td>
<td>355</td>
</tr>
<tr>
<td>Jevity</td>
<td>300</td>
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<td>320</td>
</tr>
<tr>
<td>Nutren Jr.</td>
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<td>270</td>
</tr>
<tr>
<td>Nutren 1.0 Cal</td>
<td>370</td>
<td>620</td>
<td>250</td>
</tr>
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<td>Pedialyte</td>
<td>250</td>
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<td>Pediasure</td>
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<td>Peptamen Jr.</td>
<td>260</td>
<td>620</td>
<td>360</td>
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<tr>
<td>Peptamen Jr. 1.5 Cal</td>
<td>450</td>
<td>620</td>
<td>170</td>
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<tr>
<td>Similac Advance</td>
<td>310</td>
<td>620</td>
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<td>Similac Soy Isomil</td>
<td>200</td>
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<tr>
<td>Vital</td>
<td>390</td>
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Appendix B

Data Collection Chart (Split)

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<th>Date</th>
<th>Patient #</th>
<th>Length of stay (days)</th>
<th>Age (months)</th>
<th>Admitting diagnosis</th>
<th>Past medical history</th>
<th>Trauma level</th>
<th>% TBSA</th>
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<td></td>
<td></td>
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<td>Day 2</td>
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<td>etc.</td>
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<table>
<thead>
<tr>
<th>TF started within 24hrs? (y/n)</th>
<th>RD consult within 24hrs? (y/n)</th>
<th>Type of TF (route)</th>
<th>TPN? (y/n)</th>
<th>TF orders</th>
<th>RD notes</th>
<th>Physician notes</th>
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<table>
<thead>
<tr>
<th>RD recommended volume (mL)</th>
<th>Actual volume intake (mL)</th>
<th>Formula brand</th>
<th>Change in formula brand/type? (y/n)</th>
<th>Actual TF rate (mL/hr)</th>
<th>TF rate advanced per RD recs? (y/n)</th>
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<tr>
<th>Diarrhea? (y/n)</th>
<th>Vomiting? (y/n)</th>
<th>Abdominal distention? (y/n)</th>
<th>Excess residuals? (y/n)</th>
<th>Weight (kg)</th>
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