COMPARISON IN MACRONUTRIENT CALCULATIONS
IN PARENTERAL NUTRITION:
DO DISCREPANCIES EXIST BETWEEN
MEDICAL RESIDENTS AND
REGISTERED DIETITIANS?

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BY
KATIE L. DANIELSON, RD CD
ADVISOR – JAY KANDIAH, PH.D RD CD

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CHAPTER 1

INTRODUCTION

Parenteral nutrition (PN) is a form of nutrition support that is implemented in the clinical setting when oral nutrition and enteral nutrition support are contraindicated (1). Dispersing nutrients directly into the blood stream is a highly volatile task and requires trained medical professionals (2). As with all aspects of the medical field, mistakes are possible in the prescription phase of the drug process involving PN (3).

Many medical professionals participate in the PN ordering process including registered dietitians (RD), nurse specialists, pharmacists, and medical doctors (MD), including medical residents (MR) (1, 4, 5). Each clinician who participates in the ordering process possesses a unique perspective to the patient’s overall health. Due to the specificity and extensiveness of nutrition support education in the RD’s field and the lack of sufficient nutrition education in MDs’ formal training (1, 6-9), the RD is viewed as the expert in nutritional topics (10-11). Some medical professionals may choose to further their knowledge of PN by obtaining a nutrition support credential (2). Obtaining a specialty credential in medicine gives credibility and authority to a clinician as well as providing consistency to nutrition support in health care. The credential that will be
mentioned in this thesis is the Certified Nutrition Support Clinician (CNSC), credentialed through the American Society of Parenteral and Enteral Nutrition (ASPEN).

In 2000, the Standards of Practice for Nutrition Support Dietitians declared RDs as having the ability to “recommend, write and/or obtain orders” in the PN process (12). As a result, in 2005, a survey of entry-level RDs found that 19% (n=1477) of them were already writing orders for PN (12). This ability to write orders is referred to as prescriptive authority. A survey in 2008 found that a majority (54%, n=351) of RDs do not have this authority (13). In an institution in which an RD does not have prescriptive authority the prescriber writes a PN prescription and the RD makes recommendations for the macronutrients in the PN. Therefore, the RD’s recommendation has become the primary way of communicating with prescribers concerning a patient’s PN solution (10).

Registered dietitians’ recommendations are meant to be a reference for the MD as they decide the appropriate amounts of macronutrients (carbohydrates, fats and protein) for a patient’s PN solution. The former statement is medical protocol in theory but when the RD to MD referral process is looked at more closely, it is evident through previous studies that there are large disconnects. Previous research has shown that 82% (n=153) of doctors did not consult the RD’s recommendations (10), 8% to 38% of PN orders may be prescribed inappropriately (7), and there is often verbal disagreement in patient-by-patient recommendations regarding PN among medical professionals (1). These facts demonstrate that the recommendations made by RDs are not being utilized and medical professionals often cannot agree on the appropriate nutrition support. The 2010 survey by Adams and colleagues found after surveying participating medical schools that only 27%
of the schools (n=105) are meeting the minimum recommended nutrition hours that was set by the National Academy of Sciences in 2004 (6). All of these facts may be linked to the results of the Vanek study that reported a large percentage of PN orders are prescribed incorrectly (7). It becomes a necessary research topic to determine if prescribers and RDs are making similar recommendations.

**Problem Statement**

Registered dietitians are trained as nutrition professionals but have been granted limited authority in the clinical setting for prescribing a patient’s PN needs (13). As seen briefly above, and further detail will follow in chapter II of this thesis, MRs do not receive adequate nutrition education and are, therefore, not confident in their nutrition knowledge base. If a difference exists, further research will be done to explain plausible reasons for the discrepancies. One possible explanation that will be highlighted is the RD is a more adequately trained nutrition professional. The aim of the study was to provide support for the initiative that RDs should be allowed ordering privileges and management of PN. The review of literature in chapter II will highlight upon the role of the RD, but there are many benefits of this shift in privileges including reduced hospital costs (32).

**Purpose Statement**

The purpose of this study was to examine differences in PN macronutrient calculations between prescribers and RDs by conducting a retrospective chart review of orders and notes at a Midwest teaching hospital.
Research Questions

The following questions were answered in this study:

Was there a difference between prescribers and RDs in:

I. Non-protein calories?

II. Grams of protein?

III. Carbohydrate to fat ratios prescribed?

Two sub-questions were also addressed:

IV: Was there a difference in macronutrient calculations between prescribers and RDs when body mass index (BMI) was considered?

V: Did years of medical residency experience for the MR have an effect on nutrition support recommendations?

VI. Was there a difference between MRs and RDs recommendations when years of residency were considered?

Rationale

Many hospitals are directing attention to the errors that occur in PN and the resulting harm to the patient. To Err Is Human, which was published in 2000, boldly admits that medical error is present and damaging, however, the responsibility of medical professionals still stands to reduce the prevalence of error (14). Incorrect formulations may result in detrimental electrolyte imbalances, high/low lipid levels, high/low blood
glucose values, impairment to the immune system, organ dysfunction, water retention, refeeding syndrome or a multitude of other effects (5). Due to the severity of harm in PN errors, initiatives are being introduced into hospitals to reduce these injurious occurrences. The review of literature available in chapter II discusses in greater detail some of the initiatives hospitals have implemented to decrease error. These include nutrition support teams (NST) and continuing education for hospital staff (1, 15-16).

Most attempts at reducing error assume there is uniform knowledge among medical professionals in nutrient recommendations of PN. From that assumption, they then try to find ways to prevent human error from occurring. What if the error, and resulting harm from PN formulations, lies not in human error but instead is derived from a lack of nutrition knowledge of the medical professional?

**Assumptions**

For the purpose of this study the following assumptions were identified:

1. Diseases of the patients in this current study represent diseases that occur in patient populations of hospitals across the nation.

2. Prescribers and RDs transcribed their recommendations accurately during medical charting.

3. When assessing calculations for PN, prescribers and RDs gathered anthropometric data (height/weight, etc.) from medical records.

4. There are no variations in macronutrient calculations due to a time factor because only a 48-hour window was allowed for RD notes to be collected before or after the corresponding order to begin PN was placed.
5. There are no variations in calculations when the prescriber and RD wrote their orders or recommendations.

6. Years of experience does not affect the orders and recommendations of prescribers and RDs.

**Limitations**

For the purpose of this study the following limitations were identified:

1. The current sample of prescribers and RDs are not generalized to all medical professionals.

2. There is a potential possibility for prescribers to consult the RD’s note to aid in their macronutrient calculations for PN. Although this consultation is encouraged, this may have decreased the variance in calculations when compared to the RD’s note.

3. The population selected was limited to prescribers and RDs at a single Midwestern teaching hospital.

4. The subject population included some patients with multiple admissions at separate time periods throughout the 2 years.

**Definitions**

For the purpose of this study, the following definitions were used:

1. **Adult** was defined in this study as any person greater than or equal to 18 years of age.

2. **Appropriate** is defined as “especially suitable, compatible or fitting” (17). This term is used in regards to nutrition support being warranted or not. The term “inappropriate” when referring to a prescribed nutrition support therapy indicates that a different form
of nutrition (nothing by mouth, by mouth feeding, enteral or parenteral) would have been the more proper line of therapy.

3. The carbohydrate to fat ratio is the preferred method of recording carbohydrates and fat for PN solutions at the participating institution. A ratio is defined as “the relationship in quantity, amount, or size between two or more things (17).” For this study the carbohydrate to fat ratio is the relationship in amount between carbohydrates and fat in a PN solution of the NPC and is reported as a percentage here.

4. Dietetic Intern (DI) is an individual who is in the process of “complet[ing] an accredited, supervised practice program at a health-care facility, community agency or foodservice corporation” in an accredited program through the American Dietetic Association (11).

5. Initiation is defined as the “beginning of” (17) and in this thesis refers to the start of PN in a patient.

6. Kilocalorie (kcal or calorie) is the amount of heat energy required to raise the temperature of 1 mL of water at 15 degrees Celsius by 1 degree Celsius (5). “The calorie is used in nutrition to express the energy content of food (18).” Kilocalories, calories and energy are used synonymously throughout this research paper.

7. Macronutrients are “macromolecules in plant and animal structures that can be digested, absorbed and used by another organism as energy sources and as substrates for synthesis of the carbohydrates, fats and proteins required to maintain cell and system integrity” (5).
8. **Medical doctor (MD)** describes a person who has completed undergraduate school, medical school and graduate medical education, as well as obtaining a license to practice medicine from a state or jurisdiction of the United States in which they are planning to practice (19). “They diagnose illnesses and prescribe and administer treatment for people suffering from injury or disease (20).” Medical residents are also considered medical doctors beginning in their first year of residency (see definition below). Physician is used interchangeably with MD throughout this study.

9. **Medical Resident (MR)** is any MD in an accredited graduate medical education program; these include medical interns, medical residents, and medical fellows (21).

10. **Non-protein calories (NPC)** are the total energy needs from carbohydrates and fat alone (22) that combine with protein to form the total amount of kilocalories a person will or needs to consume in a 24 hour period.

11. **Note** is used in this thesis to refer to progress notes that were collected in an electronic medical record (EMR). Notes are brief comments or explanations (17) but can also contain orders by prescribers or recommendations by non-prescribers such as a RD.

12. **Nutrition Support** is the provision of enteral or parenteral nutrients to treat or prevent malnutrition. Nutrition support therapy is part of nutrition therapy, which is a component of medical treatment that can include oral, enteral, and/or parenteral nutrition to maintain or restore optimal nutrition status and health (2).

13. **Parenteral nutrition (PN)** is intravenous nutrition for patients who are unable to tolerate nutrients through the gastrointestinal tract or in patients where enteral nutrition is contraindicated (3).
14. **Prescriber** is someone who writes or gives medical prescriptions (17). It is used in this study to refer to MDs, nurse practitioners, MRs, and pharmacists because they are the medical professionals at the participating institution who were given authority to prescribe PN for a patient.

15. **Prescriptive authority** refers to the ability “to act autonomously to provide nutritional services that include ordering diets, nutrition-related tests, or procedures authorized by the clinical privileges granted to the practitioner by the appropriate institutional authority (13)”.

16. **Refeeding syndrome** is a complication that results when PN is administered aggressively causing potentially lethal electrolyte imbalances (5).

17. **Registered dietitian (RD)** is a food and nutrition expert who can translate the science of nutrition into practical solutions for healthy living (11).

18. **Sepsis**, or a **septic state** is a systemic response by the body to an identifiable infection (5).

19. **Underfeeding** is when the total calories for a patient are determined by 60-70% of their estimated energy requirements (23).

**Summary**

The RD is a valuable part of the medical team in improving accuracy in PN ordering due to their extensiveness in nutrition training. As seen briefly in the introduction above, MDs often do not utilize the role that the RD plays as a recommending partner in nutrition support and errors continue to occur in PN (3, 7, 10). This study aimed to compare macronutrient recommendations in PN between prescribers
and RDs. This study hoped to expose that great variance exists between prescribers and RDs and then explore possibilities to explain the difference in hopes to provide evidence for RDs to be granted ordering privileges and control over PN. Assumptions, limitations and definitions have been included in chapter I due to their overall pertinence to this study.
CHAPTER II

REVIEW OF LITERATURE

The following topics were identified as pertinent to the literature review for this study; 1) Overview of nutrition support; 2) Widespread errors among parenteral nutrition (PN) ordering; 3) Hazardous effects of miscalculated PN; 4) Hospital initiatives for reducing PN error; 5) Nutrition education for the medical resident (MR); and 6) The advancing role of the registered dietitian (RD) in PN.

Overview of Nutrition Support

Nutrition is a component of life that is essential to survival. A lack of nutrition will cause a decrease in organ function and at a certain level, death is inevitable. A lack of optimal nutrition will lead to death due to weight loss associated with loss of protein mass (4). Human bodies were created to gain nutrition primarily through oral nutrition. However, for many patients oral nutrition is insufficient or sometimes they are unable to consume any nutrients at all due to either a temporary or permanent non-functioning gastrointestinal tract (2). When this is suspected, a thorough review of the patient’s condition should take place to determine other options of nutrition support that are appropriate in order to maintain optimum nutrition. These two options are enteral
nutrition or parenteral nutrition. Enteral nutrition should be the first option considered when oral nutrition is contraindicated. This form of nutrition provides adequate nutrients to the patient through tube feeding via the stomach or small intestine (2). Parenteral nutrition is a more expensive form of nutrition support where nutrients are provided intravenously, bypassing the gastrointestinal tract. This form of nutrition is used when a patient cannot eat or cannot use their stomach or small intestine for digestion and absorption (2). The indications for parenteral or enteral nutrition have been outlined in strict guidelines by the Society of Critical Care Medicine (SCCM) and the American Society of Parenteral and Enteral Nutrition (ASPEN) to prevent inappropriate use of either form of nutrition support. These guidelines were used as the main resource as they compile the results of multiple studies to determine nutrition support guidelines. If there are any other supporting studies they will be cited in the text. Unfortunately, guidelines are not always followed and many times the wrong form of nutrition support is prescribed to a patient (24, 25). This study will focus on the prescription calculations of PN.

Widespread Errors among Parenteral Nutrition Ordering

A study by Sacks and colleagues done in 2009 sought to determine overall frequency of errors that occurred during different phases of the PN ordering process. These phases included prescription (order-writing), transcription (drug processing), preparation of the PN solution ordered, and administration of PN to the patient. During a nineteen-month period, PN orders were collected (n=4730) and through self-reporting of errors, a 1.6% error rate was found. Most of these errors occurred in the transcription and administration phases. The authors pointed out that the frequency of errors found in their
study is most probably underreported because the participants were asked to self-report errors they made on the job. This is likely to occur in practice throughout all hospital systems so it is logical to assume that all known hospital errors are likely an underestimation of errors that actually occur. Furthermore, this study stated that all errors occurring in the prescription phase of their study were detected and corrected before the preparation phase (3). The prescription phase is a focal point that the Sacks study did not highlight upon. Prescription error could originate from a myriad of sources. Some of these could include manual transcription error (2), incorrect transfer of anthropometric information to the PN order, miscalculations (27), incorrect biochemical data (28), or possibly even the lack of adequate nutrition support knowledge (1, 6-9, 16). Unfortunately, the Sacks study did not take into consideration error resulting from lack of nutrition knowledge that potentially affects what physicians prescribe.

A study by Brown and colleagues in 2007 found a 27.9% (n=204) error in the prescribing rate of PN for both pediatric MRs and neonatal nurse practitioners (26). Trujillo and colleagues conducted a study in 1999 on the appropriateness of prescribing PN and found that 15% (n=209) of PN orders prescribed, in their study, were deemed inappropriate (i.e., other forms of nutrition were deemed clinically appropriate) (25). A case study was conducted by Vanek and colleagues in 1997 where 48 attending medical doctors (MD), MRs and medical students assessed three mock patients and determined their nutrition support needs. Guidelines for calculating PN were printed on the back page of each mock patient case to increase physician accuracy. The participating institution’s nutrition support team (NST) determined a clinically appropriate response
for each mock patient and ±10% of this response was defined as error. Although there were three case studies, the correct answer for the third case study was that the patient was not appropriate for PN and therefore the results of the survey only included the first 2 case studies. The researchers found that only 27% and 29% (respectively for the two case studies) of the MDs’ responses were within the clinically appropriate responses for non-protein calories (NPC). The researchers also found that only 9% and 11%, respectively, of the MDs’ responses were within the clinically appropriate responses for grams of protein (PRO). The study concluded that medical school education in nutrition support is insufficient (7).

Other researchers have proposed that error in PN prescription occurs in manual data entry or computation. One study conducted by Dr. James Legler in 1990 looked at the prescription phase by addressing MDs’ accuracy in manual computation of PN order calculations (n=350). Although error was found to occur in the MDs’ calculations, the research did not find statistically significant differences between the computer and the MDs’ calculations. However it was noted that error occurred in the MDs’ calculations to a degree that the computer could have corrected (27). Although this study was done over twenty years ago, it illustrates that the largest source of error in PN calculations is not whether a computer or human calculates the macronutrient needs but may reside in the MDs’ knowledge of PN calculations. In 2009 Mirtallo and colleagues looked at error in manual data entry of anthropometric and biochemical data. The purpose of their study was to create and then utilize a nutrition support web-based application for managing PN
It can be assumed that this error in manual data entry would translate to PN ordering as well.

However, what if the problem lies in a deficit of appropriate education? Educational strategies are a common go-to for preventing hospital errors. One study by Campino and colleagues in 2009 reported an educational intervention on drug prescriptions for MDs, registered nurses, and nurses’ aids. The researchers recorded and evaluated drug prescriptions in two phases before and after an educational intervention. The pre-intervention phase (n=4182) revealed a 20.7% error rate. The intervention consisted of fifteen informational sessions given to MDs, registered nurses and nurses’ aides by a pharmacist. After the intervention (n=1512), a prescription error rate was found to be 3% of all orders collected. The researchers found a 17.7% (p < 0.001) reduction in prescription errors directly related to education. This study did not include PN orders but revealed that despite being formally trained in drug prescription, errors occurred and were subsequently reduced with continuing education on the topic (16).

**Hazardous Effects of Miscalculated Parenteral Nutrition**

A common problem in the prescription and administration of PN is delivering excessive energy. Administering excess calories to the blood can cause hyperglycemia, oxidative stress, insulin resistance, greater infectious morbidity, hepatic abnormalities, prolonged duration of mechanical ventilation, refeeding syndrome and increased hospital length of stay (5, 23). When hyperglycemia is induced, other complications follow, including sepsis, increased intensive care unit (ICU) length of stay and mortality (23). Metabolic complications of patients on PN support can be easily traced back to an
incorrect macronutrient component in the order. The SCCM and ASPEN have guidelines to prevent these metabolic complications (23).

The 2009 ASPEN guidelines support the idea of “permissively underfeeding” obese (body mass index (BMI) > 30) patients. This is typically done by infusing no more than 60-70% of their estimated energy needs in PN (23). The guidelines additionally recommend “in all ICU patients receiving PN, mild permissive underfeeding should be considered at least initially. Once energy requirements are determined, 80% of these requirements should serve as the ultimate goal or dose (23).” Underfeeding by 60-70% of needs for the obese patient and 80% for all ICU patients is the recommended guideline (23). Owaise and colleagues performed a review of studies pertaining to this subject. The researchers looked at 591 different articles that were relevant to the subject of permissive underfeeding. They looked in-depth at 12 studies and found that permissive underfeeding was associated with improved outcomes in short-term PN. These outcomes included less metabolic burden, increased endogenous lipid mobilization, better glycemic control in insulin-dependent diabetic patients, positive leucine balance, lower nutrition-related morbidity and/or shorter duration of ventilation/antibiotics. Their findings revealed an overestimation in calorie needs in the past for what was generally thought of as appropriate feeding (29). In light of the complications that can result when specific nutrients are overfed, it is clear that underfeeding calories is often the safest approach to PN.

The SCCM and ASPEN guidelines recommend holding all fat in the 1st week of an ICU stay (23). Complications arise when unwarranted fat as well as excessive fat is
given. These problems include immune suppression, increased infections, increased morbidity, prolonged duration of mechanical ventilation and increased hospital length of stay. In addition to these, giving a patient high fat and low carbohydrate PN when it is not indicated can result in pulmonary failure (23) and/or prolonged mechanical ventilation. For this current study, fat is a part of the NPC data that was collected as it contains all calories from carbohydrates and fat.

As mentioned above, excessive administration of carbohydrates can result in a complication known as refeeding syndrome. Refeeding syndrome is largely due to the rate of parenteral infusion into the blood stream but a high carbohydrate load will also induce the syndrome. Cardiac, respiratory and neurological complications can arise as a result of refeeding and can be life-threatening (12). Additionally, a malnourished patient who has PN initiated for nutrition support can also experience refeeding syndrome. A flood of carbohydrates into the plasma causes a shift of electrolytes into the intracellular space resulting in hypokalemia, hypophosphatemia, and hypomagnesemia (5). Similarly, for this study carbohydrates are a part of the NPC data that was collected as it contains all calories from carbohydrates and fat.

Protein requirements are of concern in both the hypermetabolic and renal impaired patient. In a hypermetabolic state (e.g. sepsis, burns, trauma, major surgery) the body requires a greater amount of protein and actually depends more heavily on this macronutrient than any other (5). Acute phase proteins are released to help the inflammatory state of the body which causes the high demand for increased protein in the body. This increased utilization of proteins causes a loss of lean body mass and because
the body is utilizing more protein than it is expending, negative nitrogen balance is created (5). The medical professional can foresee the body’s increased need and supply the body with adequate amounts of protein to prevent it from using more protein than provided (23).

Another organ of the body affected by protein load is the kidney. Kidneys are responsible for the end products of protein metabolism (5). Excessive protein can cause the kidneys to incur further damage. Too much protein may require a dialysis patient to need dialysis more frequently (5). In addition to this, the breakdown of stored body protein and urea production has been shown to decrease when adequate dietary amounts of protein are supplied to the renal patient (5). It is important to supply adequate amounts of protein to the renal patient to prevent nutrient-derived complications.

With the potentially disastrous effects of incorrect amounts of macronutrients, it is clear increased precision in the prescription of these macronutrients will help to decrease complications.

**Hospital Initiatives for Reducing Parenteral Nutrition Error**

Many researchers have spent time determining where drug errors occur and based their research on trying to reduce those drug errors (1, 3, 7, 15-16, 27-28, 30). Many hospitals have incorporated a NST to prevent error (1, 15). Unfortunately, NSTs often exist with chronic disputes among team members over appropriate nutrition interventions (1). Sacks and colleagues implemented a new process for PN orders that included a new order form, transmission of the original order to the pharmacy, and decentralized
pharmacists and nurses to prevent errors from occurring on the hospital floors (3). Mirtallo and colleagues discussed the benefits of having a web application to facilitate all PN within hospitals to increase accuracy (28). Legler found in 1990 that error rate decreased among MDs when a computer program was used as opposed to manual calculations (27). As previously reviewed, the study by Campino and colleagues suggested that implementing educational strategies (continuing education) within hospitals to increase the knowledge of the medical professionals would in turn decrease errors in the general drug process (16).

**Nutrition Education for the Medical Resident**

Results of the 2008 Physician Survey demonstrated that MDs and MRs self-report only moderate confidence in their nutrition support knowledge (8). This survey was performed in an intensive care unit (ICU) among medical residents, medical fellows and attending MDs in a hospital where RDs round regularly with these clinicians. The survey was 12 questions and the confidence questions answered on a Likert scale of 1-5, 1 indicating “not comfortable” and 5 meaning “very comfortable”. In response to their confidence in nutrition support knowledge, MRs reported a mean response of 3.20 and MDs and medical fellows reported confidence of 3.33 (n=182). Both MRs and MDs were in agreement, according to the survey, that nutrition is important in the ICU (8). Despite debates about the adequacy of nutrition education in medical school (1, 6-7, 9), this particular survey showed that MDs and MRs are only moderately confident to practice what they were taught in school.
In 1997 Dr. Vanek and colleagues came to the conclusion that physicians are in need of increased education during medical school. Their study (listed in the second section of the review of literature here) showed that physicians (n=48) have difficulty prescribing accurate macronutrients in PN solutions (7). There is ongoing reform to incorporate a greater amount of nutrition training in medical schools and the current tactic is to establish the minimum recommended number of nutrition hours in all medical schools (6). The National Academy of Sciences declared in 1985 that the minimum amount of nutrition education recommendation for U.S. medical schools was 25 hours. The Nutrition in Medicine (NIM) project at the University of North Carolina at Chapel Hill regularly conducts a survey of nutrition education offered to medical students. The NIM survey that is distributed to U.S. medical schools attempts to quantify the amount of nutrition education hours required for medical students at their institutions, the types of courses in nutrition offered and then compares these results to previous surveys the NIM has conducted. In their 2010 survey, researchers received an 86% response rate (n=105) which exposed that only 27% of U.S. medical schools provided the minimum hours recommended (25 hrs) by the National Academy of Sciences (6). This “recommendation” of minimum hours of nutrition training for medical students is a 25-year-old standard that is in need of revision and rather than a recommendation, a requirement of minimum hours should be established.

Another study by Vetter and colleagues in 2008 surveyed medical interns from a university-based internal medicine program to assess their proficiency in, and attitudes toward, nutrition knowledge. This was an anonymous survey using previously validated
questionnaires and a multiple-choice quiz. The survey found interns correctly answered 66% of the knowledge questions ($p \leq 0.05$) (9). This study found higher proficiency results than the study conducted by Vanek and colleagues who found only a 9-20% correct response rate. The study by Vetter and colleagues surveyed interns on general nutrition knowledge questions, only one question had content about PN which asked if they were comfortable with their knowledge on the indication for PN. However, there were a few questions on macronutrient calculations, as opposed to the Vanek study that surveyed MDs and MRs solely on PN nutrition knowledge (7). The study also discovered, alarmingly, that medical interns who had previous exposure to nutrition education during medical school reported more negative attitudes about physician self-efficacy in general nutrition. The authors pointed out another area for consideration which is to enhance MRs’ nutrition skills by shifting the timing of their nutrition education (9). Many medical students receive nutrition education during medical school but this study may bring evidence for education to be shifted to residency training programs. This negative attitude about general physician nutrition knowledge by the MRs with prior exposure to nutrition education may also be explained by the phrase “you don’t know what you don’t know.” In other words, because they have been trained in nutrition education they may realize how much the general population of MRs does not know about nutrition knowledge.

Annalynn Skipper and her colleagues stated that “dietitians have more nutrition training than any other group of health care workers” (10). In light of this fact, their particular study, conducted in 1994, looked at physicians’ implementation of the RD’s
nutrient recommendations (n=865). Chief clinical dietitians (140 RDs nationwide) gathered recommendations made by RDs from five consecutive medical entries and 72 hours later recorded the implementation of the RD’s recommendations by the medical doctor. This study asserted that it is extremely beneficial to patient care when MDs and RDs communicate about an individual patient’s nutrition support plan. However, the study found that only 42% of a RD’s recommendations were implemented by a doctor, leaving the RD’s expertise highly unleveraged (10).

**Advancing Role of the Registered Dietitian in Parenteral Nutrition**

The *American Dietetic Association’s (ADA) Pocket Guide to Parenteral Nutrition* (12) did an excellent job of highlighting advancements in the RD’s professional role in PN. In 1986 the Standards of Practice for Nutritional Support Dietitians identified dietitians as having a participatory role in conjunction with other health professionals and stated that RDs should “provide input” on nutrition support. Fourteen years later, in 2000, the same Standards of Practice declared RDs as having the ability to “recommend, write and/or obtain orders” (as decided upon individual hospital policy) in the PN process (12). This significantly expanded the RD’s role by allowing them to be an authority in the nutrition support aspect of care. In 2005, just 5 short years later, an audit performed by the Commission on Dietetic Registration (CDR) found that 19% of entry-level RDs (n=1477) were doing just that, writing orders for PN (12). The most recent CDR survey of entry-level RDs’ responsibilities, in 2010, showed that only 14% of entry-level RDs (n=1829) were writing orders for PN (31). It is unclear why this decrease in order-writing for the RD has occurred, but the RD plays a valuable role in PN order-writing
that, as seen above, is being under-utilized. Many hospitals persist in the older school of thought that PN ordering should be controlled by MDs despite their comparative lack of training to the RD that is available at each institution.

There is overwhelming evidence for the decrease in inappropriate prescribing of nutrition support that occurs when MDs and RDs work together in the clinical setting (1, 24, 32). Most recently, a study by Martin and colleagues in early 2011 found that PN was prescribed inappropriately in 32% of the cases (n=278) costing four hospitals a total of $125,000 in preventable costs over a 15 month time period (32). On the contrary, often the least expensive therapy is not the most appropriate therapy. One study demonstrated an increase in the cost of care when RDs were involved in the order-writing process (33). However, Peterson and colleagues found a 20% decrease in overall PN costs in a two-year time period as a direct result of RDs obtaining order writing privileges (34). As patient care initiatives continue to advance, RDs with increased privileges in nutrition support have potential to support this quality care goal.

Summary

The above review of literature expanded upon the principle of nutrition support. The review revealed there are numerous errors in PN. The fact that metabolic complications are still occurring helps to show that a key arena for potential error lies in the prescription process. The above review showed there have been several unsuccessful attempts to minimize metabolic complications, such as web applications and computer calculations. This review illuminated that MRs are not only insufficiently trained during school but, they also report a lack of confidence in their own nutritional knowledge base.
The RD’s role in the nutrition support process is expanding rapidly and the RD should continue to be viewed as a key player in the ordering process for improved patient outcomes and cost savings. The aforementioned studies help to provide support for the initiative for RDs to obtain closer control and involvement in PN ordering as well as provide support for sustaining NSTs.
CHAPTER III

METHODOLOGY

The purpose of this retrospective study was to examine if there is agreement between registered dietitians (RDs) and prescribers of parenteral nutrition (PN) in macronutrient calculations for ordering PN in hospitalized patients. The results of this study (available in chapter IV) were such that only the orders for PN from medical residents (MRs) were included and then compared to RDs. Other factors were analyzed to find trends and correlations among the prescribers’ patterns. To achieve this objective it is important to describe the overall methodology that was used to design, implement, collect and analyze data in this study.

Sample and Setting

Using a sample of convenience, the sample in this study included all notes and orders within the inclusion criteria at a Midwest teaching hospital. A single hospital was chosen in order to control for varying ways that hospitals document orders and recommendations for PN. At the chosen institution, prescribers and RDs documented PN in the same format (non-protein calories (NPC), protein in grams (PRO) and carbohydrate to fat ratios). The participating institution is a 339-bed teaching hospital. It
was chosen because the investigator previously worked in the hospital and compliance with the research was already granted to her. The ideal sample size for this research study was 65-95 qualifying PN solutions calculated by approximating the number of data collected to produce a medium effect size with 80% power. The data included two notes on each patient, one written by a prescriber and one written by a RD for every PN initiated for the duration of the research period (July 1, 2008-June 30, 2010). The inclusion criteria for the sample were as follows: 1) The electronic note for PN recommendations had to be by a RD within 48 hours of the initiating order given by a prescriber to begin PN; 2) The electronic order to initiate PN had to be prescribed by a MR; 3) Data had to be the *initiation* to begin PN in a patient (not follow-up changes to the order); 4) Data was only collected on adult patients (≥ 18 years old).

**Instrument**

The data was collected by a single researcher who is a RD. The data collection instrument was a single-sided sheet of paper with information to be filled out about the prescriber’s note on the left side and the RD’s note on the right side. Please see Appendix B for an example data collection sheet used in this study. The left side started at the top with a blank box for a study number to be assigned to the patient. The study numbers were randomly assigned and are from 1-319. Directly underneath the study number was a list of prescribers and the researcher was to check one of these boxes to indicate who wrote the order for that patient’s PN order. The researcher had the option of checking the box to indicate the order was written by a MD, certified MD, a pharmacist, or a Board Certified Pharmacotherapy Specialist (BCPS) pharmacist. If the order was by a different
provider than 1 of these 4 options, the researcher wrote in the prescriber’s title (e.g. nurse practitioner). The “certified MD” refers to a MD who is a Certified Nutrition Support Clinician (CNSC) credentialed through the American Society of Parenteral and Enteral Nutrition (ASPEN). The BCPS pharmacist is a specialty credential that gives pharmacists more specialized knowledge on different pharmacological topics, including nutrition support. If the order was written by a MD, there is a question to the right of this box that asks if the MD was a staff doctor (Y or N). To avoid using names in data collection, at the start of the research, a list of fellows, residents, interns, staff physicians, pharmacists and dietitians during the research period was collected from the participating institution. If the “N” was circled, which indicated the MD who wrote the note was a non-staff MD, then the researcher looked at the list of names given from the participating institution to determine what year in residency the non-staff MD was. The researcher then recorded this information below the “Y N” space as 1st-5th year residency.

Similarly, on the right side, the researcher was to check RD, certified RD or dietetic intern (DI) with a RD signature. The “certified RD” is a RD who also is a CNSC through ASPEN. The dietetic intern is not allowed to sign their own notes so a RD must sign to state they approve of the recommendations that the DI recommended in the note. For this study, the data collected by a DI was categorized by whichever RD, that is, “certified RD” or “non-certified RD”, signed for the note.

The data sheet included a section to the right of the RD check boxes for the researcher to record what quarter of the residency year the electronic charting was performed. These were listed in quarters to avoid from using dates on the data collection
form (Quarter (Q) 1=July-Sept, Q2=Oct-Dec, Q3=Jan-Mar Q4=April-June). The researcher indicated the time of the prescriber’s order and RD’s note for PN. To the right of the “Time of PN Note” on the RD side, there was a box to indicate the difference in time between the order (written by a MD or pharmacist) and note (written by a RD) to ensure that the RD’s note was within the 48 hour window before or after the prescriber note. On the left side of the data collection sheet there was a space for the researcher to record the unit in which the patient was initially admitted into. The researcher also recorded the age, sex, height and weight of the patient to allow for demographics of the study group to be collected and for the body mass index (BMI) of each patient to be calculated in data analysis.

The researcher recorded the macronutrient variables of interest to the study. These included carbohydrate to fat ratios, non-protein calories (NPC), and total grams of protein (PRO). Carbohydrate to fat ratios were listed as ratios for the researcher to check: 100/0, 60/40, 70/30, 80/20, 50/50, or Other. The non-protein calories were recorded in calories. The grams of protein were recorded in grams. These were on both the left and right side of the sheet so the researcher could collect both what the prescriber and the RD recommended on their notes.

On the right side of the data collection sheet was the option to indicate if the patient was receiving propofol, and if they were to indicate how much they were given if the RD listed it in her note. The researcher did not use this information in the results section. Below this was a place for the researcher to indicate if the RD’s macronutrient recommendations were calculated as a response to monitoring the patient’s current
tolerance of PN. This would have caused the RD to recommend a different amount of specific macronutrients from the prescriber’s original order and would have caused decreased similarity in their recommendations. As stated above, these incidences were excluded from the data. There was another space on the data collection form for the researcher to indicate if the RD was “consulted” by the prescriber for this particular PN order. This would have meant that the prescriber asked for the RD’s professional recommendation on macronutrients before he/she put their order in. This would have caused increased similarity between the RD’s and prescriber’s recommendations. The last question on the data collection sheet asked if the RD note was written before the prescriber’s note. This is similar to the question that asked if the RD was “consulted” by the prescriber; if the RD note was written with recommendations for PN before the prescriber put in an order, this may increase similarity in their recommendations. This is because the prescriber, hopefully, would have consulted the RD’s recommendations and then made the PN order according to what was recommended. These factors were not considered in the data collection because they may have increased similarity between the RDs and prescribers.

On the left side towards the bottom was a space for the researcher to record the reason (if stated in either note) the PN was started on that particular patient. Below this was a listing of other disease states that the researcher was to circle if the patient had any other co-morbidities. Individual patient disease states and complications were grouped to show discrepancies that may exist among particular fields of medicine. Please see Appendix B for the data collection sheet.
Institutional Review Board and Study Timeline

The researcher completed the trainings from Collaborative Institutional Training Initiative (CITI) as required by Indiana University-Purdue University-Indianapolis (IUPUI). See Appendix C to view the certificate of completion and passing score for the CITI training. Upon approval from the thesis committee, the researcher sought and received approval from IUPUI’s Institutional Review Board (IRB) for human subjects approval to begin collection of data for this study (see Appendix A). This researcher was required to go through IRB approval at IUPUI because the hospital where research for this thesis was conducted is affiliated with IUPUI, not the researcher’s degree-granting institute, Ball State University (BSU). The researcher then proposed the thesis to the graduate thesis committee at BSU and received approval to move forward on collecting data. Data was analyzed and the results are included in chapter IV of this thesis.

Data Collection

The current study looked at PN orders by prescribers and notes by RDs between July 1, 2008 and June 30, 2010. The researcher gained access from the participating institution’s data and security department to research in their electronic medical record (EMR). A two-year time frame was selected based on an original estimation that the participating institution begins 25 new PN solutions every quarter. This allowed for a potential collection of 200 new PN orders and notes, before inclusion criteria was applied to each note/order collected. After a review of data, there were 195 orders to initiate PN in the selected time frame. The researcher assigned study numbers to each patient for data collection purposes (1-319). A retrospective chart review was then employed to find the
prescriber’s and RD’s electronic notes for each of these patients’ initiated PN. The prescribers’ and RDs’ names were not collected. Instead, their respective titles (e.g. RD, MR, medical doctor (MD), pharmacist, etc.) were collected identifying the MDs as either staff or on rotation.

**Reliability and Validity**

The data collection instrument was used by the researcher to gather pertinent data to the study and was utilized for internal purposes only. Therefore, the instrument is not required to be tested for reliability or validity.

**Data Analysis**

The agreement level between the prescribers and RDs on macronutrient recommendations was examined. The independent variables are the medical professionals’ position (either prescriber or RD) and their respective choices made for the non-protein calories (NPC) and grams of protein (PRO). The NPC and PRO were analyzed using a paired t-test and a subset test was run to determine the extent of agreement. The discrepancies between carbohydrate to fat ratios were analyzed using Wilcoxon Signed Ranks test. A secondary analysis was ran on PRO and NPC using a one-way ANOVA to examine the effect that BMI played on prescribing patterns. A two-way ANOVA was used to determine if years of experience in medical residency affected discrepancies when compared to RDs. Results were deemed statistically significant if the p value was $\leq 0.05$. 
Summary

The objective of this study was to examine if prescribers are able to recommend PN macronutrients similarly to RDs. This research was carried out by collecting PN orders by prescribers and notes by RDs and comparing their calculated 1) non-protein calories; 2) grams of protein; and 3) carbohydrate to fat ratios. From this information, variance was assessed to determine if RDs and prescribers recommend similarly. The assumption is that variance could lead to errors, as outlined above.
CHAPTER IV

RESULTS AND DATA ANALYSIS

This thesis sought to determine if there are significant differences in macronutrient calculations involving parenteral nutrition (PN) between prescribers and registered dietitians (RDs). The study intended to compare all PN prescribers, including medical residents (MR), staff medical doctors (MD) and pharmacists, however, due to a very small sample (n=2) of orders by staff medical doctors and (n=37) by pharmacists, the research drew conclusions from MRs only. The study aim was to provide support for the initiative that RDs should be allowed ordering privileges and/or control over PN.

Demographics

One-hundred and ninety-five data sheets were collected of notes and orders by medical doctors, pharmacists and RDs. Thirty-seven were by pharmacists or pharmacy residents and were not included in the results due to a small sample size. Two were written by a staff MD and were excluded due to a low sample size. There were 23 orders excluded due to either the RD note or MR order was outside of the 48-hour time frame inclusion criteria of the study. The time frame (48 hours) was selected in order for minimal laboratory changes to occur before the RD wrote a note. Unfortunately, this did
occur to a significant degree in 2 of the RDs’ recommendations and these were excluded. The RDs wrote on these notes that they were changing the macronutrients in the PN to compensate for an unwanted shift that had occurred in the patient’s laboratory data.

Seventeen orders were excluded because PN was not actually started (and the RD therefore did not write a note) or the RD did not write a note because PN was started and stopped within a very short amount of time. There were 3 PN orders that were started prior to July 1, 2008 and were not included because the original order to begin PN by the MR was before the start date of the study. Five of the orders and notes were on patients who were younger than 18 years old and were therefore not included. One of the orders was excluded because the medical doctor who wrote the note was not on either the list of staff MDs or the list of MRs that were used in the data collection process. Since this MD could not be identified to categorize his/her title, this order was excluded. One of the dietitian’s notes was by a dietetic intern but not signed by a RD and was therefore excluded. With all of these exclusions from the data set, there were 102 remaining data sheets included for data analysis. The projected number for results with medium effect size and 80% power was 65-95 qualifying data sheets. The results of the data collection exceeded the projected need.

Medical residents were categorized according to their year of residency. The years ranged from a first year (often called an intern) to fifth year. For statistical comparisons two groups were formed. The first group contains all first year students. The second group contains all second year through fifth year residents. The MRs were grouped like
this in order for there to be at least 30 in each group when making comparisons. See Table 1 for the breakdown of data collected and used for statistical analysis.

### Table 1. Year of Residency for Medical Residents

<table>
<thead>
<tr>
<th>Year of Residency</th>
<th>n (%)</th>
<th>Group</th>
<th>Year of Residency</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>53 (52%)</td>
<td>1</td>
<td>First</td>
<td>53</td>
</tr>
<tr>
<td>Second</td>
<td>22 (21.6%)</td>
<td>2</td>
<td>Second through Fifth</td>
<td>49</td>
</tr>
<tr>
<td>Third</td>
<td>13 (12.7%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fourth</td>
<td>8 (7.8%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fifth</td>
<td>6 (5.9%)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The average age of the patients was 49.73 (standard deviation (SD) ± 16.060) and 61% were female. The average height of the population was 67.27” (SD ± 4.0765) and the average weight was 85.08 kg (SD ± 32.95860). Majority of the patients (54.9%) were admitted to the hospital on non-intensive care units. The remaining patients were admitted to the intensive care unit (ICU) 16.6%. Table 2 also shows the disease states listed as the indication to begin PN in each patient. A majority (60%) of patients received PN due to a short bowel obstruction, resection, cancer or a fistula.
Each patient’s body mass index (BMI) was calculated and included in the data analysis. Sixteen percent of the patients were considered underweight (BMI < 20). Twenty-seven percent of the patients were of a normal weight (BMI 20-25). Fifteen percent of the patients were overweight (BMI 25-30). Forty-one percent of the patients were obese or morbidly obese (BMI >30). These percentages are based on n = 99 due to 3 of the cases having missing data for one or both variables used to calculate BMI. This information is summarized in Table 3.
Table 3. BMI of Patient Population

<table>
<thead>
<tr>
<th>BMI</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>&lt;20</td>
</tr>
<tr>
<td>Normal Weight</td>
<td>20-25</td>
</tr>
<tr>
<td>Overweight</td>
<td>25-30</td>
</tr>
<tr>
<td>Obese and Morbidly Obese</td>
<td>&gt;30 and &gt;35</td>
</tr>
</tbody>
</table>

Research Question I

The first research question looked at differences between MRs and RDs when looking at non-protein calories (NPC). A paired t-test was conducted to examine these discrepancies. As shown in Table 4, the average difference between MRs and RDs regarding NPC was 307 kilocalories with MRs recommending the higher levels of NPC (SD ± 639.237, t = 4.85, df = 101, p < 0.001). This was found to be statistically significant. For NPC, there was moderate disagreement between the recommendations of MRs and RDs (r = 0.53).

Another paired samples t-test was conducted to find specifically how much the MR was prescribing NPC differently from the RD. The analysis found that MRs on average prescribe 300 more NPC than the RD recommends (SD ± 651.136, t = 4.45, df = 93, p = < 0.001). For example, on a standard male in which the RD recommended 2000 kilocalories, the MR prescribed 2300 kilocalories on average. These results can be seen in Table 5.

Table 4. Paired Samples Test of Macronutrients, MRs Compared to RDs

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Mean</th>
<th>SD</th>
<th>t</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRO (grams)</td>
<td>5.412</td>
<td>31.651</td>
<td>1.727</td>
<td>101.000</td>
<td>0.087</td>
</tr>
<tr>
<td>NPC (kcal)</td>
<td>307.108</td>
<td>639.237</td>
<td>4.852</td>
<td>101.000</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>
Research Question II

The second research question looked at differences between MRs and RDs when prescribing grams of protein in PN orders. A paired t-test was conducted and found an average difference between MRs and RDs for PRO of 5.4 grams. However, this failed to reach statistical significance (t = 1.72, df = 101, p = 0.087). There was moderate disagreement between the recommendations of grams of protein for MRs and RDs (r = 0.62).

The same subset analysis that was conducted for NPC, paired samples t-Test, above was run for PRO and found no difference between the MRs and RDs (t = 1.78, df = 93, p = 0.078). The results can be found in Table 5.

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Mean</th>
<th>t</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRO (grams)</td>
<td>6.021</td>
<td>1.782</td>
<td>93</td>
<td>0.078</td>
</tr>
<tr>
<td>NPC (kcal)</td>
<td>299.096</td>
<td>4.454</td>
<td>93</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Table 5. Paired Samples Test of Paired Differences for Macronutrients, MRs Compared to RDs

Research Question III

The Wilcoxon Signed Ranks test was conducted in order to answer the third research question. This analysis examined differences found in prescribing patterns of the ratios of carbohydrate and fat between MRs and RDs. The comparison of carbohydrates to fat ratio between MRs and RDs did not show a statistically significant difference (Z = -0.780, p = 0.436). Therefore, a conclusion could not be drawn that the MRs and RDs recommend these macronutrients dissimilarly.
Research Question IV

As seen above, MRs prescribed more NPC on average but no statistically significant differences were found for PRO. A secondary analysis was run to address the fourth research question which asked if the weight of the patient affected how much the RD and MR recommended. The one-way analysis of variance (ANOVA) examined to see if the discrepancies in the PRO recommendations differed by the BMI category of the patient. This analysis found that the PRO discrepancies did vary by weight classification \((F_{(3, 95)} = 3.39, p = 0.021)\). Post hoc analysis showed that the gap between recommendations was largest between patients who were underweight and obese. Results are presented in Table 6. The MRs tended to prescribe lower amounts of PRO for underweight patients and higher amounts for obese patients as compared to RDs \((p \leq 0.05)\).

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>BMI</th>
<th>Mean*</th>
<th>Standard Deviation</th>
<th>Professional that Recommended More</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRO (grams)</td>
<td>p = .021</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;20</td>
<td>-4.63</td>
<td>12.511</td>
<td>RD</td>
<td></td>
</tr>
<tr>
<td>20-25</td>
<td>-1.59</td>
<td>15.293</td>
<td>RD</td>
<td></td>
</tr>
<tr>
<td>25-30</td>
<td>-1.67</td>
<td>23.727</td>
<td>RD</td>
<td></td>
</tr>
<tr>
<td>&gt;30</td>
<td>17.56</td>
<td>43.129</td>
<td>MR</td>
<td></td>
</tr>
<tr>
<td>NPC (kcal)</td>
<td>p = .001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;20</td>
<td>-78.13</td>
<td>276.025</td>
<td>RD</td>
<td></td>
</tr>
<tr>
<td>20-25</td>
<td>144.44</td>
<td>403.192</td>
<td>MR</td>
<td></td>
</tr>
<tr>
<td>25-30</td>
<td>200</td>
<td>401.782</td>
<td>MR</td>
<td></td>
</tr>
<tr>
<td>&gt;30</td>
<td>596.95</td>
<td>813.791</td>
<td>MR</td>
<td></td>
</tr>
</tbody>
</table>

*A negative mean indicates the MR recommended less and the RD recommended more.
A positive mean indicates that the MR recommended more and the RD recommended less.
Additionally, the same analysis was conducted to determine if the weight of the patient affected how much the RD and MR recommended for NPC. This analysis found that the NPC discrepancies did vary by weight classification \( (F_{(3,95)} = 6.22, p = 0.001) \). Post hoc analysis showed a larger gap in recommendations for the obese category compared to when the patient was classified as underweight or normal weight. As shown in Table 6, the MRs tended to prescribe lower amounts of NPC for underweight patients and higher amounts for obese patients as compared to RDs \( (p \leq 0.05) \).

**Research Question V and VI**

Medical residents were grouped according to year in residency (as an intern, resident or fellow) and then contrasted against the RD’s recommendations. An analysis was run using two-way ANOVA (residency year of MR vs. role of the medical professional) to determine if the years of school as a resident affected their PN recommendations. The first analysis compared PRO of first year residents to 2\textsuperscript{nd} through 5\textsuperscript{th} year residents. The ANOVA found that when 2\textsuperscript{nd} through 5\textsuperscript{th} year residents were involved with patient care, more PRO was prescribed than for 1\textsuperscript{st} year residents \( (F_{(1,100)} = 6.465, p=0.013) \). No other main effects or interactions were statistically significant. The analysis then looked at NPC and did not find significant prescribing pattern differences between patients seen by 1\textsuperscript{st} year residents and 2\textsuperscript{nd} through 5\textsuperscript{th} year residents \( (F_{(1,100)} = 3.536, p=0.063) \). There was a main effect for role of the medical professional \( (F_{(1,100)} = 23.645, p<0.001) \), with residents prescribing more NPC. The interaction was not statistically significant.
Summary

It is evident through the paired t-test that MRs consistently and significantly disagreed with RDs when prescribing NPC. A paired t-test subset was ran to determine the extent to which the recommendations were different and found that on average, MRs were prescribing 300 more kilocalories than RDs. A closer look was performed by running a one-way ANOVA which showed that MRs consistently recommend more grams of protein on obese patients and less on underweight to overweight patients than RDs. The analysis also found that MRs recommend more NPC on normal weight to obese patients and less on underweight patients than RDs do. Lastly, an analysis of the effect that years of residency played on similarity in prescribing methods found that patients with first year MRs were prescribed less protein than did those with 2nd through 5th year MRs. A more in-depth look at the implications of these results will be discussed in chapter V of this thesis.
This thesis examined differences in parenteral nutrition (PN) macronutrient calculations between medical residents (MRs) and registered dietitians (RDs) by conducting a retrospective chart review of orders and notes at a Midwest teaching hospital. One-hundred and two data sheets were analyzed and the results can be found in chapter IV of this thesis. The following information expands on the results and discusses what was found in this new research.

A more thorough explanation is found in the review of literature in chapter II but it is important to address the specificity that PN requires. As seen earlier in this thesis, extreme caution must be taken to provide the right amount of not only micronutrients, but also the macronutrients when providing nutrients intravenously (2). This study made several conclusions about the amount of calories that were prescribed by MRs and RDs. In terms of underfeeding carbohydrates, protein and fat, Owaise and colleagues concluded through a review of 12 studies that there are improved clinical outcomes when a patient is “permissively underfed”. The authors go as far to say the “benefits [of underfeeding] in terms of reduced complications outweigh potential harm from loss of lean body mass of fat stores in patients prescribed [calories] between 50% and 100% of
their requirements” (29). In overfeeding (providing too many calories), this puts the patient at risk of hyperglycemia, oxidative stress, insulin resistance, greater infectious morbidity, hepatic abnormalities, prolonged duration of mechanical ventilation, and increased hospital length of stay (5, 23). According to the 2009 American Society of Parenteral and Enteral Nutrition (ASPEN) guidelines, it is recommended that all patients be underfed when using PN (23). Looking specifically at protein, it is important to not overfeed protein in patients with renal complications and equally important is to provide adequate protein in hypermetabolic stages. It was hoped that the results of this thesis would lead to a more thorough understanding of where disagreement between the RD and MR is occurring and from this information, suggest ways for agreement to improve in the future.

**Discrepancies in Non-protein Calories**

The current research study found that MRs significantly overfed non-protein calories (NPC) when compared to RDs. The results showed specifically that there was an average difference of 300 kilocalories (SD ± 651.136) between MRs and RDs, with the MRs prescribing at a higher rate. This is significant because this discrepancy could be anywhere from a 10% to a 30% difference (increase) from the RDs’ recommendations. It could be speculated that the MR believes the patient needs more calories than they actually do. As shown in the first chapter of this thesis, the RD is the nutrition professional and deemed as the expert in the field (10-11). Therefore, it can be assumed that a large part of the 300 kilocalorie excess prescribed by MRs was done so inappropriately. This notion gains more support when compared to the ASPEN guideline
which does not give evidence for overfeeding or even sufficiently feeding the obese patient, but instead gives supporting evidence for underfeeding obese patients who made up 41.4% of the patients in this study. With the exception of the study by Vanek and colleagues, no other studies were found that look at whether prescribers are recommending the appropriate amount of calories in PN. Additionally, the ASPEN guideline recommends underfeeding all intensive care unit (ICU) patients by 80% of the estimated requirements and 46% (n=102) of the patients in this study were ICU patients (23). Vanek and colleagues found in their 1997 study that between 71% and 73% of the medical doctors in their study (MRs included) prescribed NPC incorrectly (7). Vanek’s study helped to illuminate the MR as the most logical source of error in the current study for overfeeding as opposed to the RD for inappropriately underfeeding 300 kilocalories.

By nature of the definition, overfeeding NPC results in an overfeeding of the nutrients contain in NPC which are carbohydrates and fat. As seen in the review of literature this can have a multitude of negative effects on the patient. These include refeeding syndrome, immune suppression, greater infectious morbidity, sepsis, increased ICU and hospital length of stay and prolonged duration of mechanical ventilation (5, 23). The effects that the higher prescribing of NPC had on the patient were not recorded in the present study. This will be discussed in the Future Research section of this chapter.

**Discrepancies in Recommendations among Body Mass Index**

The present study also found a surprising correlation between recommendations that MRs and RDs made and body mass index (BMI). Chapter IV of this thesis showed as BMI increased, the MR thought it appropriate to prescribe more NPC and grams of
protein (PRO) than the RD. According to the 2009 ASPEN guidelines for nutrition support, the opposite should occur; as BMI increases, the amount of calories prescribed should decrease (this results in permissive underfeeding) (23). To the best of the researcher’s ability, there are no other studies that have addressed calories in PN according to BMI. The results of the present study showed that, across all years of residency for MRs, NPC and PRO are prescribed inconsistently with the ASPEN guidelines.

**Year in Residency**

It is important to look at the results from the two-way ANOVA in light of research question I which found MRs significantly prescribed more macronutrients (NPC) than RDs. Research question V and VI found that patients with 2nd through 5th year MRs were prescribed more macronutrients (PRO) than those with 1st year MRs but a general trend is seen that shows all MRs prescribed significantly more macronutrients (PRO and NPC) than RDs.

It is also important to look at the results of this analysis in light of research question IV as well. This analysis found that as BMI increases, MRs prescribed more calories and RDs prescribed less when compared to each other. These results could possible expose that first year residents actually prescribed more similarly to RDs because first year residents prescribed less calories (PRO) than did 2nd through 5th year MRs.
Possible Advances for Improving Agreement

The results of this thesis and many other sources (6-9) are great evidence for the immense need for increased education in medical school. A thorough teaching of the most up-to-date research guidelines, as published through ASPEN, will keep medical students updated on how to accurately prescribe PN. These are evidenced-based guidelines that dietitians and other nutrition support professionals already apply in the field. It is important for them to be educated first on the basics of prescribing PN and then use these guidelines for prescribing specifics among weight and injury of the patient.

After data was collected and analyzed the preliminary statistical analysis was discussed in a nutrition support team (NST) meeting at the hospital where the research took place. One suggestion that the RDs overwhelmingly gave as a reason for discrepancy between the MR and RD is that RDs unanimously use adjusted body weight as opposed to actual body weight when recommending NPC and PRO for obese patients. This is consistent with the ASPEN guidelines that recommend feeding an obese patient between 60-70% of their estimated energy requirements (23). This would be a simple mathematical calculation that MRs could learn during training on nutrition support that would drastically cut the discrepancy in their macronutrient prescribing patterns. In the case of non-obese patients, the RDs use actual body weight.

Another way for discrepancy between the MR and RD to be lessened is to take a look at the prescribing and recommending format. According to the 2004 ASPEN Safe Guidelines for Prescribing Parenteral Nutrition, it is recommended that PN be ordered in the format of grams of dextrose (carbohydrate), grams of amino acids (PRO), and
calories of fat (35). This would eliminate the need to use NPC or a carbohydrate to fat ratio.

**Summary**

It is clear that there is not agreement in PN macronutrient recommendations between MRs and RDs. The above discussion listed several ways for discrepancies to decrease between medical residents and registered dietitians. Ultimately, this will allow for a safer patient experience in the inpatient setting and decreased costs to hospitals. The following chapter will conclude the discussion on this thesis by stating strengths and limitations of the current study as well as include recommendations for future research on this research topic.
CHAPTER VI

CONCLUSION

This study examined differences in macronutrient recommendations of parenteral nutrition (PN) formulas between medical residents (MRs) and registered dietitians (RDs). It is clear from the results that discrepancies do exist and the previous chapter expanded on possible reasons for why that may be and also offered suggestions for improving agreement. This chapter will conclude this thesis by listing strengths and limitations to the current study. Following this will be a highlight of areas of future research that can be conducted on this research topic to continue the efforts of RDs gaining greater privileges and management of PN.

Strengths

This study is a good addition to research because it is the first of its kind. There are no other studies that retrospectively compare RDs and medical doctor’s (MD) PN macronutrient calculations for discrepancies. This is a great addition to research surrounding PN because there have been several studies whose research found that MDs are prescribing inappropriately but none that compare RDs’ to MDs’ prescribing patterns
(7, 32). Other studies found general errors in PN ordering (3, 7, 14, 16, 26-27, 32) but none looked specifically at macronutrients.

Another strong point in the methodologies (chapter III) was to exclude RD notes that were written greater than 48 hours before or after the PN initiation. This will be important to include in future studies of this kind to control for variances that may not have existed in the case of orders and notes written within a short time of each other. These variances could have caused an inflated discrepancy between prescribers and RDs.

This study had strong statistics to show that discrepancies in macronutrient calculations are present between MRs and RDs. This information can add to the body of knowledge in support of RDs having more involvement and authority in PN prescribing. This study also helped to highlight other areas for future research that can additionally add to the body of research.

Limitations

This thesis, although produced significant results, could have been improved by a larger sample size. This was limiting because there were several factors that were close to significance and with a larger sample of PN orders and notes a more significant result could have been achieved. For example, although a significant difference was found in prescribing patterns between MRs and RDs for non-protein calories (NPC), a larger sample size may have been able to produce that MRs prescribed significantly more grams of protein (PRO) as well when compared to RDs.
Another limitation is that the study, due to the results of data collection, was limited to publishing results for MRs only. This thesis intended to find results for all prescribers and compare their prescribing patterns to RDs but this was not feasible due to a small sample size (MDs n = 2; pharmacists n=37), which unfortunately for this study, is the prescribing pattern in this participating institution. Future research could expand to other hospitals to gather this information from all prescribers of PN compared to RDs.

As outlined in chapter III, the instrument collected information that was not used during data analysis. These included factoring in if the RD was consulted by the MD before they wrote the PN order or if the RD wrote their note before the MD (could have allowed for the MD to consult the RD order first). Both of these factors would have increased similarity between the MD and RD’s recommendations. Future studies should control for these factors in order to get a more realistic look at the differences that exist between MDs’ and RDs’ recommendations when they do not consult each other.

**Future Research**

There is much research still to be done on this subject. We know that MRs and MDs feel education lacking in their medical nutritional training (8). Research should be further conducted to add to the body of knowledge in support of increasing nutrition support training in medical schools or residencies. An outstanding point that deserves further research was poised by Vetter and colleagues who questioned the timing of nutrition education for medical students and residents (9). It was suggested that MRs may retain the PN information better if they are trained in prescribing nutrition support during medical residencies.
Specifically, research can be conducted in the future similar to this study but also include laboratory data 24 hours pre and post-initiation of PN to show the potential harmful effects of PN ordering discrepancies between RDs and MRs. For example, if future research showed similar results to this study of MRs providing 300 calories more than the RD recommended, laboratory data following the start of PN may show refeeding syndrome, increased triglycerides and blood glucose, or possibly decreased lung function (5, 23). Additionally, it would be beneficial to research how excess calories in PN affect infection rate, mechanical ventilation duration, and length of stay in intensive care units or hospital-wide.

Future research could compare prescribers (MDs, pharmacists, nurse practitioners, physician assistants, etc.) who have furthered their knowledge with a nutrition support credential to those prescribers who have not received this credential. Research with this aim could then compare each PN prescription to the RD recommendation and see if RDs were more similar to those prescribers with or without the nutrition support credential. This could add support to the implementation of a nutrition support team (NST) with trained medical professionals representing nutrition which include RDs, MDs, pharmacists and other prescribers with a nutrition support credential.

Another area for future research includes expanding the data collected to include more than one hospital. This study only looked at one hospital in order for data collected to be in a similar form (NPC, PRO and carbohydrate to fat ratio). Future research could look at other hospitals in order to increase the variety of RDs, types of patient populations
represented, and expand the experience to include staff MDs as well as other prescribers. Gathering PN data from multiple hospitals may allow for a shorter time frame (less than 2 years) for retrospective data collection.

Future research could be conducted to examine the influence of experience for RDs and MRs may have on macronutrient PN recommendations. This study had 53 first year residents, but significantly less 4th and 5th year residents (n=8, n=6, respectively). A study that looked at years of residency may find that more experienced MRs are more similar to RDs. Additionally, a future study may look at first year RDs compared to staff prescribers to assess similarity.

Vanek and colleagues as well as the study by Adams and colleagues both examined the hours of nutrition classes that individual MRs took during medical school. Future research could compare the nutrition support education that MRs and RDs receive. All of the nutrition education offered to dietetic students is required, as opposed to medical students who can elect to take particular nutrition courses (6, 11). This would be good supporting evidence for future studies to state exactly how much nutrition support training RDs receive when compared to MRs.

At the institution where the current research took place, MRs received nutrition support training at the beginning of their rotation at the hospital. This nutrition support education was taught by a staff RD who is also a Certified Nutrition Support Clinician (CNSC). A future study could examine if this MR education increases the similarity in prescribing patterns. It is known that education is a helpful tool for increased accuracy so
this area of research could aid the body of knowledge in support of MRs receiving increased education on nutrition support.

Summary

This study is the first of its kind in comparing prescribing practices of medical residents and registered dietitians regarding PN. The above thesis exposed that MRs prescribe higher amounts of macronutrients than do RDs. It is clear through previous research that medical doctors do not feel confident in their nutrition-related knowledge (8, 9) and overwhelmingly, nutrition-related education has been shown to be lacking in medical schools (1, 6-9). These are both plausible rationale for why discrepancies between MRs and RDs occurred in the current research. Although this study found areas of dissent, this can be treated as an opportunity for prescribers and RDs to collaborate and work more closely together utilizing each other’s expertise, hopefully through the use of a nutrition support team. The results of this study add to the body of knowledge in support of RDs gaining greater ordering privileges and control over PN as well as support for forming nutrition support teams.
REFERENCES


APPENDIX A

IUPUI IRB Acceptance Letter

INDIANA UNIVERSITY
OFFICE OF RESEARCH ADMINISTRATION

Date: February 15, 2011
To: Dr. Todd Wulroth
    Pharmacy
    WD Dunlap Building, 2nd Floor
From: Regina Weber
      Research Compliance Administration, IUPUI
      UN 618
Subject: IUPUI/Clarian Institutional Review Committee - Exempt Review of
         Human Study
Study Number: EX1102-05
Study Title: Comparison in Macronutrient Calculations in Parenteral Nutrition: Do
            Discrepancies Exist Between Certified and Non-Certified
            Ordering Providers and Registered Dietitians?

Your application for approval of the study named above has been accepted as meeting
the criteria of exempt research as described by Federal Regulations [45 CFR 46.101(b),
paragraph 4]. A copy of the acceptance is enclosed for your file.

Although a continuing review is not required for an exempt study, prior approval
must be obtained before change(s) to the originally approved study can be initiated. When
you have completed your study, please inform our office in writing.

If the research is conducted at or funded by the VA, research may not be initiated until
approval is received from the VA Research and Development Committee.

Please contact the Office of Health Care Billing and HIPAA Programs at 317-278-4891
for information regarding a Data Use Agreement, if applicable.

Enclosures:  ☑ Copy of acceptance

Phone: 317-274-8289 • Fax: 317-274-5932 • Email: irbexp@iupui.edu • Website: http://research.iupui.edu
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Data Collection Instrument

APPENDIX B
CITI Collaborative Institutional Training Initiative

Human Research 2 Curriculum Completion Report
Printed on 11/6/2011

Learner: Katie Danielson (username: klynnd29)
Institution: Indiana University - Indianapolis
Contact Information: Department: Clinical
Email: klynnd29@gmail.com

Biomedical Researcher:

Stage 1. Stage 1 Passed on 01/17/11 (Ref # 5448441)

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For this Completion Report to be valid, the learner listed above must be affiliated with a CITI participating institution. Falsified information and
Unauthorized use of the CITI course site is unethical, and may be considered scientific misconduct by your institution.

Paul Braunschweiger Ph.D.
Professor, University of Miami
Director Office of Research Education
CITI Course Coordinator

CITI Collaborative Institutional Training Initiative (CITI)

Biomedical Responsible Conduct of Research Curriculum Completion Report
Printed on 11/6/2011

Learner: Katie Danielson (username: klynnd29)
Institution: Indiana University - Indianapolis
Contact Information
Department: Clinical
Email: klynnd29@gmail.com

Biomedical Responsible Conduct of Research: This course is for investigators, staff and students with an interest or focus in Biomedical Research. This course contains text, embedded case studies AND quizzes.

Stage 1. Basic Course Passed on 01/17/11 (Ref # 5448440)

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Paul Braunschweiger Ph.D.
Professor, University of Miami
Director Office of Research Education
CITI Course Coordinator