ANALYZING THE APPROPRIATENESS OF PARENTERAL NUTRITION AT A UNIVERSITY HOSPITAL AFTER IMPLEMENTATION OF NUTRITION SUPPORT ALGORITHM

By

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Bachelor of Science in Nutritional Sciences

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Stillwater, Oklahoma

May 2016

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
May, 2018

ANALYZING THE APPROPRIATENESS OF

PARENTERAL NUTRITION AT A UNIVERSITY

HOSPITAL AFTER IMPLEMENTATION OF

A NUTRITION SUPPORT ALGORITHM

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ACKNOWLEDGEMENTS

A special thank you goes out to employees at Oklahoma State University Medical Center for allowing me to conduct research at your facility. Thank you, Carolyn Robinson RD LD, for taking appropriate measures to ensure this opportunity came to fruition. Last but not least, thank you, Sara Hallgren-Tillery MA RD LD, for supervising this project and being available to answer any questions.

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Date of Degree: MAY, 2018

Title of Study: ANALYZING THE APPROPRIATENESS OF PARENTERAL NUTRITION AT A UNIVERSITY HOSPITAL AFTER IMPLEMENTATION OF A NUTRITION SUPPORT ALGORITHM

Major Field: NUTRITIONAL SCIENCES

Abstract: *Background:* Parenteral nutrition (PN) is a key form of nutrition support and is used as a last resort for nutrient provision. While PN can be extremely beneficial, there are increased costs and some risks and complications associated with its use, such as hyperglycemia and infections. Therefore, it is important to utilize PN when clinically appropriate to minimize these complications. There are several quality improvement methods that may help medical professionals determine when PN use would be appropriate. One of these methods is a nutrition support algorithm. The purpose of this study was to analyze the appropriateness of PN at Oklahoma State University Medical Center (OSUMC) after implementation of a nutrition support algorithm. *Methods:* A nutrition algorithm was implemented at OSUMC in April 2015 prior to the initiation of this research. A retrospective chart review was conducted on PN patients admitted during the year of 2016. A total of 85 PN patient charts were reviewed and 67 were included in this study. The appropriateness of PN initiation was determined based on the 2009 American Society of Parenteral and Enteral Nutrition and the Society of Critical Care Medicine (A.S.P.E.N./SCCM) nutrition support guidelines. The results were then compared to a previous study conducted at the university hospital that analyzed appropriate and inappropriate PN use prior to nutrition support algorithm implementation. *Results:* Of the 67 PN patient charts, 23 (34.3%) were inappropriately given PN. The number of days patients were NPO before PN initiation ($p=0.002$), GI function ($p<0.001$), and patient refusal of enteral nutrition ($p=0.017$) were found to be significantly different between patients who received appropriate and inappropriate PN. This study also found a significantly higher percentage ($p=0.002$) of appropriate PN use when compared to the previous study conducted prior to implementation of the nutrition support algorithm. *Conclusions:* Nutrition support algorithms are effective in reducing the number of inappropriate initiations at a university hospital. Nutrition support/multidisciplinary teams or other quality improvement procedures used in conjunction with an algorithm may continue to improve appropriate use of PN.

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INTRODUCTION

Medical Professionals and Their Role in Parenteral Nutrition Management

Medical professionals are ethically obligated to follow current medical care guidelines and utilize evidence-based research when providing patient care (Brotherton, 2016). However, current practices vary by medical institution and may not always accurately reflect these guidelines. The various guidelines are intended to show the most appropriate practices to ensure the safety of patients. Just like any other form of medical care, nutrition support has a set of guidelines used to help medical professionals provide the best quality care for patients. In the United States, the most current and widely accepted guidelines for nutrition support are the American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.) and Society of Critical Care Medicine (SCCM) guidelines released in February of 2016 (McClave et al., 2016). These guidelines provide crucial and evidence-based protocols regarding both enteral and parenteral nutrition use.

When it comes to parenteral nutrition (PN), many medical professionals can be involved with the ordering process. "The primary medical or surgical service prescribes the PN most often (71.6%). Nutrition support team members (30.5%) and other pharmacists (28.3%), dietitians (20.9%), advanced practice nurses (14.7%), or physician assistants (12.8%) are also involved in ordering PN" (Boullata, Guenter, & Mirtallo, 2013, p. 214). The variety in medical

professionals may be one area that can cause deviation in guideline compliance. Not all medical professionals receive the same amount of nutrition education and training. For example, a registered dietitian (RD) receives at least a bachelor's degree from an accredited dietetic/nutrition program and 1200 hours of supervised practice (Commission on Dietetic Registration, 2017). On the other hand, other health care professionals, such as nurses or physicians, may receive a varied quantity and quality of nutrition education depending on what institution they attended (Kris-Etherton et al., 2014). While both of these medical professions play a significant role in health and have the opportunity to specialize in nutrition, they are typically not as specialized in the area of nutrition as registered dietitians. PN prescribing errors most often occur when there is a lack of education or knowledge (Boullata, Guenter, & Mirtallo, 2013). In addition, there "are a wide variety of methods for ordering PN components, many of which are inconsistent with safe practices" (Boullata, Guenter, & Mirtallo, 2013, p. 212). It appears there may be a need to assess and improve consistency and compliance with evidence-based guidelines at medical institutions.

Determining Appropriateness of Parenteral Nutrition

Assessing the appropriateness and inappropriateness of PN can sometimes be difficult, but it is not an extremely convoluted process. In general, the process begins by using current guidelines like the A.S.P.E.N./SCCM or European Society for Parenteral and Enteral Nutrition (ESPEN) as a basis for appropriateness. Appropriateness can be determined by observing the timing of PN initiation, presence of an enteral nutrition (EN) contraindication, or the composition of a PN formula and then assessing whether or not they follow current practice guidelines. Assessment and data collection can either occur as patients are admitted into hospitals or a review can be conducted retrospectively. Nutrition or multidisciplinary teams can be used to help conduct an assesment (Boitano et al., 2010; Schaik & Niewold, 2014). This typically involves a variety of medical professionals such as physicians, pharmacists, and dietitians collaborating with each other to assess and help determine the best mode of nutrition support. Nutrition support

algorithms may also be used to help assess appropriateness (Kirkpatrick et al., 2013 unpublished; Kiss et al., 2012; Martin et al., 2004). This brings to question how well medical care facilities actually comply with current guidelines as well as what methods effectively help improve compliance and minimize inappropriate PN use.

Parenteral Nutrition Guideline Compliance

As of 2013, only 39.9% of medical organizations utilized some form of quality improvement process to help improve PN guideline compliance (Boullata, Guenter, & Mirtallo, 2013). The quality improvement process included at least one or a combination of the following: assessing PN appropriateness, receiving verification about orders from nurses or pharmacists, following dietitian's or nutrition support team's recommendations, pharmacists assessing the appropriateness of PN formula orders, and reviewing orders (Boullata, Guenter, & Mirtallo, 2013).

It is apparent hospital practices play a significant role and can greatly impact patient health status. Deviating from evidence-based guidelines may affect appropriateness or inappropriateness of patient treatment. Several methods have been attempted to address and improve appropriate prescribing of PN. However, it is not fully clear what quality improvement practices work best when addressing compliance and minimizing inappropriate use of PN.

Previous Research at Oklahoma State University Medical Center

In an unpublished study by Kirkpatrick et al. (2013), a former resident of Oklahoma State University Medical Center (OSUMC) reviewed medical charts in order to determine the appropriate or inappropriate use of PN. Following the 2009 American Society of Parenteral and Enteral Nutrition (A.S.P.E.N.) and the Society of Critical Care Medicine (SCCM) guidelines, it was determined that 53.3% of the patients were inappropriately prescribed PN (Kirkpatrick et al., 2013 unpublished). This research provided a baseline evaluation for inappropriate PN use at OSUMC and showed a need for a quality improvement process.

Shortly after this research was conducted, a nutrition support algorithm was created and implemented in April 2015 at the university hospital in the hopes of improving these statistics. The algorithm was reviewed and approved by the hospital's Surgery Service Line, Adult Medical Service Line, Quality Council, and Executive Council. Prior to implementation, the lead researcher of the study, Dr. Kirkpatrick, presented the findings of the study and briefly introduced the algorithm to medical staff. Medical staff were also sent an email from the Nutrition Services Manager informing them about the implementation of the nutrition algorithm. The nutrition support algorithm has been utilized for about 2 years now. However, Dr. Kirkpatrick's study had not been expanded in order to determine the inappropriate use of PN after implementation of the nutrition support algorithm, as well as the algorithm's overall effectiveness in reducing inappropriate PN use.

The Current Study

The current study was a follow up to the previous research conducted at OSUMC and aimed to address the gap in research mentioned above. The first goal of the current study was to determine the occurrence of inappropriate parenteral nutrition use at the university hospital during 2016. A data collection tool based on the 2009 A.S.P.E.N. and SCCM guidelines was used to determine parenteral nutrition appropriateness. The secondary goal was to compare the results of this study to that of the prior research conducted by Kirkpatrick et al. (2013, unpublished). The primary purpose of the study was to determine if implementing a nutrition decision algorithm influenced the occurrence of inappropriate parenteral nutrition use. The researcher hypothesized the nutrition support algorithm would effectively decrease inappropriate PN use at OSUMC.

Research Questions

Research Question #1: What is the prevalence of inappropriate parenteral nutrition use?

Research Question #2: What are predictors of inappropriately prescribed parenteral nutrition?

Research Question #3: Is a nutrition support algorithm effective in reducing the occurrence of inappropriate parenteral nutrition use?

Abbreviations:

A.S.P.E.N.-American Society of Parenteral and Enteral Nutrition

BMI- Body Mass Index

CRBSI- Catheter Related Blood Stream Infections

CPN- Central Parenteral Nutrition

EN-Enteral Nutrition

ESPEN- European Society for Parenteral and Enteral Nutrition

GI- Gastrointestinal

HPN- Home Parenteral Nutrition

ICU- Intensive Care Unit

IV- Intravenous

OSUMC- Oklahoma State University Medical Center

PN- Parenteral Nutrition

PPN- Peripheral Parenteral Nutrition

PICC- Peripherally Inserted Central Catheter

RD- Registered Dietitian(s)

SCCM- Society of Critical Care Medicine

TPN- Total Parenteral Nutrition

CHAPTER II

REVIEW OF LITERATURE

Nutrition Support

Nutrition support is a popular method of introducing nutrients into the body of individuals who cannot effectively do so orally. Parenteral nutrition (PN) is a form of nutrition support that delivers nutrients directly to the circulatory system through an intravenous line (IV) or catheter. PN should not be confused with enteral nutrition (EN), also known as tube feeding, which is another form of nutrition support that delivers nutrients through a tube directly to a section of the gastrointestinal (GI) tract.

While current statistics regarding the total number of people prescribed PN in the U.S is difficult to accurately determine, a two-year study started in 2005 provided a breakdown of common PN patients. Out of 11 million hospitalized patients, 112,845 received PN, and 106,374 of these inpatients were included in the study. The average age of adult PN patients was 66 years old, and the predominant ethnicity was white. Emergency related hospital visits occurred with 55.6% of PN patients. Primary diagnoses for PN patients were "intestinal or peritoneal adhesions with obstruction, followed by acute pancreatitis, unspecified septicemia, diverticulitis of the colon, or acute respiratory failure" (Wischmeyer et al., 2013, p. 61). As evidenced by this study, many of these PN patients can safely be classified as critically ill. Critically ill patients who are malnourished are more likely to receive PN than well-nourished patients due to the current

guidelines (McClave et al., 2016). According to the *A.S.P.E.N. Data Brief 2014,* 3.2% of hospital patients were documented as malnourished. Out of these individuals, a total of 13.4% received nutrition support, and 8.9% specifically received PN (Corkins et al., 2014).

Parenteral nutrition has taken many years to advance to where it is today. The first steps toward using PN first began in the 11th century when an Arab surgeon "supplied 'nourishment' to a human with the aid of a silver hollow needle of his own design" (Vassilyadi et al., 2013: p. 211-212). While the outcome of this was not well documented, it was a notable attempt given the time period. The next influential event was William Harvey's accurate portrayal of the circulatory system in the 17th century. Another milestone toward the implementation of PN, was Sir Christopher Wren's invention of the IV "made of goose quill and porcine urinary bladder" in 1658 (Vassilyadi et al., 2013: p. 212). From that point forward, using an IV to help facilitate nourishment gained attention in the realm of research. Throughout the 19th and 20th centuries, many individuals manipulated the type and form of nutrients infused into the IV. However, it wasn't until 1968 that Stanley Dudrick successfully used PN in a clinical setting (Vassilyadi et al., 2013). For a more detailed outline of the historical advancements of PN, refer to Appendix A. Without these attempts and achievements throughout history, PN would not be nearly as effective or successful as it is today.

How Parenteral Nutrition is Administered

There are two delivery methods of PN: peripheral parenteral nutrition (PPN) or central parenteral nutrition (CPN). For either form of PN to be administered, the skin must be punctured to insert the proper equipment. Peripheral parenteral nutrition delivers nutrients through an IV or catheter that is inserted in a vein located in the hands or arms. PPN is typically used in individuals who are not severely malnourished and who will not need PN for longer than two weeks. Very concentrated formulas are not well tolerated via PPN, and PPN formulas contain more fluid to ensure optimal and safe infusion of nutrients (Gottschlich, 2007; Nelms, Sucher, &

Lacey, 2016). Central parenteral nutrition, on the other hand, delivers nutrients through a catheter inserted into a large-diameter vein such as the superior vena cava. A central venous catheter can also be inserted peripherally and then threaded to the proper position in a central vein. Due to the vein diameter and blood flow rate, formulas used for CPN tend to be more concentrated than PPN formulas (Gottschlich, 2007). CPN is the form of parenteral nutrition used in long term cases.

Appropriate Administration of Parenteral Nutrition

When possible, enteral nutrition is used as the primary form of nutrition support (McClave et al., 2016). Utilizing the GI tract through EN is preferred because it promotes GI integrity, gut barrier functions, and effective nutrient utilization (Mueller, 2012). However, there are certain conditions and time frames in which parenteral nutrition (PN) would be considered the best source of nutrition support if a patient is hemodynamically stable. One common reason that PN would be necessary is if a patient has an enteral nutrition (EN) contraindication, a situation in which it is difficult or impossible to use enteral nutrition support (Mueller, 2012).

An EN contraindication typically involves a medical condition or situation that has impacted abdominal or gastrointestinal integrity, making it unlikely to safely provide EN. EN contraindications include "non-operative mechanical GI obstruction; intractable vomiting/diarrhea refractory to medical management; severe short-bowel syndrome (less than 100 cm of small bowel remaining); paralytic ileus; distal high-output fistulas (too distal to bypass with feeding tube); severe GI bleed; severe GI malabsorption (e.g. enteral nutrition failed as evidenced by progressive deterioration in nutritional status); need is expected for <5 to 7 days for malnourished adult patients or 7 to 9 days if adequately nourished; aggressive intervention not warranted or not desired" (Mueller, 2012, p. 173).

For most of the EN contraindications listed above, providing EN may cause further complications for a patient. There are several conditions in which refraining from using EN and allowing the bowel to rest may promote healing and prevent further damage. In situations where

splanchic perfusion or gastrointestinal blood flow is impaired, such as trauma or surgery, it is believed that provision of EN increases intestinal metabolic demand and thereby increases the risk of intestinal ischemia and necrosis (Gottschlich, 2007). Providing EN to an individual with a mechanical obstruction or paralytic ileus would further add bulk into the intestines and may worsen the impaction. A typical treatment option for mechanical obstruction and ileus is bowel rest (Gottschlich, 2007; Mueller, 2012). It would be difficult to provide EN to patients with intractable vomiting/diarrhea refractory to medical management because the increased transit time may prevent nutrients from being digested and absorbed efficiently (Mueller, 2012). In addition, excessive vomiting presents difficulty in maintaining EN tube placement (Gottschlich, 2007). Individuals with severe short bowel syndrome may experience malabsorption and increased small bowel transit time due to the decreased absorptive surface area as a result of intestinal resection. While the intestines are functionally capable of adapting after a resection, it may take up to 2 years (Mueller, 2012). Distal high output fistulas are located quite low in the GI tract, and cannot be bypassed with an EN tube. The provision of EN above a distal high output fistula may result in leakage through the fistulae and increase risk of infection. Some situations in which fistulas manifest include but are not limited to inflammatory bowel disease, ischemic bowel, penetrating trauma, and various GI surgeries (Mueller, 2012). In the case of severe GI bleeds, bowel rest may be the best option to promote wound healing. Lastly, individuals with severe GI malabsorption and documented EN failure require PN, as it is the only option left for nutrition support and nutrients should be provided to prevent malnutrition.

While the last two EN contraindications are not due to GI issues, they are both significant and practitioners should be aware of them. Despite the 2016 A.S.P.E.N/SCCM guidelines stating that it is appropriate to provide EN within 24-48 hours when a patient cannot maintain volitional intake, most hospitals have a protocol that addresses the timeframe in which EN can be appropriately initiated. If EN is initiated before the determined timeframe, its use would be inappropriate or contraindicated. Finally, no medical practices should be used against a patient's

will and their autonomy must be respected. Under any of these circumstances, it would be optimal to administer PN to ensure the patient receives adequate energy and nutrition to support life and promote healing.

When it has been deemed that a patient can and should be given PN, it is necessary to determine a suitable time frame for nutrition support. One factor that may influence the appropriate time frame of nutrition support initiation is malnutrition status. The NRS 2002 (Nutritional Risk Screening 2002) and NUTRIC (Nutrition Risk in Critically Ill) are two screening and assessment tools hospitals can utilize to determine nutritional risk and malnutrition status (Mueller, 2012; Rahman et al., 2016). According to the 2016 American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.) guidelines, parenteral nutrition would be appropriate to administer to an individual with low nutritional risk (NRS 2002 score less than 3 or a NUTRIC score less than 5) 7 days after patient admission if the patient cannot consume enough food orally and enteral nutrition is not possible. However, in a severely malnourished or high nutritional risk patient (NRS 2002 greater than 5 or NUTRIC score greater than 5), PN can be administered immediately after admission. If any patient, regardless of high or low nutritional risk, cannot consume greater than 60% of their energy and protein needs from EN after 7-10 days, it would be appropriate to administer supplemental PN (McClave et al., 2016).

It should be noted that the A.S.P.E.N./SCCM guidelines were determined using current, evidence-based research. For the 2009 A.S.P.E.N./SCCM guidelines, each recommendation was given a grade (A through E) based on the strength of the research used to create it. Grade A signified that research used was relatively strong and used large, randomized trials with little error, while a Grade E signified weaker research that used nonrandomized or uncontrolled trials (McClave et al., 2009). On the other hand, the 2016 A.S.P.E.N./SCCM guidelines categorized as "high", "moderate", "low", and "very low". Strong research that used randomized controlled trials were categorized as "high" or "moderate", while considerably weaker research that used observational studies were categorized as "low" or "very low" (McClave et al., 2016).

Inappropriate Use of Parenteral Nutrition

The presence of PN contraindications in patients is a clear sign PN was used inappropriately. Some peripheral parenteral nutrition (PPN) contraindications include "Significant malnutrition; severe metabolic stress; large nutrient or electrolyte needs (potassium is a strong vascular irritant); fluid restriction; need for prolonged parenteral nutrition (greater than 2 weeks); and renal or liver compromise" (Mueller, 2012: p. 236). If any of these conditions applies to a patient and PPN is administered, PPN use would be deemed inappropriate. Other signs of inappropriate use of PN are not as apparent but can include improper formulation of PN and noncompliance with current guidelines.

Determining whether or not to use PN is a critical and important decision that should be well thought out. It can seriously influence a patient's health status in a positive or negative manner and impact hospital costs. Inappropriate use of PN may unnecessarily put a patient at risk for developing PN related complications, when they could have been avoided entirely had the patient originally been prescribed the appropriate form of nutrition support.

When comparing the costs of PN to EN, PN is 1.4 to 12.5 times more expensive than EN, and these statistics do not include the accrued yearly charges of inappropriate PN use (Gottschlich, 2007). A study conducted by Trujillo et al. (1999) analyzed the monetary costs of inappropriate use of PN at one hospital. During the time of this study, A.S.P.E.N./SCCM had guidelines to categorize individuals given PN into three groups: indicated, not indicated, and preventable. The indicated group had known enteral nutrition contraindications. The preventable group had a functional GI tract, however no sites could be accessed for EN (Trujillo et al., 1999). The not indicated group included patients with functional GI tracts who were well nourished. It was discovered that use of PN in individuals categorized as "not indicated" and "preventable" resulted in an excess of over half a million dollars in patient charges (Trujillo et al., 1999). When EN has been utilized instead of PN, studies have shown a "reduction in the costs related to treating infections, wound healing, and length of stay" (Gottschlich, 2007: p. 192). It is also

important to note that PN is more expensive than EN due to the complicated and invasive equipment. With such variation in cost between PN and EN, it is important to administer the most appropriate form of nutrition support to provide the most cost effective outcome for the hospital as well as the patient.

Complications Associated with Parenteral Nutrition

Parenteral nutrition (PN) is a more invasive form of nutrition support when compared to enteral nutrition (EN) and with its use comes the possibility of certain complications. One common complication associated with PPN is phlebitis and thrombophlebitis (Pertkiewicz & Dudrick, 2009). Phlebitis is inflammation of a vein, while thrombophlebitis is vein inflammation caused by a blood clot. Another serious potential complication that can occur in either form of PN is infection. The source of infection can be microbiota naturally found on the skin, the use of a contaminated catheter, or the use of contaminated PN formula (Gottschlich, 2007; Nelms, Sucher, & Lacey, 2016). The introduction of bacteria into the body may result in a serious blood infection called sepsis. Wischmeyer and colleagues (2013) reported that blood stream infections occurred in 25.5% of adult PN patients with a higher occurrence in the critically ill. A systematic review assessing the incidence of infection in patients receiving home parenteral nutrition (HPN) found a median catheter related bloodstream infection (CRBSI) rate of 1.31 out of 1000 catheter days (Dreesen et al., 2013). Out of these infections, 61% were caused by gram positive bacteria commonly found on the skin (Dreesen et al., 2013).

Total parenteral nutrition (TPN), nutrition support that solely uses PN as a means to deliver nutrients, can also negatively impact the GI tract, mostly because of disuse. Common complications in the GI tract include cholestasis, “a condition in which bile accumulates in the gallbladder because it contracts infrequently without enteral stimulation”, and an increase in permeability which makes the gut susceptible to bacteria (Nelms, Sucher, & Lacey, 2016: p. 111).

Other issues that may arise can be the result of mechanical complications. Mechanical

complications can be classified as either immediate or long term. Immediate mechanical complications, "including pneumothorax, arterial cannulation, and line malposition, occur in 1%-4% of cases of central lines" (Ghabril et al., 2004). Other immediate mechanical complications, like air embolisms, caused by malfunctioning of the airtight seals of equipment can occur but are rare (Ghabril et al., 2004). Long-term mechanical issues include, but are not limited to, thrombosis, occlusion, and line damage. The latter two occur more commonly in patients with peripherally inserted central catheters (PICC) (Ghabril et al., 2004).

The third form of PN related complications is metabolic issues. Selecting a PN formula must be done carefully to ensure the body stays in homeostasis. PN formula bags are available in standardized forms, however they can also be altered to cater to a patient's specific needs. Providing the wrong formula to a patient may have several metabolic impacts because PN bypasses the liver. For example, associated complications include but are not limited to: hyperglycemia, hypoglycemia, essential fatty acid deficiency, hypertriglyceridemia, micronutrient and electrolyte imbalances, underfeeding, overfeeding, and refeeding syndrome (Gottschlich, 2007; Nelms, Sucher, & Lacey, 2016). Many of these occur due to improper formulation and ratio of nutrients based on a patient's current condition and needs. Hyperglycemia is one of the most common metabolic complications and occurs because of high dextrose infusion or by the effects of severe stress in critical care patients (Btaiche & Khalidi, 2004). Patients who are at a particularly high risk of developing refeeding syndrome are those who are severely malnourished (McKee, 2014). For these patients, nutrients should be introduced slowly to reduce the development of this condition. In general, metabolic complications are not as common as line infections, but their occurrence does need to be monitored and minimized when possible (McKee, 2014). A study found 39% of TPN patients in England and Wales experienced metabolic complications, 46% of which were deemed as the result of inadequate monitoring (Burch & Stewart, 2011). Providing appropriate application and monitoring of PN is a key component to ensuring nutrition support remains beneficial.

Approaches Utilized to Improve Patient Care and Reduce Inappropriate PN

Due to the many negative aspects and potential complications associated with the inappropriate use of PN, it is critical to determine which nutrition support route is the most appropriate. In the United States, medical professionals are expected to adhere to the current A.S.P.E.N. guidelines and evidence based research when determining what form of nutrition support to administer. However, there are many exceptions and situations that make the decision-making process more convoluted and less black and white. Accurately choosing nutrition support based on needs, preexisting conditions, as well as choosing the correct formulas can be quite complex. To minimize human error and risk, there are several ways in which the inappropriate use of PN can potentially be managed. Methods and practices vary by location, but several approaches are worth consideration.

One approach to minimize the use of avoidable PN and reduce associated costs is to use a nutrition support and/or multidisciplinary team. One study in particular implemented a new protocol that required the nutrition team to review the nutritional status of patients and monitor whether parenteral nutrition use was appropriate. The project resulted in a 40% decrease in costs after one year, and the "reduction of costs was mainly due to a decrease of 29% in the number of patients on TPN" (Schaik & Niewold, 2014: p. *e*60). A similar study took this approach one step further and implemented a quality improvement project. The process involved updating the PN order form and hospital policy, providing education to all of the medical staff, increasing collaboration between registered dietitians (RD) and pharmacists, implementing more frequent medical team meetings, and introducing PN monitoring rounds a couple times a week. Within two years, the hospital was able to significantly decrease the inappropriate use of PN. PN use decreased from 15 to less than 5 average PN patients a day, which translated into a 6.9 million dollar reduction in PN related costs (Boitano et. al, 2010).

In instances when a nutrition care or multidisciplinary team cannot be fully developed due to limited resources, other methods should be considered. A more cost-effective approach

that may be used to reduce the inappropriate use of parenteral nutrition is to implement a nutrition support algorithm. While there may not be research on the specific costs associated with implementing a nutrition support algorithm, one can assume there would fewer labor costs when compared to other quality improvement methods (i.e. nutrition support teams/multidisciplinary teams). A nutrition support algorithm is a document, similar to a flowchart, that acts as a simple and easily accessible guide to determining what form of nutrition support to use. In 2004, a study was published addressing the outcomes at several hospitals after an evidence-based algorithm was implemented (Martin et al. 2004). Minimal education and RD supervision ensured the algorithm was used properly. While the study did not intentionally observe whether or not the algorithm could determine the most appropriate nutrition support route, it did look at the number of patients receiving EN/PN, patient mortality, and length of stay. The study found a significant increase (p=0.04) in the number of days receiving EN, a decrease in hospital stay (p=0.003), and a trend suggesting a reduction in mortality (p=0.058) (Martin et al., 2004). Researchers concluded "evidence-based recommendations for nutritional support can be implemented as a set of algorithms and can improve nutritional support to critically ill patients" (Martin et al., 2004: p. 202). A more recent study in Switzerland developed a nutrition support algorithm based on the 2009 Society of Critical Care Medicine (SCCM) and American Society of Parenteral and Enteral Nutrition (A.S.P.E.N.) guidelines, and the algorithm was implemented to see if it made a positive, significant impact. The algorithm utilized was rather in depth and included information on EN/PN contraindications, tolerance, formulas, additives, feeding volume, and so on (see APPENDIX B). The results showed improvement in providing adequate energy and protein delivery. It also showed a significant decrease in PN use and increase in EN with supplemental PN. Although the researchers stated the nutrition support route was minimally influenced by the nutrition support algorithm, these results may have been impacted by the population of patients used in the study and the complexity of the algorithm (Kiss et al., 2012). Seventy percent of the patients were admitted to the ICU after a surgical procedure and were there for less than 72 hours (Kiss et. al,

2012). This could have minimized the effectiveness of the algorithm in determining nutrition support route because many would not have been PN eligible based on time admitted.

Future Research

To the researcher's knowledge, much of the research available regarding nutrition support algorithms primarily focus on enteral nutrition rather than PN. Many studies also observed the impact of nutrition algorithms in collaboration with nutrition education of medical staff or nutrition support/multidisciplinary teams but not of nutrition algorithms alone (Kiss et al., 2012; Martin et al., 2004; Steele et al., 2016). Several studies observed the impact nutrition algorithms have on patients (Kiss et al., 2012; Martin et al., 2004; Woien & Bjork, 2006). However, few research studies have looked in depth at its impact on determining nutrition support route. There seems to be a lack of research looking at nutrition support algorithms and their potential role in reducing the inappropriate use of parenteral nutrition.

This study aims to address these gaps in research by specifically looking at nutrition support algorithms' impact on appropriate versus inappropriate parenteral nutrition use. In addition, another goal of this study is to help identify areas that may need modification in order to help improve quality and patient care at OSUMC.

CHAPTER III

METHODS

Research Design and Patient Chart Selection

This research was a retrospective, follow-up study. It was classified as exempt and approved by Oklahoma State University Health Sciences' Institutional Review Board (see APPENDICES E & F). Any individual over 18 years old who was prescribed any form of PN between January 2016 and December 2016 was included in this study. However, pregnant women, inmates, and mentally impaired individuals were excluded. Individuals receiving home parenteral nutrition (HPN) were also excluded from the study. Patients on HPN had a documented need and reason to be receiving PN, and PN use for these patients was a continuation not initiation. Therefore, these patients were not applicable to this study.

A list of patients who received PN during the year of 2016 was obtained through the pharmacy of OSUMC, and patient charts were reviewed using OSUMC's Meditech Network. The Meditech Network is a computer program that keeps digital records of patient information. Other documents, such as a completed nutrition support algorithm, could be scanned and saved into a patient's chart records. While an algorithm was not uploaded to every single patient chart, the pharmacy required that an algorithm be completed prior to PN prescription. Patient charts were assigned a three or four-digit number by the researcher in order to maintain patient anonymity and confidentiality.

A data collection tool was developed and utilized to ensure a consistent and objective review of patient charts. The data collection tool was based off of the 2009 A.S.P.E.N./SCCM guidelines for parenteral and enteral nutrition (McClave et al., 2009). Although there was a more current version of the guidelines available, it was determined that OSUMC did not follow the 2016 A.S.P.E.N./SCCM guidelines at the time of this study. The data collection tool included information such as ethnicity, age, gender, BMI, medical diagnosis and symptoms, EN/PN contraindications, malnutrition status, and how long a patient was NPO (nothing by mouth). Appendix C depicts the data collection tool used in this study.

To determine whether or not EN/PN contraindications were present, key words were searched for throughout each patient chart. For example, the words "fistula" or "obstruction" were used to determine if there was a distal high output fistula or a mechanical GI obstruction. If any of the key words were found in a patient's chart, the patient was automatically categorized as having a true EN/PN contraindication. In addition, a patient's malnutrition status was determined by reviewing the physician's and registered dietitian's notes within the chart. These areas of the patient chart clearly stated whether or not a patient was malnourished.

A total of 85 patient charts were reviewed, and 67 patient charts were included in the study. The 18 charts omitted from the study were due to insufficient chart data, patients were on HPN, and/or the patients were recurrent admits with no change in medical status. Patient charts were reviewed by a dietetic intern/nutrition graduate student. The primary researcher was supervised by an RD familiar with Dr. Kirkpatrick's study (Kirkpatrick et al., unpublished, 2013). Multiple RDs were also available to assist with decision making. After review, charts were then categorized as appropriate, inappropriate, or inconclusive. Inconclusive charts lacked pertinent information and were omitted from the statistical analysis. The primary goal of this portion of the study was to determine appropriateness upon initiation of PN. The results of this portion of the study were then compared to the previous study by Kirkpatrick et al. (unpublished, 2013)

conducted at the same hospital prior to nutrition support algorithm implementation. Appendix D represents the algorithm implemented at OSUMC.

Statistical Analysis

The statistical analysis in this study was performed using the Statistical Package for Social Sciences (SPSS for PC; 20.0). A p-value of <0.05 was set as the level of significance. Descriptive statistics, including means and standard deviations, frequencies and ranges were computed. To describe differences between the appropriate and inappropriate PN use, t-test was used for age and BMI. Chi-square was used to compare inappropriate and appropriate PN use by ethnicity, gender, GI function, EN/PN contraindications, NPO status, and documentation of malnutrition. In addition, a one sample chi-square was also used to compare these findings of inappropriate parenteral nutrition to those found in the previous study conducted at OSUMC (Kirkpatrick et al., unpublished, 2013).

CHAPTER IV

FINDINGS & DISCUSSION

Results

For this study, 85 charts of PN patients admitted during the year of 2016 were reviewed. A total of 18 charts were excluded from the study (n=67). Three of the excluded charts had insufficient data. The remaining 15 excluded charts were omitted due to patients being HPN recipients and/or being recurrent patients with no change in medical status. These 15 excluded charts were split between 5 individual patients.

Demographics and basic characteristics of patients are featured in Tables 1 and 2. The majority of patients were Caucasian (68.7%). Other ethnicities observed were Native American (17.9%), African American (10.4%), Hispanic (1.5%), and "Undetermined" (1.5%) (Table 2). Patient gender was fairly equally distributed with there being 33 females (49.3%) and 34 males (50.7%). The average age of patients was 60 years old, with the youngest being 21 years old and the eldest being 88 years old (Table 2). The mean Body Mass Index (BMI) of patients was 26.7 kg/m^2, with a minimum BMI of 11 kg/m^2 and a maximum BMI of 66 kg/m^2 (Table 1). Nearly half of the patients had a BMI between 18 kg/m^2 and 24.99 kg/m^2 (43.3%). The next most common BMI range were patients with a BMI greater than or equal to 30 kg/m^2 (31.3%), followed by patients with a BMI between 25 kg/m^2 and 29.99 kg/m^2 (16.4%). The remaining nine percent of patients had a BMI $\leq$17.99 kg/m^2 (Table 2). The majority of patients were NPO less than 7 days

before receiving PN (67.2%) and malnourished when admitted into the hospital (61.2%). In addition, patients were hospitalized anywhere from 0 to 28 days before receiving PN.

Table 1: Prevalence of Appropriate & Inappropriate PN Use by Patient Characteristic

Characteristics	Full Sample N=67 n (%)	Appropriate PN Use n= 44 n (%)	Inappropriate PN Use n= 23 n (%)	*P* Value
Ethnicity				0.279 [b]
"Undetermined"	1 (1.5)	0 (0.0)	1 (4.3)	
African American	7 (10.4)	6 (13.6)	1 (4.3)	
Caucasian	46 (68.7)	30 (68.2)	16 (69.6)	
Hispanic	1 (1.5)	0 (0.0)	1 (4.3)	
Native American	12 (17.9)	8 (18.2)	4 (17.4)	
Gender				0.535 [a]
Female	33 (49.3)	22 (50.0)	11 (47.8)	
Male	34 (50.7)	22 (50.0)	12 (52.2)	
BMI (kg/m2)				0.844 [b]
≤ 17.99	6 (9.0)	3 (6.8)	3 (13.0)	
18-24.99	29 (43.3)	20 (45.5)	9 (39.1)	
25-29.99	11 (16.4)	7 (15.9)	4 (17.4)	
≥30	21 (31.3)	14 (31.8)	7 (30.4)	
# of Days NPO Before PN *				0.002 [a]
< 7 days	45 (67.2)	24 (54.5)	21 (91.3)	
≥ 7 days	22 (32.8)	20 (45.5)	2 (8.7)	
Malnourished Upon Admit				0.202 [a]
No	26 (38.8)	15 (34.1)	11 (47.8)	
Yes	41 (61.2)	29 (65.9)	12 (52.2)	

[a] Fisher's Exact Test was used to compare differences between groups with a smaller sample size (2 subcategories) and inappropriate or appropriate PN use
[b] Pearson's Chi-Square was used to compare differences between groups with a larger sample size (more than 2 subcategories) and inappropriate or appropriate PN use
*p ≤ 0.05

Out of 67 charts, 44 (65.7%) of the patients were categorized as appropriately receiving PN and 23 (34.3%) as inappropriately receiving PN. There were no significant differences in

Table 2: Age & BMI

Category	Minimum	Maximum	Mean
Age (years)	21	88	60 ± 14.2
BMI (kg/m^2)	11	66	26.7 ± 9.5

ethnicity or gender between patients who received appropriate or inappropriate PN (Table 1). No significant differences were found between BMI and appropriately or inappropriately prescribed PN, neither when BMI was divided into categories nor when mean BMI was used. Significantly (p=0.002) more patients who were inappropriately given PN were NPO less than 7 days before receiving PN. There were no significant differences in patients' malnourishment status when admitted into the hospital and inappropriate or appropriate PN use. There were no significant differences between age and appropriate or inappropriate PN use.

Table 3 represents the chi-square analysis used to determine any differences between EN contraindications and appropriateness of PN. There were no significant differences between GI obstruction as an EN contraindication and appropriate or inappropriate PN use. There were no significant differences between inability to gain or maintain GI access as an EN contraindication and appropriate or inappropriate PN use. Significantly (p<0.001) more patients who had abnormal GI function were provided appropriate PN, and significantly more patients who had normal GI function were inappropriately given PN. There were no significant differences between a fistula or ileus as an EN contraindication and patients appropriately or inappropriately given PN. Significantly (p=0.017) more patients who refused EN as a form of nutrition support were appropriately prescribed PN. There were no significant differences between GI bleed as an EN contraindication and patients appropriately or inappropriately prescribed PN. One patient had severe short bowel syndrome as an EN contraindication. There was no significant difference in severe short bowel syndrome and appropriately or inappropriately prescribed PN. No statistical analyses were run on any PN contraindications because no patients experienced any PN contraindications.

Table 3: Predictors of Inappropriate PN Prescription

EN Contraindication	Full Sample N=67 n (%)	Appropriate PN Use n= 44 n (%)	Inappropriate PN Use n= 23 n (%)	*P* Value
GI Obstruction				0.154
No	52 (77.6)	32 (72.7)	20 (87)	
Yes	15 (22.4)	12 (27.3)	3 (13.0)	
Inability to Gain or Maintain GI Access				0.431
No	53 (79.1)	34 (77.3)	19 (82.6)	
Yes	14 (20.9)	10 (22.7)	4 (17.4)	
GI Function ***				<0.001
(-)	39 (58.2)	34 (77.3)	5 (21.7)	
(+)	28 (41.8)	10 (22.7)	18 (78.3)	
Fistula				0.177
No	63 (94.0)	40 (90.9)	23 (100.0)	
Yes	4 (6.0)	4 (9.1)	0 (0.0)	
Ileus				0.112
No	62 (92.5)	39 (88.6)	23 (100.0)	
Yes	5 (7.5)	5 (11.4)	0 (0.0)	
Patient Refusal *				0.017
No	58 (86.6)	35 (79.5)	23 (100.0)	
Yes	9 (13.4)	9 (20.5)	0 (0.0)	
GI Bleed				0.564
No	62 (92.5)	41 (93.2)	21 (91.3)	
Yes	5 (7.5)	3 (6.8)	2 (8.7)	
Severe Short Bowel Syndrome				0.657
No	66 (98.5)	43 (97.7)	23 (100.0)	
Yes	1 (1.5)	1 (2.3)	0 (0.0)	

Fisher's Exact Test was used to compare group differences between appropriate and inappropriate PN use

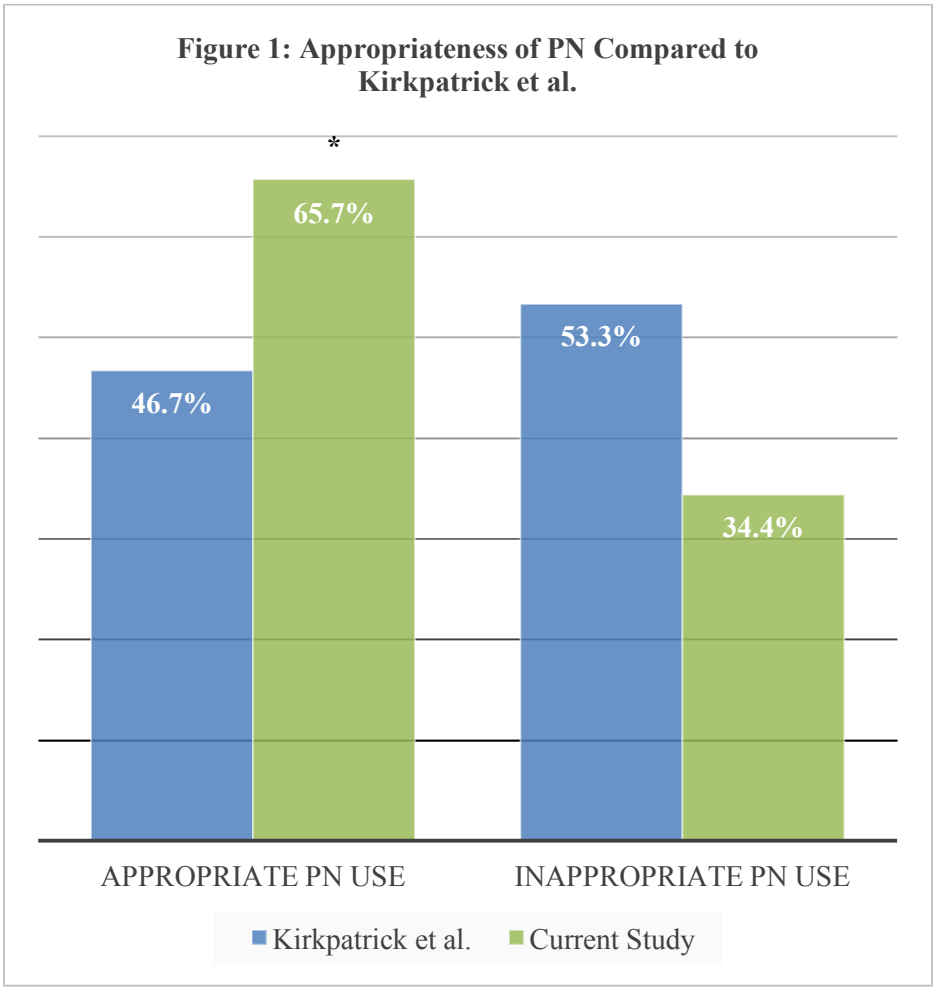
* $p \leq 0.05$

***$p \leq 0.001$

(-) Abnormal GI Function

(+) Normal GI Function

Lastly, a one sample chi-square analysis was used to determine any differences in appropriateness of PN use between this study and the study conducted by Kirkpatrick et al. (2013, unpublished). It was determined that significantly (p=0.002) more PN orders were appropriate (65.7%) in 2016 when compared to the percentage of appropriate PN (46.7%) in the earlier study (2013). Please see Figure 1.



* $p \leq 0.05$

Discussion

This research had several different objectives in order to determine the effectiveness of implementing a nutrition support algorithm. The study first determined and analyzed the

prevalence of appropriate and inappropriate PN use. Second, factors that may have influenced appropriately or inappropriately prescribed PN were reviewed to identify trends. Finally, all of the results were compared to a previous study by Kirkpatrick et al. (2013, unpublished) to determine if implementing a nutrition support algorithm had an impact on the occurrence of inappropriate PN use. Overall, the data collected suggests that the nutrition support algorithm used had an influential impact on determining the most appropriate form of nutrition support and minimizing inappropriate PN prescription.

This study found more patients were appropriately prescribed PN than inappropriately prescribed PN during the year of 2016. This result is consistent with other research that analyzed the appropriateness of PN (Boitano et al., 2010; DeLegge et al., 2007; Feng et al., 2015; Martin et al., 2011; Peterson et al., 2010; Smyth et al., 2013). However, some of these studies incorporated quality improvement processes while others simply assessed appropriateness of PN use at baseline. Research studies on this topic has shown considerable variation in appropriate vs. inappropriate use. Worthington and colleagues (2017) stated inappropriate PN use was seen anywhere between 5% and 45% within various studies. Differences in results may be due to hospital protocols, nutrition support knowledge of medical professionals prescribing PN, the manner in which data were collected, or how data were analyzed. The focus of data collection and statistical tests utilized can vary tremendously and sometimes are not clearly stated within the research. While all of the articles reviewed for comparison did analyze the appropriateness of PN, each research study had a different area of focus. For example, this study focused on factors that may influence the appropriateness of PN initiation (e.g. NPO status) and whether or not these factors were significantly different when comparing patients with inappropriate and appropriate PN use. On the other hand, some studies focus on the costs associated with PN and the cost savings that occurred when inappropriate PN use is reduced (Boitano et al., 2010; Martin et al., 2011). Despite the variability in research design and results of appropriateness of PN use, each study can be used to determine what methods may help reduce inappropriate PN use and how an

institution may be able to make improvements.

One study in particular found 82% of PN use to be appropriate, 13% to be "appropriate but avoidable, and 5% to be inappropriate (Smyth et al., 2013). While it also determined appropriateness based on the A.S.P.E.N./SCCM guidelines, it is considerably different than this study. Smyth and colleagues (2013) study was one of only a handful to categorize some PN use as "appropriate but avoidable". PN use was put into this category when a portion of a patient's GI tract was functional but had not been accessed via surgical operation. For instance, a PN patient who had their esophagus and stomach removed but a jejunostomy was not attempted would have fallen under this category (Smyth et al., 2013). The high percentage of appropriate PN could be attributed to the fact that every patient that received PN was visited by a registered dietitian (RD) at some point, 83% of which was initiated after the dietetic consultation (Smyth et al., 2013). While PN could still be prescribed inappropriately at the beginning, the RD had the opportunity to correct the mistake quickly or at least reduce PN use in instances where it was appropriate but avoidable. As mentioned previously, not all medical professionals receive the same amount of nutrition education as RDs. Given the amount and detail of nutrition education they receive, RDs are the primary source of nutrition information within a hospital. Peterson and colleagues (2010) analyzed the effect on PN use after RDs were given order-writing privileges. They found a decrease in overall PN use and an 18% reduction in inappropriate PN use (Peterson et al., 2010). In addition, the hospital where Smyth and colleagues (2013) conducted research consistently provided nutrition support education, monitored PN use, and encouraged multidisciplinary interaction. These studies show that having an RD play a role in PN prescription can reduce the percentage of inappropriate PN use.

While having a higher percentage of appropriate PN use versus inappropriate PN use is strived for in any establishment, the data clearly shows there is still a need for improvement. The improved but relatively low percentage of appropriate PN use at OSUMC may be attributed to the fact that OSUMC is a teaching hospital. It may be difficult to reach every single individual and

inform them how to effectively understand and utilize the nutrition algorithm. OSUMC may need to consider a method to increase the reach and understanding of nutrition support among medical students and professionals. In addition, the hospital may need to implement another method, such as quarterly educational meeting, to increase understanding and adequate use of the nutrition support algorithm.

Although medical diagnoses of patients were not statistically analyzed, many patients who were given PN during 2016 had a wide variety of diagnoses and preexisting conditions. Frequently observed diagnoses and issues were (but not limited to) diabetes, kidney disease, hypertension, abdominal pain, GI obstructions, and sepsis. Other studies had some similarities in the primary diagnoses observed. Wischmeyer and colleagues (2013) examined common characteristics of PN patients. They found patients given PN had primary diagnoses of various GI disorders and conditions, acute pancreatitis, sepsis, and acute respiratory failure. PN patients may have a variety of diagnoses related or not related to the GI tract, however primary diagnosis and issues do not effectively depict a patient's entire medical situation. That is why one must look at nutritional concerns in order to consider the appropriateness of PN and why an RDs' role is highly important in the process. RDs use PES (problem/etiology/signs & symptoms) statements to objectively make decisions regarding nutrition. They consider both the medical issues as well as nutritional concerns, which makes them well equipped for determining the most appropriate form of nutrition support.

In this study, patients were hospitalized anywhere from 0 to 28 days before receiving PN. While four weeks may appear to be a long time to wait before receiving PN, this study did not statistically analyze patient length of stay or any associations between it and PN use. Therefore, no conclusive decision regarding length of stay and PN appropriateness could be drawn. However, extended length of stay before receiving PN may be associated with a change in patient status throughout their stay. For example, some of these patients may not have tolerated EN or could have developed an EN contraindication after admission.

Wischmeyer et al. (2013) found similar percentages of Caucasian (73.1%), African American (11.3%), and Hispanic (4.6%) patients who received PN when compared to the percentages of ethnicities in this study. When compared to the 2010 U.S. Census, the percentage of ethnicities of patients in this study differed slightly from the percentage of ethnicities found in Tulsa alone as well as the state of Oklahoma. The study sample had a comparable percentage of Caucasians and African Americans, but had a higher representation of Native Americans and a lower representation of Hispanics when compared to the ethnicities found in the general population of Oklahoma as well as Tulsa. These results show that the population in this study represents the PN patient population fairly well. This is important to point out because the representation is not significantly skewed in any one direction. If they were skewed toward one ethnicity or age group, it would signify an underlying reason or cause for these patients to receive more PN. In this study, no significant differences were found in ethnicity and appropriately or inappropriately prescribed PN.

The average age of individuals in this study was 60 ±14.18 years old, which coincided with a study (66.4±17.0) that analyzed common characteristics of patients who receive PN (Wischmeyer et al., 2013). Kraft and colleagues (2014) found a similar average age of PN patients (65 ± 1.4 years). Although, they did have less variation in age compared to other studies.

Limited studies have analyzed the appropriateness of PN and evaluated BMI in PN patients. Kraft and colleagues (2014) found patients had a mean BMI of 23.2 ± 0.5 kg/m^2, which is similar to this study's mean BMI of 26.7 ± 9.53. In this study, no significant differences were found in age or BMI and appropriately or inappropriately prescribed PN.

Although this study did not distinguish the difference between severely and moderately malnourished patients, there was a considerably large number of patients admitted with varying severity of malnutrition when compared to those who were not malnourished. This study had a higher percentage of patients with malnutrition when compared to other studies. Smyth et al. (2013) conducted a study that looked at PN appropriateness and reported 41% of patients were

severely malnourished, while Wischmeyer et al. (2013) conducted a study that observed common characteristics of PN patients and reported 33.2% of PN patients were malnourished. The high percentage of malnourished patients at OSUMC could be due to illness, demographics, economic situation of patients, or mere coincidence. It is possible that care may have been delayed due to a lack of resources, which resulted in a higher percentage of patients with malnutrition. It is not expected for the majority of PN patients to be malnourished when admitted. However, the severity of a patient's illness or presence of trauma may put a patient at risk for becoming malnourished throughout the hospital stay. To the researcher's knowledge, no studies assessing the appropriateness of PN in adult patients have openly stated how malnutrition was diagnosed. According to Phillips (2014: p. 59), "there is no universally accepted definition for malnutrition or set of signs and symptoms for classifying the degree of malnutrition". This leaves defining and diagnosing malnutrition up to each institution (Phillips, 2014). Therefore, differences in the percentage of malnourished PN patients compared to other studies may also be influenced by how malnutrition is defined and diagnosed by each institution. To increase consistency of malnutrition diagnoses, RDs should be notified when other medical professionals are concerned about the nutrition status of a patient so they can make a decision based on a nutrition focused physical examination. Once a patient is classified as malnourished, coding for malnutrition should be similar at each institution. To the researcher's knowledge, OSUMC was not required to code and bill for malnutrition until midway through the year of 2016. Prior to this requirement, malnutrition may have been diagnosed differently depending on the medical professional who did the diagnosing. For example, the RD most likely used a nutrition focused physical examination, while some physicians may have used medical lab work. Due to this, there may be some discrepancies with how malnutrition was defined and diagnosed throughout 2016. While the majority of patients from this study were malnourished when admitted to the hospital, there were no significant differences between appropriate or inappropriate PN use and malnourishment status upon admission.

A patient must remain NPO for at least 7 days before receiving PN, with the exception of malnourished individuals, is one of the main standards of practice for PN initiation (McClave et al., 2016). PN initiated within the first 7 days after hospitalization is not very beneficial in individuals who were previously well nourished prior to injury or sickness (McClave et al., 2016). EN is always the preferred form of nutrition support. Waiting 7 days allows medical professionals a chance to see if GI function returns and whether or not EN can be initiated. Unfortunately, this study found significantly more of the individuals who were inappropriately given PN were NPO less than 7 days. These results coincide with the study conducted by Kirkpatrick et al. (2013, unpublished). Out of the individuals inappropriately given PN, 75% were because patients were not NPO at least 7 days and they had a functioning GI tract. The results reveal a need for medical professionals to focus more on nutrition support standards of practice and further standardize methods of prescribing nutrition support based on the A.S.P.E.N./SCCM guidelines.

This study analyzed data to see if there were any differences between EN contraindications and appropriate or inappropriate PN use. To the investigator's knowledge, it may be one of the first studies to analyze and compare inappropriate and appropriate PN use in this manner. Identifying possible EN contraindications was a primary focus when reviewing charts because the presence or absence of an EN contraindication could reverse a decision on whether or not a patient was appropriately or inappropriately given PN. The data showed no significant differences between appropriate or inappropriate PN use and several EN contraindications, such as GI obstructions, inability to gain GI access, fistulas, an ileus, a GI bleed, or severe short bowel syndrome. However, significant differences were found between GI function and patient refusal in whether or not a patient was appropriately or inappropriately given PN.

In regards to GI function, significantly more patients who were appropriately given PN had abnormal GI function. GI function is a predominant deciding factor on whether or not to

appropriately use PN. Any abnormal GI function that severely impacts the digestion and absorption of nutrients would suggest that the preferred form of nutrition support, EN, would not have been appropriate under the circumstances. Therefore, PN would have been the most appropriate option in those situations. This finding is reassuring and positive because it shows the A.S.P.E.N./SCCM guidelines for prescribing PN were being followed for this condition for most patients. On the other hand, 18 individuals who were inappropriately given PN had normal GI function. Overall, the data shows some medical professionals are not following A.S.P.E.N./SCCM guidelines. More emphasis and training on a patient's GI function may be needed when deciding whether or not to use PN.

The other significant difference in EN contraindications was in patient refusal between appropriate or inappropriate PN use. None of the patients who were inappropriately given PN refused EN, while the patients who did refuse EN were appropriately given PN. This is another positive finding because it reveals that the medical professionals followed the A.S.P.E.N./SCCM guidelines while still respecting patients' autonomy and wishes. A limitation of this includes "patient refusal" may be subjective in the eyes of medical professionals.

Despite reviewing charts of patients who were admitted throughout the entire year of 2016, this study found fewer patients were provided PN (N=85 prior to exclusion) than Kirkpatrick et al. (2013, unpublished), which reviewed 113 charts of patients (prior to exclusion) who were admitted during a 6-month span. While the difference in appropriate and inappropriate PN prescriptions between the 2013 and 2016 may be circumstantial, the reduction of PN use at OSUMC during a 3-year span may be attributed to the implementation and utilization of the nutrition algorithm. Kiss and colleagues (2012) used a multifaceted strategy in in studying the conjunction with implementing a nutrition algorithm and reported a reduction in PN use after implementing a nutrition algorithm. Another study by Steele, Salazar, & Rypkema (2016) implemented a nutrition algorithm and found a reduction (26%) in PN days. In contrast to other studies, it observed pediatric oncology patients and was conducted differently than this study.

Overall, studies support that a nutrition algorithm can be capable of reducing PN. Any reduction in PN use would also translate into a reduction in costs related to PN formula and potentially the labor involved with initiating, maintaining, monitoring lab values, and dealing with complications associated with PN (Smyth et al., 2013).

The key finding of this study was that significantly more patients were appropriately given PN (65.7%) in 2016 when compared to the percentage of patients appropriately given PN (46.7%) in the Kirkpatrick et al. study (2013, unpublished). Unfortunately, there is limited research on nutrition support algorithms and little to no published research that looks at the effect of nutrition support algorithms on the appropriateness of PN, at least in adult PN patients. A study by Steele and colleagues (2016), which observed the effect of a nutrition support algorithm on PN use in pediatric oncology patients, found that "unnecessary PN use" was reduced but not dramatically without continuous efforts made by multidisciplinary support. While the studies by Kiss et al. (2012) and Woien & Bjork (2006) did not assess the appropriateness of PN, they did show positive outcomes on nutrient delivery after implementing a nutrition support algorithm. Martin et al. (2004) also saw improved nutrient delivery after implementing a nutrition support algorithm in addition to a significant reduction in hospital stay. While there are many reported benefits of implementing a nutrition support algorithm, the current study reveals that the implementation of the nutrition support algorithm may have influenced the decision-making process on what form of nutrition support to use and helped reduce the inappropriate use of PN.

Strengths and Limitations

One strength of this study was that there was one individual who decided whether or not patients were appropriately or inappropriately given PN. On the other hand, Kirkpatrick et al. (2013, unpublished) had one doctor, two registered dietitians, and several medical students reviewing charts. To the investigator's knowledge, research assistants had the opportunity to discuss questions regarding PN appropriateness with Dr. Kirkpatrick but were not required to

prior to making a decision. With so many research assistants, there could have been discrepancies between how each individual made decisions. It can be confidently assumed that the decision-making process of the current study was consistent throughout the study and extraneous variables were minimized. Although, this may be viewed as a limitation as well since the results are based on the opinion of one researcher who was not an experienced RD or medical professional. To decrease its power of limitation, several RDs were available to discuss cases and make accurate decisions on the appropriateness of PN to minimize the limitation.

A second limitation of the study was that many of the charts were not as detailed and descriptive as A.S.P.E.N./SCCM recommendations. This is a common limitation associated with retrospective chart reviews. As a result, determining factors for EN contraindications had to be altered slightly. For example, one EN contraindication is a paralytic ileus, but it had to last longer than 7 days in order to qualify as a true contraindication. Unfortunately, not all charts were specific about when an ileus was officially diagnosed. In addition, several patients that received PN were transfers from other hospitals and medical information gathered from the previous hospital generally was not provided in detail in OSUMC's medical charts. Due to these discrepancies, certain potential EN contraindications, like mechanical obstruction and ileus, were automatically counted as EN contraindication if it was mentioned anywhere in a patient's chart.

It was also difficult to fully compare this study to Kirkpatrick et al. (2013, unpublished) because more statistical analyses were conducted on this study than the original study. In addition, the original research article did not provide significant details about how research was conducted or what statistical tests were used. However, we were able to draw assumptions and conclusions from data that was available for comparison as well as gathering more information from some of the researchers directly involved with the original study.

CHAPTER V

CONCLUSION

While PN is a crucial form of nutrition support, the use of PN should be carefully and critically contemplated. Based on current nutrition support guidelines from A.S.P.E.N. and SCCM (McClave et al., 2016), the potential complications associated with PN use, as well as the cost of utilizing PN, research is warranted for quality improvement methods that may decrease PN use, especially inappropriate PN use. Implementing a nutrition support algorithm is one method that can be utilized to improve decisions regarding what form of nutrition support to use as well as significantly reduce inappropriate PN use. Implementing a nutrition support algorithm also helps standardize the process of prescribing PN because it provides a consistent and accurate method for determining the most appropriate form of nutrition support to use. Utilizing standardized processes for PN management, like nutrition support algorithms, can help minimize complications associated with PN use (Worthington, 2017). Implementing a nutrition support algorithm is worth consideration because the algorithm can help with improving the quality of patient care.

However, the 33% with of inappropriate PN orders at OSUMC shows a need for additional changes and protocols to help improve the adherence to the A.S.P.E.N./SCCM guidelines. A study published by the *Journal of Parenteral and Enteral Nutrition* that addressed when to appropriately use PN recommended using clinical reviews, clinical audits, plan-do-study-

act cycles, and medical use evaluations to track and monitor the appropriateness of PN use (Worthington et al., 2017). These strategies can help further identify areas for improvement and whether certain strategies were effective or not. This study could be categorized as an element of a clinical audit and the plan-do-study-act cycle strategies. The hospital may need to implement protocols that monitor PN use more closely while PN is initiated, PN formula is determined, and when PN is used. This would require more communication between medical professionals involved in PN management.

The results of the current study also bring into question whether the improved percentage of appropriate PN prescription was the result of the nutrition algorithm itself or if the 33% inappropriate PN use demonstrates a need for additional efforts, such as another quality improvement method, used in conjunction with the nutrition algorithm. In general, there are limited studies available that analyze the effect of implementing a nutrition support algorithm, which shows there is still a need for more research regarding nutrition support algorithms. Nutrition support algorithms examined differed depending on the study, which could have potentially made an impact on each study's results. Future research could explore what style or format of nutrition algorithm is the most effective. For example, a study could question whether the flowchart format is the most effective, or if there is a better option available. Determining how much information and how specific a nutrition support algorithm should be may also be crucial research. In addition, simply evaluating and redesigning the charting process to ensure pertinent information is provided that accurately follows the A.S.P.E.N./SCCM guidelines may be beneficial. Future research could explore whether or not nutrition algorithms are currently providing too little or too much information, and if they are easily understood by the individuals who utilize them. Research is needed to make nutrition algorithms the most effective they could possibly be.

If the relatively high percentage of inappropriate PN prescriptions was not the result of flaws in the algorithm itself, perhaps it was the method in which it was implemented or a need for

another quality improvement component. Current research consistently supports the use of nutrition support teams or multidisciplinary teams as the most effective quality improvement method to help monitor and reduce inappropriate PN use. (Boitano et al., 2010; Hvas et al., 2014; Mueller, 2012; Schaik & Niewold, 2014; Worthington et al., 2017). Unfortunately, implementing these kinds of teams may not be possible, easy, or as budget friendly when compared to nutrition support algorithms (DeLegge & Kelley, 2013). However, this does not mean that communication and collaboration between medical professionals involved with managing PN cannot be increased. A volunteer nutrition support team may be an option for an institution on a shoestring budget. More research may be needed to determine other methods that can be used in conjunction with nutrition support algorithms, specifically cost-effective ones, to help decrease the occurrence of inappropriate PN use at this hospital.

Overall, nutrition support algorithms can significantly reduce the inappropriate use of PN as well reduce PN use in general. However, with such variability in inappropriate PN use across studies (Worthington et al., 2017), a change in protocol or implementing a new method to use with nutrition support algorithms is needed to help improve their effectiveness. It is imperative to find a budget friendly solution to help decrease the inappropriate use of PN. Patients deserve to receive the same quality and most appropriate treatment regardless of the size or monetary budget of an institution. They also deserve individualized care because each patient portrays a unique set of characteristics that should be taken into consideration prior to medical treatment.

Future Research & Recommendations for OSUMC

This research provides a solid basis for future PN related studies at OSUMC. For example, a continuation of this research may observe the number of consecutive days a patient received PN and compare that to current standards of practice and regulations for PN use. Future studies could also go in other directions and determine whether or not the PN formulas or the PN delivery route was appropriate. In addition, the cost related appropriate and inappropriate PN use

from this study as well as Dr. Kirkpatrick's study (2013, unpublished) could be calculated in order to determine if any cost savings occurred after algorithm implementation.

At the time of this writing, OSUMC had not implemented the 2016 A.S.P.E.N./SCCM guidelines. In order to implement these guidelines, the hospital would need to incorporate new hospital policies and practices for all patients. One of the main differences (in relation to this research) between the 2009 and 2016 A.S.P.E.N./SCCM guidelines is the suggestion to assess nutritional risk specifically using NRS 2002 scores and/or NUTRIC scores (McClave et al., 2016). At the time of research, these scores were not calculated and displayed in medical charts nor were they able to be calculated due to missing pertinent information in charts. Implementing these new guidelines would not only directly affect the practices of RDs, but also other medical professionals who work directly with patients admitted to the hospital. When these guidelines are eventually adopted and implemented, future research could duplicate this study and use the 2016 A.S.P.E.N./SCCM guidelines to determine how well the hospital appropriately or inappropriately prescribes PN.

The nutrition algorithm itself is also in need of an update to correspond with the 2016 A.S.P.E.N./SCCM guidelines. In addition, the algorithm could be modified so that it is more effective, precise, and user friendly. For example, the algorithm is lacking some information regarding which PN route to choose or what formulas work best for certain PN routes. So, the algorithm could state contraindications for PPN in order to help physicians choose the most appropriate PN route, or it could provide a list of formulas that would work best for PPN versus CPN. By including this information, certain PN contraindications and potential complications, like giving a formula with a high osmolality (>900 m/Osm) through a peripheral vein, can be avoided.

It may also benefit this hospital and other institutions to implement some other form of quality improvement method in addition to the algorithm. While the algorithm itself appeared to significantly reduce inappropriate PN use, the percentage of appropriate PN use could still

improve. Implementing another quality improvement method in conjunction with the nutrition support algorithm may help further reduce that percentage. Worthington and colleagues (2017) suggest implementing a quality improvement process like clinical reviews, clinical audits, plan-do-study-act cycles, and medical use evaluations in order to monitor and track the appropriateness of PN at an institution. The algorithm could be used as part of a clinical audit or a plan-do-study-act style, however employees of OSUMC who are in charge of hospital protocols must review these results and address changes accordingly. Worthington and colleagues (2017) also stated that "algorithms with ongoing monitoring education and appropriate feedback" are helpful in PICUs (pediatric intensive care units) when attempting to correct nutrition monitoring deficits, so this may translate well with the adult population. Perhaps providing a PN refresher meeting every so often for veteran medical professionals and introductory meetings for incoming students and staff would help improve results. Even incorporating a required annual computer training regarding PN may be beneficial. OSUMC may even consider increasing the RDs' current scope of practice by requiring them to visit each and every PN patient during their hospital stay to review PN appropriateness, which is similar to what was practiced by Smyth and colleagues (2013). The hospital could also encourage increased collaboration and cooperation between medical professionals in order to help make more appropriate decisions.

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APPENDICES

APPENDIX A

DEVELOPMENT OF PARENTERAL NUTRITION THROUGHOUT HISTORY

Date	Contributor	Contribution	Reference
300 BC	Herophilus and Erasistratus	First description of the circulatory system	15
1091–1161	Ibn Zuhr	Early attempt at "nourishing" a human with the aid of hollow silver needle	25
1628	Harvey	Detailed description of blood circulation	28
1658	Wren	IV device made from goose quill that infused wine, ale, and opiates into a dog	31, 32
1710	Courten	Infusion of vinegar, salts, and urine into a dog with no adverse effects; dog died when infusing olive oil	34
1733	Hales	IV infusion of water, leading to discovery of dropsy	36
1831	Latta	IV infusion of saline solution to successfully treat cholera	41, 42
1843	Bernard	IV infusion of sucrose that was soon detected in the patient's urine	44
1869	Menzel and Perco	SC infusion of fat, milk, and camphor into dogs showing high doses of fat can be given without diverse effects	58
1873	Hodder	IV infusion of milk to treat cholera	43
1875	Krug	Fed a patient suffering from anorexia nervosa with SC injections of oil and protein	46
1904	Friedrich	Administered PN by SC infusion of peptone, fat, glucose, and salt	74
1909	Abderhalten	First successful attempt at PN	75
1911	Kausch	Infused glucose postoperatively	78
1913	Henriques and Andersen	Achievement of positive nitrogen balance in a goat fed animal protein IV	76
1915	Woodyatt et al	Used infusion pump for constant infusion of IV glucose	80
1934	Rose	Identification of essential amino acids in humans	91
1936	Elman	Successful IV infusion of enzymatically hydrolyzed proteins to dogs and humans	92
1939	Shohl	IV infusion of hydrolyzed proteins with glucose and laevulose—satisfactory results	94
1949	Rhode et al	Successful infusion of adult dogs with PN	103
1963	Schuberth and Wretlind	Successful testing of fatty emulsion containing soya oil and egg yolk phospholipids	97
1964	Bansi et al	IV supply of synthetic L-amino acid	111
1967	Dudrick et al	Successful infusion of beagle puppies with PN	102
1968	Wilmore and Dudrick	Successful long-term infusion of an infant with PN	105
1973	Hofert et al	First amino acid formula designed for infants	112
1974	Grotte et al; Borresen and Knutrud; Jurgens et al	Designed programs of PN with emulsified fat for infants and children	99–101
1983	Wretlind	Developed a synthetic formula solution called Vamin for postoperative patients	113
1987	Panteliadis et al	Designed formula of middle-chain and long-chain triglycerides, containing taurine	96

IV, intravenous; PN, parenteral nutrition; SC, subcutaneous.

(Vassilyadi et al., 2013).

APPENDIX B

NUTRITION SUPPORT ALGORITHM

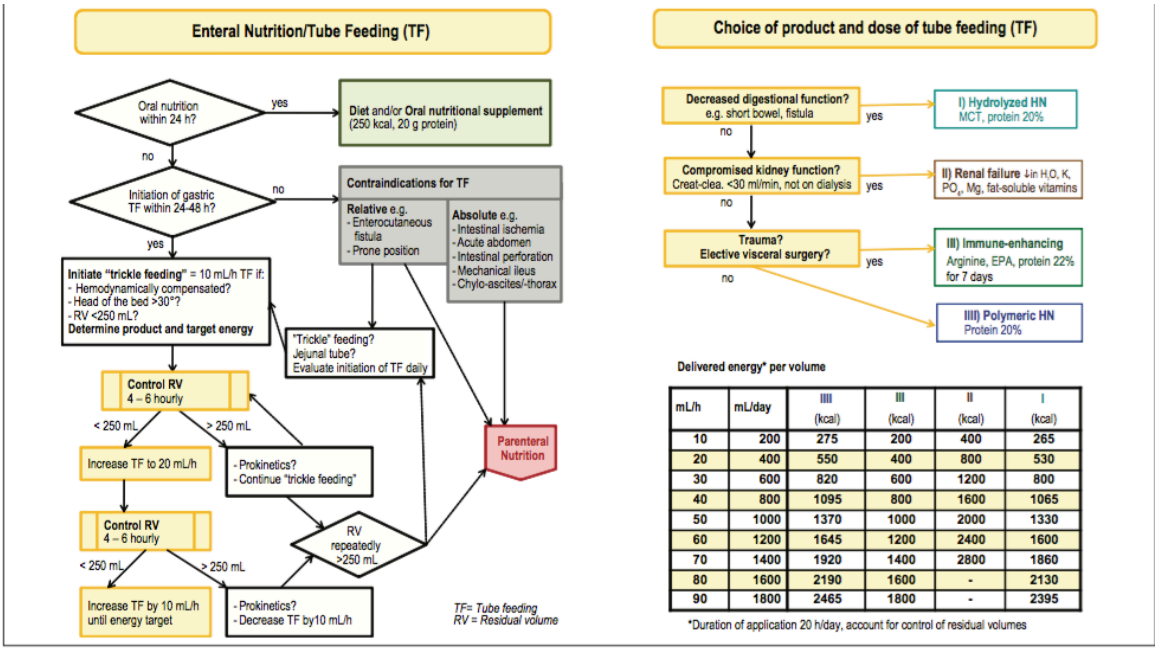


Figure 1. Example from the nutrition support algorithm for initiating enteral nutrition support and for choice of enteral tube feeding. creat-clea, creatinine clearance; EPA, eicosapentaenoic acid; MCT; medium-chain triglyceride; HN, high-nitrogen; RV, residual volume; TF, tube feeding.

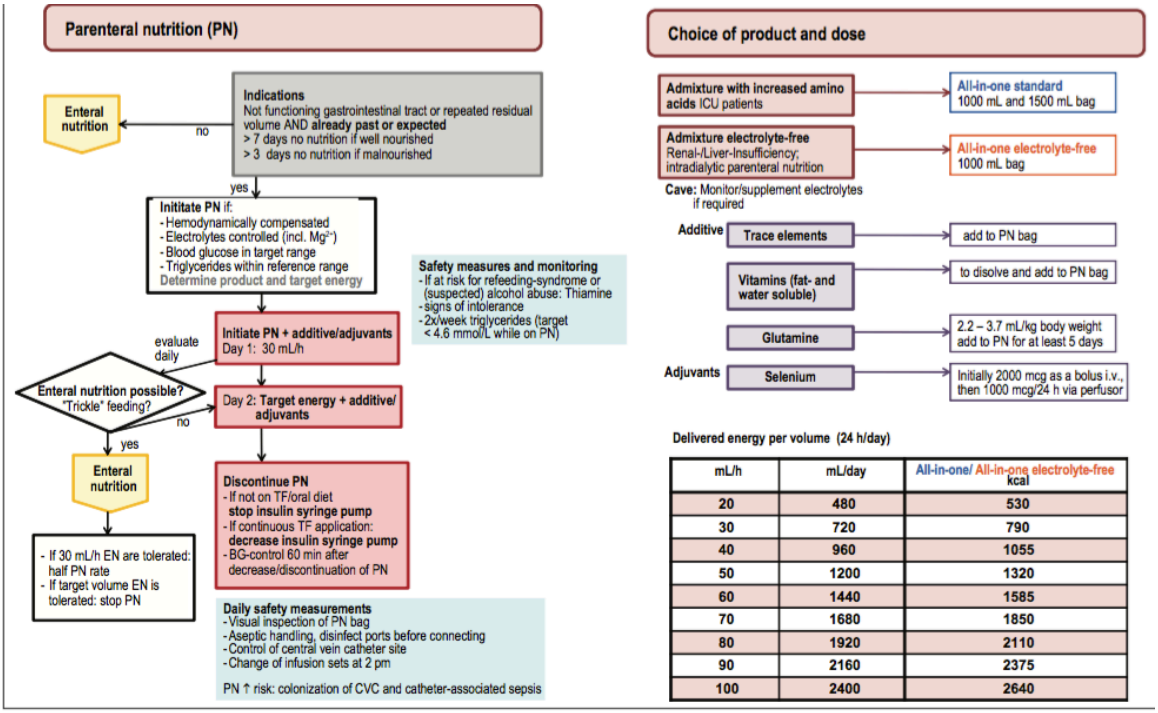


Figure 2. Example from the nutrition support algorithm for parenteral nutrition and for choice of parenteral nutrition. BG, blood glucose; CVC, central venous catheter; EN, enteral nutrition; ICU, intensive care unit; TF, tube feeding.

(Kiss et al., 2012)

APPENDIX C
DATA COLLECTION TOOL

Chart Review Data Collection Guide

Admit Date:_____

Ethnicity:_____ Age:_____ Gender:_____

Admit Weight:_____ Height:_____ BMI:_____

Medical Diagnosis:_____

GI Function:

Does the patient have appropriate [+] GI Function? *YES* or *NO*

Does the patient have altered or no [-] GI Function? *YES* or *NO*

Contraindications:

Contraindications for Enteral Nutrition:

- Mechanical GI Obstruction
- Severe Short Bowel Syndrome
- High Output Fistula
- Severe GI Bleed
- Inability to Gain GI Tract Access
- Severe GI Malabsorption
- Severe N/V Refractory Medications
- Prolonged Paralytic Ileus (>7 days)
- Patient Refusal
- Other:_____

Contraindications to Parenteral Nutrition:

- Fluid Restriction
- Large Nutrient and Electrolyte Need
- Significant Malnutrition
- Other:_____

Dietary Recommendations:

Is there documentation of malnutrition upon admission? *YES* or *NO*

PN Start Date: _____ Number of days before starting PN: _____

Number of days NPO prior to starting oral diet or enteral nutrition: _____

Appropriate vs. Inappropriate:

Was the initiation of PN appropriate? *YES* or *NO*

NOTE:

APPENDIX D
NUTRITION SUPPORT ALGORITHM

DRUG ALLERGY	1.	2.	3.	Weight:

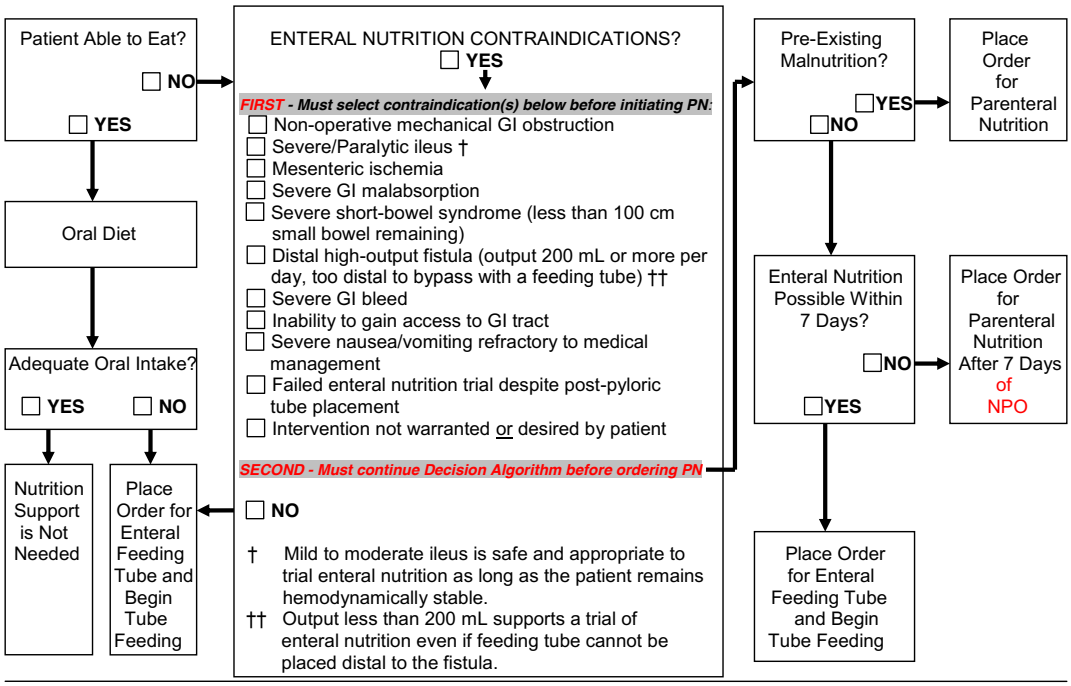
Do not use abbreviations - U, IU, QD, QOD, X.0, .X, MS, MSO4 and MgSO4
Check the boxes to activate or select desired orders.

Strike through entire line to cancel a prechecked order, initial, date and time.
RBTO = Telephone orders RBVO = Verbal orders

DATE & TIME

PARENTERAL VS ENTERAL NUTRITION DECISION ALGORITHM
***** Completion of Entire Algorithm Required for Initiation of Parenteral Nutrition (PN)*****

**** Enteral Nutrition is the preferred route of feeding****



Criteria for Peripheral versus Central Parenteral Administration:
- Peripheral administration - anticipate more than 5 days/no more than 2 weeks
- Central administration - anticipate more than 2 weeks

Indication(s) for initiation of Parenteral Nutrition are noted in algorithm above. *(REQUIRED)*

Physician Signature _____ **Date** _____ **Time** _____

Noted: Nurse Signature _____ **Date** _____ **Time** _____

Oklahoma State University Medical Center

Patient Label

PARENTERAL VS ENTERAL NUTRITION DECISION ALGORITHM
MR-PO-1049 (Draft 11/7/15)

Page 1 of 1
ORIGINAL TO CHART SCAN TO PHARMACY

APPENDIX E
ORIGINAL INSTITUTIONAL REVIEW BOARD MEMO

College of
Osteopathic Medicine

Office of Research and Sponsored Programs
1111 West 17th Street
Tulsa, Oklahoma 74107-1898
(918) 561-1400
Fax (918) 561-1416

Institutional Review Board
FWA # 5037

Memo

To: Adriana Tucker,
Nutritional Science

From: Amber Hood, MS, CPIA, CIP Amber Hood
Administrator, Institutional Review Board

Date: December 19, 2016

Re: **IRB Protocol # 2016033**

Titled: **Analyzing the Appropriateness of Parenteral Nutrition at a University Hospital**

On behalf of the OSU-CHS Institutional Review Board (IRB), I reviewed your protocol entitled *"Analyzing the Appropriateness of Parenteral Nutrition at a University Hospital"* and determined it meets exempted criteria under federal guidelines, 45CFR 46.101(b)(2); therefore, you are free to begin the study.

As principal investigator of this protocol, it is your responsibility to:

- Conduct the research study in a manner consistent with the requirements of the IRB and federal regulations 45 CFR 46.
- Request approval from the IRB prior to implementing any/all modifications as changes could affect the exempt status determination.
- Maintain accurate and complete study records for evaluation by the university, or inspection by regulatory agencies.

When your study is completed, please notify the IRB.

If you have questions please contact me at 918-561-1413 or amber.hood@okstate.edu.

APPENDIX F
INSTITUTIONAL REVIEW BOARD MEMO WITH UPDATES

College of
Osteopathic Medicine

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Institutional Review Board
FWA # 5037

Memo

To: Adriana Tucker,
Nutritional Science

From: Amber Hood, MS, CPIA, CIP Amber Hood
Administrator, Institutional Review Board

Date: March 22, 2017

Re: **IRB Protocol # 2016033 - AMENDMENT**

Titled: **Analyzing the Appropriateness of Parenteral Nutrition at a University Hospital After Implementation of a Nutrition Support Algorithm**

On behalf of the OSU-CHS Institutional Review Board (IRB), I reviewed your request for changes to your protocol previously entitled *"Analyzing the Appropriateness of Parenteral Nutrition at a University Hospital."* The IRB file has been updated with the changes itemized below. Your amended protocol still meets exempted criteria under federal guidelines, 45CFR 46.101(b)(2); therefore, you are free to continue with the study.

- Revision of the study title from "*Analyzing the Appropriateness of Parenteral Nutrition at a University Hospital*" to "*Analyzing the Appropriateness of Parenteral Nutrition at a University Hospital After Implementation of a Nutrition Support Algorithm*".
- Usage of the 2009 ASPEN/SCCM guidelines, instead of 2016 ASPEN/SCCM guidelines
- Revised data collection tool (received 3/13/2017)

As principal investigator of this protocol, it is your responsibility to:

- Conduct the research study in a manner consistent with the requirements of the IRB and federal regulations 45 CFR 46.
- Request approval from the IRB prior to implementing any/all modifications as changes could affect the exempt status determination.
- Maintain accurate and complete study records for evaluation by the university, or inspection by regulatory agencies.

When your study is completed, please notify the IRB.

If you have questions please contact me at 918-561-1413 or amber.hood@okstate.edu.

VITA

Adriana Cristina Tucker

Candidate for the Degree of

Master of Science

Thesis: ANALYZING THE APPROPRIATENESS OF PARENTERAL NUTRITION AT A UNIVERSITY HOSPITAL AFTER IMPLEMENTATION OF A NUTRITION SUPPORT ALGORITHM

Major Field: Nutritional Sciences

Biographical:

Education:

Completed the requirements for the Master of Science in Nutritional Sciences at Oklahoma State University, Stillwater, Oklahoma in May, 2018.

Completed the requirements for the Bachelor of Science in Nutritional Sciences at Oklahoma State University, Stillwater, Oklahoma in May, 2016.

Experience:

August 2016-Present	*Nutrition Graduate Assistant*, OSU-Department of Wellness, Stillwater, OK
February 2015- May 2016	*Parking Cadet,* OSU-Parking and Transit, Stillwater, OK
Summer 2015	*Kitchen Staff and Management Intern,* UNL-Cedar Point Biological Station, Ogallala, NE
Summer 2014	*Kitchen Staff,* UNL-Cedar Point Biological Station , Ogallala, NE
Summer 2013	*Camp Counselor and Equine Program Co-Leader,* Camp McFadden, Ponca City, OK

Professional Memberships:

Academy of Nutrition and Dietetics