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Comparing MUST and the NRI Tools in the Identification of Malnutrition in Heart Failure Patients

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The document mentioned above has been reviewed and accepted by the student's advisor, on behalf of the advisory committee, and by the Assistant Dean for MSN and DNP Studies, on behalf of the program; we verify that this is the final, approved version of the student's DNP Project including all changes required by the advisory committee. The undersigned agree to abide by the statements above.

Cassondra D. Degener, Student

Dr. Melanie Hardin Pierce, Advisor

FINAL DNP CAPSTONE REPORT

Comparing MUST and the NRI Tools in the Identification of Malnutrition in Heart Failure Patients

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Melanie Hardin-Pierce, DNP, APRN, ACNP-BC Committee Chair/Academic Advisor

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Dedication

I would like to dedicate this final capstone project to my husband Kyle Degener. You have been my inspiration, my rock and motivation for the last five years. Thank you for encouraging me to pursue my dreams of becoming a Nurse Practitioner, and for all the sacrifices you have made to help me accomplish this endeavor. Without you all this would not be possible.

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Introduction to Final DNP Capstone Report

Cassondra Degener

University of Kentucky

Heart failure (HF) is one of the top five leading causes of death in the United States and each year roughly 825,000 people are newly diagnosed (Go et al., 2013). It is estimated that one million Americans with decompensated HF are admitted to the hospital every year, which contributes to over $35 billion in healthcare costs (Chaudhry et al., 2013). The high incidence of hospitalizations and increased healthcare costs among HF patients may be attributed to a number of causes, including malnutrition (Lemon et al., 2009). Malnutrition prevalence in HF patients is as high as 66% (Aziz et al., 2011).

The dietary intake and quality of those with HF is poor, which may lead to damaging effects on disease progression and overall health status (Lemon et al., 2009; Arcand et al., 2009). Poor dietary intake may be attributed to diminished appetite and early satiety due to hepatic and gastrointestinal congestion, which is common in this population (Kalantar-Zadeh, Anker, Horwich, & Fonarow, 2008; Nicol et al., 2002). Other reasons for inadequate nutrient intake may be attributed to dietary restrictions, fatigue, shortness of breath, nausea, anxiety and depressed mood (Lennie, Moser, Heo, Chung, & Zambroski, 2006). Dietary intake in HF patients may be calorically the same as healthy individuals, but they differ significantly in macro and micronutrient composition (Machado d'Almeida, Perry, Clausell, & Souza, 2015). This lack of macro and micronutrients can be detrimental to the overall health status of patients and lead to worsening disease progression and outcomes (Machado d'Almeida et al., 2015).

Early identification of malnutrition is important to improving outcomes and overall nutritional status of patients (Corkins et al., 2014). Traditional measures of nutrition status such as laboratory (i.e. serum albumin and prealbumin) and anthropometric measures (i.e. body mass index and percentage weight loss) are beneficial in identifying malnutrition; however, they are not enough and can delay the recognition of malnutrition, especially in HF patients (Araujo, Lourenco, Rocha-Gonocalves, Ferreira, & Bettencourt, 2011; Corkins et al., 2014). To assist with the early identification of malnutrition, researchers have developed a number of different screening tools. Subjective screening tools can be rapid, easy and inexpensive ways to identify malnutrition among hospitalized patients. With all the subjective screening tools available, there are few studies available which evaluate the best methods of identifying malnutrition in the HF population. Two screening tools, the Malnutrition Universal Screening Tool (MUST) and Nutritional Risk Index (NRI), have shown some potential to be reliable methods of evaluating the nutritional status of HF patients.

This practice inquiry project, through a retrospective electronic medical record review, evaluated the presence of malnutrition in 100 HF patients admitted to the University of Kentucky Chandler Medical Center. The primary goal of this project was to test the performance of albumin, NRI and MUST in comparison to the reliable screening measure of prealbumin, among HF patients admitted to the hospital. The objectives were to (i) evaluate HF patients for the presence of malnutrition using four screening measures (i.e., albumin, prealbumin, NRI and MUST), and (ii) determine laboratory and co-morbidity trends among malnourished patients.

This evaluation project of HF patients will provide insight and guide further research on effective objective and subjective screening methods that may help in the identification of malnutrition in hospitalized patients with HF. This practice inquiry project includes three manuscripts each of which discuss relevant aspects of malnutrition and HF, and the best methods to screen for malnutrition.

- Manuscript one is a literature review that examined the available studies in which MUST was evaluated and compared to other, similar screening tools and objective nutritional methods. Sixteen studies were evaluated in the review with respect to MUST's effectiveness in screening malnourished patients in multiple patient populations in hospital and outpatient settings.
- Manuscript two evaluated the available literature on NRI and provided evidence to support whether or not it is reliable in various populations. The review evaluated ten studies which compared NRI to other reliable screening tools and made recommendations for practice.
- Manuscript three evaluated hospitalized HF patients for the presence of malnutrition. Four screening measures were used in order to determine laboratory and co-morbidity trends among malnourished HF patients admitted to the University of Kentucky Chandler Medical Center.

Manuscript 1

Malnutrition Universal Screening Tool: A Review of the Literature

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Abstract

Purpose: The purpose of this literature review was to find the studies available evaluating the Malnutrition Universal Screening Tool (MUST) and comparing it to similar screening tools and objective nutritional methods. The strengths, weaknesses and reliability of MUST will be evaluated in comparison to other reliable screening tools, and recommendations for practice will be provided.

Design and Methods: Literature review to find the available studies from 2004-2014 published in English using the databases of EBSCOhost, Academic Search Complete, CINAHL, and MEDLINE. Ancestry searching was used to find additional articles meeting the above criteria.

Results: Overall the search produced 52 articles, but only sixteen met the inclusion criteria. Of the studies included in this review, six screened hospitalized patients, two evaluated outpatients, seven articles examined chronic diseases (cancer, HF, and renal failure), and one assessed elderly patients.

Practice Implications: The MUST has demonstrated evidence of reliability and validity in multiple patient populations including outpatients, hospitalized, cancer, elderly, and chronic disease. Many researchers noted the best nutritional screening methods were those which combined a subjective screening tool and objective measures. There is a growing need for studies that evaluate MUST and multiple subjective screening methods against objective measures in the HF population.

Search Terms: *Adult, elderly, cancer, chronic disease, heart failure, hospitalized patients, malnutrition, malnutrition universal screening tool, screening tools,* and *surgery*.

Background and Significance

Malnutrition is a major health problem in the United States. The prevalence of malnutrition is 23% among hospitalized inpatients, with malnourished patients spending 4.5 days longer in the hospital compared to well-nourished ones (Gout, Barker, & Crowe, 2009). The increased hospital length of stay can triple healthcare costs from $9,485 for the average hospitalized patient to $26,944 for malnourished ones (Corkins et al., 2014). Disease-related malnutrition occurs with chronic diseases such as rheumatoid arthritis, cancer, renal failure and HF (Jensen et al., 2010).

Heart failure is one of the top five leading causes of death in the United States (Go et al., 2013). Every year roughly 825,000 people are newly diagnosed with HF and one in five will die within one year of diagnosis (Go et al., 2013). Heart failure accounts for 1 million hospital admissions per year, with an average length of stay (LOS) of 4.9 days (Centers for Disease Control, 2013).

Malnutrition is highly prevalent in the HF population and can lead to a condition called cardiac cachexia (Hoes, 2007). Roughly 15 percent of HF patients will develop cardiac cachexia, which is associated with a poor prognosis (Hoes, 2007). Cardiac cachexia is responsible for increased morbidity and mortality, and decreased quality of life among patients with HF (Moughrabi & Evangelista, 2007). There is a growing need for a reliable, easy to use screening tool that can be used in the HF population which will assist health providers to identify and treat malnourished patients.

Many instruments are available to help evaluate nutrition risk in hospitalized patients. The Malnutrition Universal Screening Tool, or MUST, was originally developed by the Malnutrition Advisory Group for the British Association of Parenteral and Enteral Nutrition (Elia, 2010). The MUST is a five-step tool that evaluates BMI score, recent weight loss and acute disease, assigns an overall numerical risk, and then provides management guidelines (Elia, 2010). Step one is the BMI category which provides scores as follows: BMI >20 = 0 points, 18.5 – 20 = 1 point, and <18.5 = 2 points (Appendix A). Step two provides a weight loss score based on the amount of weight lost in the past 3-6 months: a score of 0 for 5%, 1 for 5 – 10%, and a 2 for >10%. Step three is to determine if the patient has been acutely ill and if there has been or is likely to be no nutritional intake for >5 days which provides a score of 2. For step four, the user adds all point scores together: a total score of 0 = low risk, 1 = medium risk, and 2 or more = high risk. Step five provides appropriate management guidelines based on the overall malnutrition risk score. Patients who score a 0 are at a low nutritional risk, and no interventions are necessary. A score of 1 indicates moderate risk patients and close dietary monitoring is recommended. A score of 2 or more means the patient should have a complete nutrition assessment by a registered dietitian (Elia, 2010). One benefit of the MUST tool is that it guides the user to either seek immediate nutrition consultation for high risk patients, or to observe medium risk patients upon hospital admission.

Purpose of the Integrative Review

The purpose of this literature review was to examine the available studies in which MUST was evaluated and compared to other, similar screening tools and objective nutritional methods (i.e. albumin and prealbumin). This paper also seeks out to determine if MUST is reliable in screening for malnutrition in multiple patient populations including HF. Sixteen studies were evaluated in the following review with respect to MUST's effectiveness in screening malnourished patients in multiple patient populations in hospital and outpatient settings. The strengths, weaknesses and reliability of MUST were evaluated in comparison to other reliable screening tools and practice recommendations were made. MUST was chosen over other screening measures because of its ease of use and rapid completion by the user, making it practical to use in any healthcare setting.

Methods

Search Method

The EBSCOhost, Academic Search Complete, CINAHL, and MEDLINE databases were searched through the UK Libraries website. Inclusion criteria involved published studies which compared MUST to other reliable screening methods in adult patients in multiple settings such as the hospital, outpatient clinics, or long term care facilities. The search only included articles from 2004-2014 which were either published in English or translated into English. Keywords used in the search included *adult, elderly, cancer, chronic disease, heart failure, hospitalized patients, malnutrition, malnutrition universal screening tool, screening tools,* and *surgery*. I used ancestry searching to find additional articles meeting the above criteria. Studies were excluded if they were published before 2004, not written or published in English, and if they did not compare MUST to other nutritional screening methods.

Search Outcome

Overall the search produced 52 articles, but only sixteen met the inclusion criteria. Of the studies included in this review, six studies involved hospitalized patients, two evaluated outpatients, and one screened the elderly. Disease specific studies included four oncology, two cardiac and one renal. The cardiac studies consisted of patients undergoing heart surgery, not specific medically managed HF patients. Of the sixteen studies, eight were prospective, five were cross-sectional, two were observational, and one was longitudinal.

Findings and Synthesis of Themes

Several themes emerged during this literature review with regards to screening tools and practice recommendations for nutritional screening. In addition to MUST, a number of subjective screening tools were compared in the studies including the following: Subjective Global Assessment (SGA), Patient-Generated SGA (PG-SGA), Nutrition Risk Screening 2002 (NRS-2002), Nutritional Risk Index (NRI), Geriatric NRI (GNRI), Malnutrition Screening Tool (MST), Modified MST (Mod-MST), Short Nutritional Assessment Questionnaire (SNAQ), Mini-Nutritional Assessment (MNA), MNA Short Form (MNA-SF), and the Cardiac Surgery Specific MUST (CSSM). Overall ten studies recommended specific screening tools for use in malnutrition risk assessment, while two suggested anthropometric or objective measures, two proposed a combination of subjective screening tools and objective measures, and two recommended further research as opposed to any specific screening measures. The following section will illustrate those themes. Refer to Table 1 for specifics about each study and their limitations.

MUST Recommended Alone or in Combination with Other Screening Tools

Of the sixteen studies in this review, seven found MUST to be reliable. Four of those seven recommended MUST alone, while three suggested MUST and other subjective screening tools. Stratton et al. (2004) evaluated eight different screening tools among medical and surgical patients and found MUST and MST to be the easiest tools to complete, according to feedback from nurses, nutritionists and medical students. Based on their statistical analysis (Table 1), overall MUST showed high validity (Table 1) compared to the other evidence based malnutrition diagnostic tools (Stratton et al., 2004). Poulia et al. (2012) on the other hand conducted their study to evaluate the nutritional status of hospitalized elderly patients using six screening tools. The authors found MUST and MNA-SF to be the most reliable with sensitivities of 87.3% and 98.1% respectively, but MUST and SGA demonstrated the best agreement compared to the gold standard, with kappa values of 0.64 and 0.71 respectively (Poulia et al., 2012). Both studies suggested the use of MUST over all the other tools used in their studies (Stratton et al., 2004; Poulia et al., 2012).

Tu, Chien, and Chou (2012) compared MUST, NRI and SGA in their study comprised of forty five colorectal cancer patients. They demonstrated MUST and NRI to be comparable measures with higher sensitivities (96.0% & 95.2%) and lower specificities (75% & 62.5%). The authors found MUST to be easier to complete, inexpensive and faster compared to NRI and SGA (Tu et al., 2012). Another study also compared three screening tools in the oncology setting (Amaral, Antunes, Cabral, and Kent-Smith, 2008). The MUST showed the highest agreement with the reference tool of NRS-2002 based on its sensitivity of 97.3%, specificity of 77.4% and kappa agreement of 0.64 (Amaral et al., 2008). The authors also recommended MUST based on its reliability (Amaral et al., 2008; & Tu et al., 2012).

Among hospitalized patients, Velasco et al. (2010) and Kyle, Kossovsky, Karsegard, and Pichard (2006) compared three different screening tools using SGA as the standard. Velasco et al. (2010) found good agreement between NRS-2002 and SGA (kappa 0.62) and MUST and SGA (kappa 0.64). Based on their statistical analysis (Table 1), both studies demonstrated that MUST and NRS-2002 were the most reliable tools and one or the other should be implemented for malnutrition screening upon hospital admission. In addition to MUST and NRS-2002, one study also recommended the use of SGA (Kyle et al., 2006).

Vicente et al. (2013) evaluated gastric and colorectal patients using NRI, MUST, MST, SGA, BMI and albumin. Statistical analysis showed MUST had a sensitivity and specificity of 84% and 73.4% respectively. Vicente et al. (2013) suggested MUST and SGA were the best screening methods among cancer patients. These seven studies demonstrated MUST to be reliable in multiple populations including medical, surgical, cancer and elderly patients. The authors recommended MUST alone or in combination with NRS-2002 or SGA.

Alternative Screening Tools Recommended for Practice

Neelemaat et al. (2011) evaluated hospitalized medical and surgical patients to compare six subjective tools and two anthropometric measures. They found MST and SNAQ to be faster and easier tools, when compared to the more comprehensive tools of MUST and NRS-2002. The MST and SNAQ had adequate sensitivities and specificities of ≥70%, but their scores were slightly lower than the other tools. Based on all the available information, the authors suggested the use of either MST or SNAQ upon hospital admission (Neelemaat et al., 2011). Like Neelemaat et al. (2011), hospitalized medical and surgical patients were also screened by Olivares et al. (2014), but the authors only used four subjective tools. The authors found the NRS-2002 and MNA-SF to be highly reliable measures compared to SGA, with kappa values of 0.57 and 0.67

respectively (Table 1; Olivares et al., 2014). In contrast to other studies, the authors suggested the use of NRS 2002 because it was the easiest and took the least amount of time to complete (Olivares et al., 2014).

One study evaluated the nutritional status of hospitalized medical patients using three screening tools (Gibson, Sequeira, Cant and Ku, 2012). Based on statistical analysis, MUST and Mod-MST had sensitivities of 80% and 77% respectively, with specificities of 85% and 83% (Gibson et al., 2012). Both tools had 29 false negatives, but MUST had 14 false positives while Mod-MST had 16. Noting similar scores between the tools, the authors suggested the use of the Mod-MST on hospital admission given it was easier and faster to use (Gibson et al., 2012). In these three studies evaluating surgical and/or medical patients, the authors recommended four different subjective tools including MST, SNAQ, NRS-2002 and Mod-MST (Neelemaat et al., 2011; Olivares et al., 2014; & Gibson et al., 2012).

Alternative Objective Measures Recommended for Practice

One study did not recommend MUST, but rather objective screening measures (Boleo-Tome, Monteiro-Grillo, Camillo, & Ravasco, 2011). The authors evaluated the nutritional status of cancer patients using objective measures and two subjective tools. Results indicated that MUST was the best tool for routine screening in radiation cancer patients given its sensitivity of 80% and specificity of 89% (Boleo-Tome et al., 2011). Given the time constraints of health professional however, the authors suggested the use of percent weight loss over the last 3-6 months to be used with admission screenings (Boleo-Tome et al., 2011).

In contrast to Boleo-Tome et al. (2011), Leistra et al. (2013) compared objective and subjective methods in the outpatient setting and did not find MUST or the other subjective tool (SNAQ) to be reliable. They found both subjective screening tools to have insufficient validity, noting SNAQ identified too few and MUST too many patients as being malnourished (Table 1). Their recommendation was to use anthropometric measures and weight loss to better identify malnourished patients in the outpatient setting (Leistra et al., 2013). These two studies suggest that subjective tools may be useful but are not comparable to objective measures in terms of efficiency and reliability.

Combination of Screening Tools and Objective Measures

A few researchers noted the best nutritional screening methods were those which combined a subjective screening tool and objective measures such as lab values and anthropometric measures (Almeida, Correia, Camilo, and Ravasco, 2011; Van Venrooij et al., 2011). Almeida et al. (2011) compared four screening tools to the objective measures of percentage weight loss and BMI in surgical patients to determine their nutritional status. Van Venrooij et al (2011) on the other hand, used four screening tools and two objective measures to screen cardiac surgery patients. Based on statistical analysis, found the NRS-2002 and MUST tools to be the most concordant with sensitivities of 80% and 85% respectively (Table 1; Almeida et al., 2011). The authors went on to suggest the combination of either NRS-2002 or MUST with percentage weight loss on admission (Almeida et al., 2011). In contrast, Van Venrooij et al. (2011) found the CSSM tool to be the most reliable, noting a sensitivity and specificity of 74.1% and 70.1% respectively. They too recommended a combination of objective and subjective screening measures in the cardiac surgery population in order to accurately identify those who may truly be malnourished.

No Specific Tool Recommendations

In two studies screening chronic disease patients, the authors did not find sufficient evidence to recommend a specific subjective screening tool. Lawson et al. (2012) evaluated the nutritional status of renal patients using the three screening tools, while Lomivorotov et al. (2013) compared SGA to three screening tools in cardiac surgery patients. Lawson et al. (2012) found MUST and MST were not sensitive enough for all types of renal patients with sensitivities of 53.8% and 48.7% respectively. They did note both tools showed fair reliability compared to anthropometric nutritional markers (Table 1). Based on statistical analysis the authors did not recommend one specific tool for nutritional screening, but did stress the need for larger studies which evaluate multiple screening methods in renal patients (Lawson et al., 2012). Lomivorotov et al. (2013) found SNAQ and MUST had comparable accuracy in detecting malnutrition but not in predicting post-operative outcomes (Table 1). This led the authors to not recommend a specific screening tool but suggest that more research is needed to understand the use of nutrition screening tools in the HF and cardiac surgery populations (Lomivorotov et al., 2013). The above research studies indicated more research is needed to evaluate subjective screening tools among patients with chronic diseases such as HF and renal failure (Lawson et al., 2012; Lomivorotov et al. 2013).

Practice Implications

Malnutrition is highly prevalent in hospitalized, chronic disease patient populations but often remains unidentified and untreated (Lawson et al., 2012). The overwhelming cost of malnutrition suggests the need for a consistent and reliable nutrition screening method that is easy to use and transferable across multiple patient populations (Elia, 2009). The Malnutrition Universal Screening Tool has demonstrated evidence of reliability and validity in multiple patient populations including outpatients, hospitalized, cancer, elderly, and chronic disease.

There appear to be major gaps in the literature involving a consistent and reliable screening tool which can be used for patients with chronic diseases such as renal and HF. The MUST was utilized in cardiac surgery patients, but not specifically in medically managed HF patients. Through this literature review, MUST showed reliability and validity in various patient populations. Implementing its use upon hospital admission may help identify those at malnutrition risk earlier and possibly improve patient outcomes. There is a growing need for studies that evaluate MUST and multiple subjective screening methods in combination with objective measures (i.e. albumin, prealbumin and recent weight loss) in the HF population.

Conclusions

No one tool has demonstrated consistent reliability and validity in screening for malnutrition among multiple patient populations in various healthcare settings. Malnutrition can occur in many patient populations including chronic diseases such as cancer, liver failure and HF (Jensen et al., 2010). In HF, malnutrition can be as prevalent as 36% based on serum albumin levels and the presence of less than 90% ideal body weight (Nicol, Carroll, Homeyer, & Zamagni, 2002). The use of MUST in the HF patient population is not well described in the literature; however, it has been used with success in other adult and elderly populations. More research needs to be conducted within the HF population to better identify a reliable and valid tool for this population.

Table 1 Review of the MUST Literature

Author and Year	Study Design and Purpose	Sample and Demographics	Nutrition Screening Methods	Results	Conclusions	Limitations
Almeida, Correia, Camilo, & Ravasco: 2011	Prospective cross-sectional study, over eight months with all data collected by a single research dietitian to determine nutritional status.	Three hundred surgical hospitalized patients; ages 43 - 77; 44% male; 46% cancer patients	BMI, recent % weight loss, Nutrition Risk Screening 2002 (NRS 2002), Malnutrition Universal Screening Tool (MUST), Nutritional Risk Index (NRI), Subjective Global Assessment (SGA)	Compared to SGA the Sensitivity, Specificity, PPV, NPV: **NRS 2002** - 80%, 89%, 87%, 100%; **MUST** - 85%, 93%, 89%, 99%; **NRI** - 29%, 27%, 24%, 27%; **BMI** - 43%, 39%, 35%, 31%; **% wt loss** - 89%, 93%, 81%, 89%	NRS 2002 and MUST are the most concordant, valid and reliable tools to detect nutrition risk in surgical patients. >5% weight loss over six months was reliable and valid. Percent weight loss estimation should be mandatory in routine practice to increase outcome driven nutrition management.	MUST and NRI were made into two categories for the purpose of the study, but each were originally developed into three and four categories. Made two categories in order to determine comparisons, but only two categories could affect the results.

Table 1 (continued)

Author and Year	Study Design and Purpose	Sample and Demographics	Nutrition Screening Methods	Results	Conclusions	Limitations
Amaral, Antunes, Cabral, Alvest, & Kent-Smith: 2008	Prospective study over two months at a comprehensive cancer center in Portugal. One researcher collected all data to determine nutritional status and the tools' ability to predict length of stay.	One hundred thirty cancer patients (head and neck, GI, GU, breast, lymph, endocrine, respiratory, bone); ages 43-71; 44% female	MUST, Malnutrition Screening Tool (MST) & NRS 2002	Compared to NRS 2002; sensitivity, specificity, PPV, NPV, kappa agreement: **MUST** - 97.3%, 77.4%, 63.2%, 98.6%, 0.64; **MST** - 48.7%, 94.6%, 78.3%, 82.2%, 0.49	MUST is most concurring with NRS 2002 in hospitalized cancer patients and better at identifying patients at risk for increased length of stay. MST was a better diagnostic value in head/neck, peritoneal and GI cancers. The three screening tools agreed with respect to identifying head/neck cancer patients at highest nutritional risk. MST was easiest for patients to use for self-screening because it required no training compared to MUST and NRS-2002.	Inherent to design, patients admitted to the study may not represent the full spectrum of cancer patients. Small sample size in some diagnostic groups compromised the influence for some types of patients. Excluded critically ill patients because their nutritional status would seriously be affected. But this limited the usefulness of the studied tools in such diagnoses.

Table 1 (continued)

Author and Year	Study Design and Purpose	Sample and Demographics	Nutrition Screening Methods	Results	Conclusions	Limitations
Boleo-Tome, Monteiro-Grillo, Camilo, & Ravasco: 2011	Prospective cross-sectional study over ten months to classify nutritional risk and status categories; compare results between nutritional parameters; and validate MUST in the cancer population. All data collected by single research dietitian.	Four hundred fifty adult cancer patients; ages 18-95; 60% male; predominantly with breast, prostate, lung and colorectal cancer	BMI, % weight loss, Patient Generated-Subjective Global Assessment (PG-SGA), and MUST	Compared to SGA: **MUST** sensitivity 80%, specificity 89%, PPV 87%, NPV 100%, kappa 0.86; Percentage of malnourished patients: **BMI** 4%, **SGA** 29%, and **MUST** 31%	MUST was strongly recommended to be integrated in routine screening in the radiation oncology setting. It should be the primary tool to refer patients for exact nutritional screening with the PG-SGA tool. Based on time constraints of health professionals, it is recommended to use % weight loss in last 3-6 months as a valid and minimum parameter to predict nutritional risk.	Included a heterogeneous population of cancer patients in terms of primary site, nutritional goals, radiologic fields and prognosis. Study population was restricted to radiotherapy patients and cannot be generalized to all cancer patients; however it is a good basis for future studies in oncology.

Table 1 (continued)

Author and Year	Study Design and Purpose	Sample and Demographics	Nutrition Screening Methods	Results	Conclusions	Limitations
Gibson, Sequeira, Cant, & Ku: 2012	Prospective study to explore the ease of use of two screening tools. Compare the validity in adult acute hospital patients over 2 months in 2 separate screening phases.	Two hundred sixty two medical ward patients; mean age 70.8 ± 16.3yrs; 51.5% female	MUST, Modified Malnutrition Screening Tool (Mod-MST), SGA	Malnutrition risk by tool: **MUST** 32.4%; **Mod-MST** 32.8%, **SGA** 26.7%. Compared to SGA, sensitivity & specificity: **MUST** 80%, 85%; **Mod-MST** 77%, 83%. False negatives/false positives: **MUST** 14/29; **Mod-MST** 16/29.	MUST and Mod-MST were valid and feasible to use with medical patients. Little variation between the two tools compared to SGA, but sensitivity and specificity were ≤ 85%. MUST took up to five minutes longer and Mod-MST was easier to use. Mod-MST was recommended because one needs to choose tools that are effective and easy to use in massive-screening programs.	Large sample may have more confidently predicted the two groups of misclassified patients. There were a number of patients admitted to the hospital but missed in the screening process. Only three staff members completed the interviews and may need a larger sample in order to apply to other groups.

Table 1 (continued)

Author and Year	Study Design and Purpose	Sample and Demographics	Nutrition Screening Methods	Results	Conclusions	Limitations
Kyle, Kossovsky, Karsegard & Pichard: 2006	Population study to test the sensitivity and specificity of three screening tools compared to SGA, to assess the association between nutritional risk and hospital LOS over a 3 month period.	Nine hundred ninety five adult medical and surgical patients; 53% male; mean age 50.5 ± 21.9 (<10d LOS), 65.4 ± 18.7 (>11d LOS)	NRI, MUST, NRS-2002, SGA	Moderate/severe nutritional risk: **SGA** 39%, **NRI** 25%, **NRS-2002** 28%, **MUST** 37%. Compared to SGA, sensitivity, specificity, PPV, NPV, kappa: **NRI** 43.1%, 89.3%, 76.2%, 66.3%, 0.24; **MUST** 61.2%, 78.6%, 64.6%, 76.1%, 0.26; **NRS-2002** 62%, 93.1%, 85.1%, 79.4%, 0.48	Significant association between LOS and moderate to severe malnutritional status among all tools. NRS-2002 had higher sensitivity and specificity compared to SGA than NRI and MUST. The authors recommended using the NRS-2002, MUST and SGA tools on admission to screen patients for malnutrition.	SGA does not allow for categorization of mild malnutrition and focuses on chronic not acute malnutrition. Screeners should have been better trained on the screening tools before implementing the study. LOS was studied as an outcome parameter, but many other factors influence LOS, not just malnutrition, which were not assessed in this study.

Table 1 (continued)

Author and Year	Study Design and Purpose	Sample and Demographics	Nutrition Screening Methods	Results	Conclusions	Limitations
Lawson, Campbell, Dimakopoulos, & Dockrell: 2012	Cross-sectional and longitudinal study to determine the validity and reliability of two screening tools in renal patients over six months in a London tertiary hospital. Study divided into three study arms: 1) concurrent and predictive validity; 2) construct validity; 3) reliability.	Two hundred seventy six patients; in three study arms: 1) 190 pts, median age 65, 48% female; 2) 46 pts, median age 61, 49% female; 3) 40 pts, median age 64, 48.5% female. All patients received peritoneal or hemodialysis, renal replacement therapy, or transplant.	SGA, MUST, MST	**1)** Validity compared to SGA, sensitivity, specificity, PPV, NPV, & k: **MUST** - 53.8%, 78.3%, 73.7%, 60%, 0.316; **MST** - 48.7%, 85.5%, 78.7%, 60.2%, 0.335. **2)** Risk of malnutrition classification: **MUST** 22.5%; **MST** 27.5%. **3)** Agreement between repeat tests, k value: **MUST** 0.58 (moderate); **MST** 0.33 (fair).	MUST and MST not sensitive enough to identify all of the malnourished renal in-patients; despite being fairly reliable and related to other markers of nutritional status. There is a growing need for more research on a renal-specific nutrition screening tool.	Need a larger sample to better determine reliability in all renal patients. Fluid status could not be determined in this patient population which may skew patient weights and effect nutritional status estimates.

Table 1 (continued)

Author and Year	Study Design and Purpose	Sample and Demographics	Nutrition Screening Methods	Results	Conclusions	Limitations
Leistra, Langius, Evers, van Bokhorst-de van der Schueren, Visser, de Vet, & Kruizenga: 2013	Cross-sectional multicenter study at nine hospitals in the Netherlands to determine the validity of screening tools in identifying severely undernourished patients.	Two thousand two hundred thirty six hospital outpatients patients; ages 40-72 years; 52.4% female	BMI, % weight loss, MUST, Short Nutritional Assessment Questionnaire (SNAQ)	**BMI and % weight loss** - 6% severe, 7% moderate; **MUST** - 9% severe, 6% moderate; **SNAQ** - 3% severe, 2% moderate. Sensitivity, Specificity, PPV, NPV (severe/moderate): **MUST** - 75%/82%, 94%/95%, 43%/71%, 98%/97%; **SNAQ** - 43%/29%, 99%/98%, 78%/72%, 96%/90%.	Validity of MUST and SNAQ is insufficient for hospital outpatients. SNAQ identified too few undernourished patients, while MUST identified too many. It is recommended to measure weight, height and weight loss to better determine undernourishment in hospital outpatients.	Patients completed the assessment forms, rather than trained medical professionals. There remains an absence of a gold standard screening tool with which to compare other tools. Only two tools were used in the study and with the variety of tools available, more could have been used.

Table 1 (continued)

Author and Year	Study Design and Purpose	Sample and Demographics	Nutrition Screening Methods	Results	Conclusions	Limitations
Lomivorotov, Efremov, Boboshko, Nikolaev, Vedernikov, Lomivorotov, & Karaskov: 2012	Prospective cohort study over eight months to assess the prognostic value of different screening tools in cardiopulmonary bypass patients.	Eight hundred ninety four patients; > 53 years of age; 21% > 65 years; 37% female, 14% with Diabetes; 2.4% with EF < 35%; 8.7% redo surgery	SGA, NRS 2002, MUST, Mini-Nutritional Assessment (MNA), SNAQ	Compared to SGA, malnourished patients, sensitivity, specificity, PPV, NPV: **NRS 2002** - 6%, 38.3%, 95.4%, 31.6%, 96.5%; **MUST** - 17%, 97.9%, 87.1%, 29.7%, 99.9%, **MNA** - 23%, 81.8%, 80.7%, 20.4%, 98.6%; **SNAQ** - 17%, 91.5%, 87.5%, 28.9%, 99.5%;	SNAQ and MUST have comparable accuracy in detecting malnourished patients. MUST independently predict post-op complications. All tools were insufficiently sensitive to the risk for development of post-op complications. Need to study if pre-op nutrition interventions will improve patient outcomes. Need to develop more sensitive methods for screening this population.	SGA is limited in cardiac disease because it relies on the interviewer's training and on the interpretation of the results, making it less able to reproduce in daily clinical practice. It has also been known to miss acute changes in nutritional status and miss some cases of malnutrition. The precise analysis of body composition using bioelectrical impedance was not performed, and can affect the lack of correspondence between nutritional screening results and BMI. Long term data was not analyzed.

Table 1 (continued)

Author and Year	Study Design and Purpose	Sample and Demographics	Nutrition Screening Methods	Results	Conclusions	Limitations
Neelemaat, Meijers, Kruizenga, van Ballegooijen, & van Bokhorst-de Vander Schueren: 2011	Cross sectional screening to compare five malnutrition screening tools against a reliable screening method in one hospital.	Two hundred seventy five patients; 62% over 60 yrs; 37% female	MST, SNAQ, MNA short form (MNA-SF), MUST, NRS 2002, BMI, unintentional weight loss	No risk compared to at risk patients; sensitivity, specificity, PPV, NPV: **MST** 78%, 96%, 89%, 91%; **SNAQ** 75%, 84%, 66%, 90%; **MUST** 96%, 80%, 69%, 98%; **NRS 2002** 92%, 85%, 72%, 96%; **MNA-SF** 100%, 41%, 42%, 100%. The authors suggested a sensitivity and specificity of ≥70% for a tool to be considered adequate.	MST and SNAQ are quick and easy tools and suitable for use in hospital inpatient settings with sensitivity and specificity ≤ 70%. MST and SNAQ performed well compared to the more comprehensive tools, MUST and NRS 2002, on criterion validity. MNA-SF showed great sensitivity but low specificity in the elderly population. MUST was less applicable in the study because there were a lot of missing values.	Pre-set definition of malnutrition (BMI and weight loss) could not be determined in all patients. Data was completed by trained Dietitians, but 25% did not have their nutritional status determined. Selection bias was excluded because of this, and the actual rate of malnutrition could be higher.

Table 1 (continued)

Author and Year	Study Design and Purpose	Sample and Demographics	Nutrition Screening Methods	Results	Conclusions	Limitations
Olivares, Ayala, Salas-Salvado, Muniz, Gamundi, Martinez-Indart, & Masmiquel: 2014	Prospective study to determine the prevalence of malnutrition, identify malnutrition risk factors, and compare validity of tools to the SGA in hospitalized patients during a four month period.	Five hundred thirty seven adult patients; 45% medical, 55% surgical; ages 43-78; 56.4% male	SGA, MNA-SF, NRS 2002, MUST	Compared to SGA, sensitivity, specificity, PPV, NPV, k-value: **MNA-SF** - 69.9%, 94.7%, 93%, 75.8%, 0.67; **NRS 2002** - 68.9%, 90.1%, 92.4%, 62.3%, 0.57; **MUST** - 64.1%, 91.9%, 91.5%, 65.3%, 0.56	Any of the tests would be good to use on admission to screen for malnutrition. NRS 2002 was chosen because it was the easiest and took the least amount of time. Difference in malnutrition rates between tools can be explained by severity of underlying disease, population setting, and age. NRS-2002, MNA-SF and SGA have high reliability. MUST is invalidated after adjusting for risk factors because weight loss and low BMI are not frequent in the study population.	Could not be extrapolated to other hospitals in different countries because it was conducted in a second level hospital in Spain. Could not assess other population types for malnourishment such as surgery or transplant patients.

Table 1 (continued)

Author and Year	Study Design and Purpose	Sample and Demographics	Nutrition Screening Methods	Results	Conclusions	Limitations
Poulia, Yannakoulia, Karageorgou, Gamaletsou, Panagiotakos, Sipsas, & Zampelas: 2012	Prospective study to evaluate of the efficacy tools to predict malnutrition in elderly patients admitted to the hospital in Athens, Greece over nine months.	Two hundred forty eight elderly patients > 60 years; mean age 75.2 +/- 8.5yrs; 52% male; admitted for neurologic syndrome, fever, blood disease, rheumatologic disease, malignancy, hemorrhage, diabetes, GI, kidney or respiratory disease	NRI, GNRI, SGA, MUST, MNA-SF, and NRS-2002	Compared to true nutritional status (combined index), sensitivity, specificity, PPV, NPV, kappa: **NRI** - 71.7%, 48.8%, 85.4%, 29.3%, 0.550; **GNRI** - 66%, 92.1%, 94.6%, 56.45%, 0.465; **SGA** - 84.3%, 91.4%, 95.2%, 74.3%, 0.707; **MUST** - 87.3%, 76.8%, 88.4%, 75%, 0.638; **MNA-SF** - 98.1%, 50%, 79.9%, 93.2%, 0.545; **NRS 2002** - 99.4%, 6.1%, 68.2%, 83.3%, 0.088	The NRI was higher in sensitivity and PPV than the other tools, but scored lower in specificity and NPV. MUST and MNA-SF were the most valid. MUST and SGA showed better agreement with the combined index. The researchers concluded that the combination of objective and subjective diagnostic tools that are easy to use are the best for nutritional screening.	Some patients had to have the questionnaires translated for them and results then had to be translated again, making for some miscommunication among patients and researchers. Some patients estimated height and weight instead of being accurately measured by researchers and in 4.8% of patients, anthropometric measurements were not available. These variations in accuracy of measurements could affect calculations and results.

Table 1 (continued)

Author and Year	Study Design and Purpose	Sample and Demographics	Nutrition Screening Methods	Results	Conclusions	Limitations
Stratton, Hackston, Longmore, Dixon, Price, Stroud, King, & Elia: 2004	Series of prospective studies (one outpatient, four inpatient settings) to assess the prevalence of malnutrition risk between MUST and other screening tools for inpatients and outpatients, determine concurrent validity of MUST and other tools, and the ease of use of the screening tools.	Among all series of studies: a) 50 outpatients, b) 75 medical inpatients, c) 85 surgical inpatients, d) 86 elderly patients, e) 50 medical inpatients, and f) 52 surgical inpatients. Specific patient demographics not reported	MUST, MEREC Bulletin tool (MEREC), Hickson and Hill tool (HH), NRS, MST, MNA-SF, SGA, and undernutrition risk score (URS)	Concurrent validity = percentage of patients placed in same nutrition risk category as MUST: a) **MEREC** 92%, **HH** 84%; b)**NRS** 89% (<65yrs), 92% (>65yrs),**MST** 88% (>65yrs); c) **MNA** 80%; d) **MNA** 77%; e) **SGA** 72%/92%; f) **URS** 67%/77%. Ease of use of tools/time to complete: **MUST** - very easy and easy (3-5min); **MST** - very easy (3 min); **MNA** - easy (5 min); **NRS, HH** (5-7 min), **SGA & URS** (5-10 min) - difficult.	A desirable screening tool should be rapid and easy to use. Results indicate MUST was rapid and easy/very easy to use and showed 'fair-good' to 'excellent' concurrent validity with most of the other tools.	Bias in concurrent validity is possible. The sample demographics of the five separate investigations were not disclosed. The only thing known about those patients are the age classifications and patient cohorts (medical or surgical, inpatient or outpatient). This leaves the inability to reproduce the same studies.

Table 1 (continued)

Author and Year	Study Design and Purpose	Sample and Demographics	Nutrition Screening Methods	Results	Conclusions	Limitations
Tu, Chien, & Chou: 2012	Prospective study to assess the nutritional status of patients with colorectal cancer before and after surgery in Taiwan over two years.	Forty five patients; mean age 62.1 yrs ± 11.5; 56% male	Anthropometric measures, biochemical markers, MUST, NRI, & SGA	Compared to prealbumin, sensitivity, specificity, PPV, NPV, kappa: **MUST** - 64%, 60%, 66.7%, 57.1%, 0.239; **NRI** - 80.9%, 70.8%, 70.8%, 80.9%, 0.51; **SGA** - 72.4%, 81.2%, 87.5%, 69.1%, 0.50	Overall the NRI had the highest sensitivity and second highest specificity when compared to prealbumin than the MUST and SGA tools. The MUST and NRI tools were comparable measures, easy to administer and require minimal training to complete, compared to the SGA. MUST is best to use.	Small sample size and convenience of inclusion. Not many patient demographics noted in the study.

Table 1 (continued)

Author and Year	Study Design and Purpose	Sample and Demographics	Nutrition Screening Methods	Results	Conclusions	Limitations
Van Venrooij, Van Leeuwen, Hopmans, Borgmeijer-Hoelen, De Vos, & De Mol: 2011	Single-center prospective observational cohort study over 23 months. Purpose was to compare undernutrition screening tools to low-fat free mass index in patients undergoing cardiac surgery, and assess association with postoperative adverse outcomes.	Three hundred twenty five adult cardiac surgery patients; mean age 65.7 ± 10.1; 27.7% female; 19.4% had BMI > 30; 4% had BMI < 21	low-fat free mass index (FFMI), MUST, SNAQ, cardiac surgery-specific version of MUST (CSSM)	Accuracy in detecting FFMI, prevalence, sensitivity, specificity, PPV, NPV, positive likelihood ratio, area under the curve: **MUST** - 8.3%, 59.3%, 82.7%, 23.9%, 95.7%, 3.4, 0.71; **SNAQ** - 8.3%, 18.5%, 93.6%, 20.8%, 92.6%, 2.9, 0.56; **CSSM** - 8.3%, 74.1%, 70.1%, 18.5%, 96.7%, 2.5, 0.72. Post-op adverse outcomes defined by MUST & SNAQ: 5.8% infection, 2.5% mortality, 36.4% prolonged ICU LOS, 33.1% prolonged hospital LOS.	Accuracy in detecting FFMI before surgery was considerably higher for MUST than SNAQ. SNAQ does not identify 'unintentional weight loss' which is important in determining malnutrition risk. Further research on the cardiac specific MUST is recommended because it integrates age and sex. It is recommended to use the FFMI measure with unintentional weight loss and low BMI to identify and refer malnourished patients.	The bioelectrical impedance makes assumptions and therefore the true nutritional status may be affected by disease state. In cardiac patients bioelectrical impedance can be affected by higher BMIs and extracellular fluid imbalances. The reference standard for undernutrition does not take into account weight loss and low BMI. BMI is only a blunt tool for measuring body fatness. Experts lack agreement about an optimal definition and operationalism of undernutrition.

Table 1 (continued)

Author and Year	Study Design and Purpose	Sample and Demographics	Nutrition Screening Methods	Results	Conclusions	Limitations
Velasco, Garcia, Rodriguez, Frias, Garriga, Alvarez, Peris, & Leon: 2010	Observational multicenter study to evaluate nutritional risk in hospitalized patients using four screening tools. Evaluations performed by a single investigator at each hospital over five months.	Four hundred patients; mean age 67.4 ± 16.1 yrs; 60% male; 66% medical, 34% surgical patients. Main diagnoses were pneumonia, HF, COPD, surgery, neurologic vascular disease, and other medical diagnoses.	NRS 2002, MUST, SGA, & MNA	Compared to SGA, sensitivity, specificity, PPV, NPV, agreement: **NRS 2002** - 74.4%, 87.2%, 76.1%, 86.2%, 0.62; **MUST** - 71.6%, 90.3%, 80.1%, 85.4%, 0.64; **MNA** - 95%, 61.3%, 57.2%, 95.7%, 0.491. LOS for patients ($p<0.001$): No risk - **NRS 2002** 8.9days, **MUST** 9.2days, **MNA** 8.1days, **SGA** 8.8days; At risk - **NRS 2002** 13.7days, **MUST** 13.6days, 12.4days, **SGA** 13.7days.	Best agreement with MUST and SGA, and NRS-2002 and SGA. It is recommended to use MUST and NRS-2002 upon admission. MNA detected more patients at risk but it can only be used in the elderly population.	Some patients who could not be weighed gave an estimation of their weight, which could lead to skewed results. There was a lower prevalence of malnourished patients compared to similar studies in surgical populations. This may be due to the fact that this study mainly comprised of elective surgeries where patients may be in better nutritional health.

Table 1 (continued)

Author and Year	Study Design and Purpose	Sample and Demographics	Nutrition Screening Methods	Results	Conclusions	Limitations
Vicente, Barao, Silva, & Forones: 2013	Cross-sectional study to evaluate nutritional screening methods used to screen patients seen in an oncology clinic in Sao Paulo during an 18 month period.	One hundred thirty seven colorectal (n=116) and gastric (n=21) cancer patients divided into two groups; group one undergoing treatment for cancer, mean age 60.2 ± 12.2yrs, 48% male; group two patients post tumor removal undergoing follow-up treatment, mean age 61.3 ± 11.6 yrs, 45.2% male	BMI, albumin, SGA, NRI, MUST and MST	Compared to SGA; **Group 1** sensitivity, specificity: **BMI** - 10%, 100%; **albumin** - 30%, 92%; **NRI** - 68%, 64%; **MST** - 52%, 84%; **MUST** - 72%, 49%. **Group 2** sensitivity, specificity: **BMI** - 15.3%, 100%; **albumin** - 15.3%, 93.8%; **NRI** - 55.8%, 83.6%; **MST** - 61.5%, 91.8%; **MUST** - 84%, 73.4%.	MUST was the most sensitive tool for screening nutrition, but with a lower specificity. NRI had a lower sensitivity but a higher specificity. Overall the subjective tools showed a higher sensitivity but lower specificity then objective measures. MUST and SGA in combination are better for identifying nutritional risk.	Although the sample size was large, it included a small number of patients with gastric cancer, only 15% of the study population. The authors noted inconsistency with other studies in the number of malnutrition patients compared to other studies in similar populations. This was attributed to the patients not being hospitalized and in fairly good health.

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Manuscript 2

Nutritional Risk Index: A Review of the Literature

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Abstract

Purpose: The purpose of this literature review was to analyze the available literature on the Nutritional Risk Index (NRI) tool and provide evidence to support its reliability and validity in various populations. The literature review will examine the strengths and weaknesses of NRI compared to other nutrition evaluation methods, compare results between studies and make recommendations for practice.

Design and Methods: Literature review for articles in English or translated into English from 2004 to 2014 using the following databases: EBSCOhost, CINAHL, MEDLINE and Academic Search Complete. Once articles were chosen to be included in the review, footnote chasing took place to find additional studies which evaluated NRI and other screening methods.

Results: Over 34 articles were found but ten studies which met the inclusion criteria of NRI and other screening methods. Of the included studies, three evaluated hospital inpatients, three screened cancer patients, two assessed the nutritional status of the elderly, and two examined the nutritional status of HF patients.

Practice Implications: Implementation of the NRI on admission in combination with anthropometric measures may help assist providers in identifying multiple patient populations at risk for malnutrition. No one tool has been proven as the gold standard of nutrition assessment, making it necessary to evaluate multiple tools in the HF population.

Search Terms: *malnutrition, screening tools, adult, nutritional risk index, hospitalized patients, heart failure, cancer, surgery, chronic disease* and *elderly*

Background and Significance

Malnutrition is associated with increased healthcare costs and worse outcomes among hospitalized patients (Elia, 2009). According to the most current nationally-representative data describing US hospital discharges, the average patient remains in the hospital for 4.4 days, while malnourished patients spend an average of 12.6 days (Corkins et al., 2014). The longer hospital stay triples healthcare costs for malnourished patients, increasing from $9,485 for the average patients to $26,944 for malnourished ones (Corkins et al., 2014). Malnutrition is present when a patient's serum albumin level is less than 3.3g/dL, the transferrin is less than 0.16g/dL, and/or the prealbumin is less than 15mg/dL (Beck & Rosenthal, 2002). Malnourished patients have increased hospital length of stay (LOS) and increased readmission rates and are more likely to be discharged to a long term care or rehabilitation facility (Chima et al., 1997).

Heart failure is one of the leading causes of death in the United States, and in 2009 one in nine deaths included HF as a contributing cause (Centers for Disease Control and Prevention [CDC], 2013). The CDC estimates 5.1 million people in the United States have HF (2013). Malnutrition is highly prevalent among hospitalized HF patients at a rate of 66%, but often remains unidentified and untreated (Aziz et al., 2011; Stratton et al., 2006). Most HF patients are unable to consume enough calories to meet the body's demands, which often leads to a condition called cardiac cachexia (Nicol et al., 2002). Cardiac cachexia is a disorder characterized by muscle wasting and protein-energy malnutrition (Moughrabi & Evangelista, 2007). A patient with HF who loses 7.5% or more of his or her body weight over a period of six months most likely has cardiac cachexia (Anker et al., 1997). Cardiac cachexia is responsible for increased morbidity and mortality and decreased quality of life among patients with HF (Moughrabi & Evangelista, 2007). There is a growing need to find a standardized tool to help providers identify malnourished patients earlier and intervene faster. Early recognition of malnutrition by healthcare providers could lead to early intervention, decreased morbidity and mortality, and decreased healthcare costs and LOS (Elia, 2009; Stratton, Green, & Elia, 2004).

Researchers have developed a number of different screening tools to assist healthcare providers with the identification of malnutrition in hospitalized patients. One tool in particular, the Nutritional Risk Index (NRI), was developed by the Veterans' Affairs Total Parenteral Nutrition Cooperative Study Group to determine nutritional risk in the postsurgical patient population (Al-Najjar & Clark, 2012). The NRI uses objective measurements to calculate a score from the following formula: 1.5 x serum albumin + 41.7 x current weight/ideal body weight (Aziz et al., 2011). A score of > 100 means there is no evidence of malnutrition, 97.5 – 100 indicates mild malnutrition, 83.5 – 97.5 means moderate malnutrition, and < 83.5 signifies severe malnutrition (Al-Najjar & Clark, 2012). Since its development, the tool has demonstrated evidence of validity in many patient populations including hospitalized patients, outpatients, surgical patients, the elderly and those with HF and cancer, making it useful to implement in any setting or population (Al-Najjar & Clark, 2012; Faramarzi, et al., 2013; Almeida et al., 2011).

Purpose of the Integrated Review

The purpose of this literature review was to analyze the available literature on the NRI and provide evidence to support whether or not it is reliable in various populations (i.e. oncology, hospitalized, elderly and HF). The following review evaluates ten studies which compared NRI to other reliable screening tools such as Subjective Global Assessment (SGA), Nutrition Risk Screening 2002 (NRS 2002), Mini-Nutritional Assessment (MNA) and MUST in multiple patient populations. As of now, no one tool has been shown to be a gold standard for evaluating nutritional status among all patient populations in the different healthcare settings. The literature review will examine the strengths and weaknesses of the NRI compared to other nutrition evaluation methods, compare results between studies as to which screening tools are the most reliable and make recommendations for practice.

Methods

Search Method

A search for published studies comparing NRI to other reliable nutritional screening instruments and methods was executed using EBSCOhost via the UK Libraries website. Databases used within EBSCOhost included Academic Search Complete, CINAHL, and MEDLINE. The search only included articles in English or translated into English ranging from 2004 to 2014. Keywords used in the search were *malnutrition, screening tools*, *adult*, *nutritional risk index*, *hospitalized patients*, *heart failure*, *cancer, surgery, chronic disease* and *elderly*. Once articles were chosen to be included in the review, I used ancestry searching to find additional studies which evaluated NRI and other screening methods. Inclusion criteria involved recent studies that compared NRI to other screening methods. Studies were excluded if they were not published in English, were written before 2004, or did not compare NRI to other reliable tools or screening methods.

Search Outcome

The overall search produced 34 articles, of which ten met the criteria of comparing NRI to other reliable screening tools and objective measures (albumin, weight loss and BMI). Of the included studies, three evaluated hospital inpatients, three screened cancer patients, two assessed the nutritional status of the elderly, and two evaluated HF patients. The designs of the studies varied ranging from three prospective, three cross-sectional, two controlled population, one retrospective cohort and one retrospective analysis.

Findings and Synthesis of Themes

There were major themes that arose from this review which related to malnutrition risk screening and the best methods in which to do so upon healthcare admission. This review included ten studies which compared NRI to other reliable screening methods in order to evaluate the nutritional status of various patient populations. Screening tools evaluated in addition to NRI in the studies included: NRS-2002, MUST, SGA, Patient Generated SGA (PG-SGA), Geriatric Nutritional Risk Index (GNRI), Mini-nutritional Assessment Short Form (MNA-SF), and Malnutrition Screening Tool (MST).

Of the ten studies, three recommended specific screening tools as the most reliable methods of nutritional screening. Kyle, Kossovsky, Karsegard, and Pichard (2006) recommended NRS-2002, MUST and SGA, while Aziz et al. (2011), and Al-Najjar and Clark (2012) suggested the use of NRI. Six studies found the best methods were a subjective screening tool in combination with anthropometric measures or objective laboratory values. Of those six studies, MUST and SGA were suggested as the subjective measures of choice by Poulia et al. (2012) and Vicente, Barao, Silva and Forones (2013), while Tu, Chien and Chou (2012) suggested MUST and NRI. Three studies did not mention specific subjective screening tools to be used in combination with objective measures (Faramarzi, Mahdavi, Mohammad-Zadeh and Nasirimotlagh, 2013; Meireles, Wazlawik, Bastos and Garcia, 2012; & Cereda, Limonta, Pusani, and Vanotti, 2006). The final study simply recommended recent percentage of weight loss as the minimal screening method, even though the authors found NRS-2002 and MUST were the most concordant, reliable and valid tools to use in surgical patients (Almeida, Correia, Camilo, & Ravasco, 2011).

According to all the authors, they did agree that the best method for nutritional screening is the use of an easy and inexpensive tool that requires little training. A few authors suggested more research be done to determine the best all-around screening tool to use in multiple patient populations, noting the inconsistency among current literature and screening tools (Al-Najjar & Clark, 2012; Aziz et al., 2011; Cereda et al., 2006). The following sections will illustrate those themes. Refer to Table 1 for specifics about each study and their limitations.

Recommendation of Specific Subjective Tools

Two studies that reviewed NRI and HF were conducted by Al-Najjar and Clark (2012) and Aziz et al. (2011). In their study, Al-Najjar and Clark (2012) included outpatients with left ventricular chronic HF attending a community HF clinic, while Aziz et al. (2011) evaluated serum albumin and NRI to assess the incidence of malnutrition and outcomes of adults admitted to the hospital with acute decompensated HF. Al-Najjar and Clark (2012) found NRI to be a univariable predictor of mortality (chi-square 25, p<0.001), and an independent predictor of outcomes in multivariable analysis (chi-square 12, p<0.001). Aziz et al. (2011) determined NRI was the strongest predictor for LOS (odds ratio 1.7, 95% confidence interval 1.58-1.9; p=0.005). The authors also found moderate to severe NRI scores were associated with higher death and readmission rates (Aziz et al., 2011). Based on their statistical analysis, the authors of both studies concluded the NRI was a helpful prognostic marker in patients with HF compared to BMI or albumin alone (Al-Najjar & Clark, 2012; Aziz et al., 2011). The authors also recognized the need for more randomized controlled studies which evaluate NRI and HF patients in order to find a consistent and reliable screening method in this population (Al-Najjar & Clark, 2012; Aziz et al., 2011).

The other study which recommended specific subjective screening tools evaluated the nutritional status of hospitalized adult medical and surgical patients (Kyle et al., 2006). The authors used SGA as the gold standard and compared results between three other tools, NRI, MUST, and NRS-2002 (Kyle et al., 2006). They found MUST and NRS-2002 to be the most concordant with SGA with kappa values of 0.26 and 0.48 respectively. The MUST had the advantage of being less time consuming and required less examiner training, even though it produced a lower sensitivity and specificity of 61.2% and 78.6% respectively (Kyle et al., 2006). Based on statistical analysis and the tool's ease of use, the authors concluded that NRS-2002, SGA, and to a lesser extent MUST, were the best screening tools to evaluate patients upon hospital admission (Kyle et al., 2006).

Combination of Objective and Subjective Screening Methods

Poulia et al. (2011) evaluated the efficacy of six subjective screening tools to predict malnutrition in hospitalized elderly patients (>60 years old) admitted to the hospital in Athens, Greece. Tu et al. (2011) used three screening tools to evaluate the nutritional status of colorectal cancer patients, while Vicente et al. (2013) used four tools to screen colorectal and gastric cancer patients. Poulia et al. (2011) found MUST and MNA-SF to be the most reliable with a sensitivity of 87.3% and 98.1%, and specificity of 76.8% and 50% respectively. The best agreement with the combined index (gold standard) was with SGA and MUST noting kappa values of 0.71 and 0.64 respectively (Poulia et al., 2011). In their study, Tu et al. (2011) found MUST, NRI and SGA to have sensitivities of 64%, 80.9%, and 72.4% with specificities of 66.7%, 70.8%, and 81.2% respectively. In contrast to SGA, the authors determined MUST and NRI were comparable measures, easy for healthcare providers to administer, and required minimal training to complete (Tu et al., 2011). Vicente et al. (2013) determined MUST had a sensitivity of 84% and specificity of 73.4% when compared to SGA. They also found the subjective measures to have higher sensitivities but lower specificities than the objective measures (Table 1). Based on statistical analysis, the authors suggested that MUST and SGA were the best screening measures (Poulia et al, 2011; & Vicente et al., 2013). Tu et al. (2011) on the other hand recommended the use of MUST and NRI when screening hospitalized cancer patients due to their ease of use and requirement of minimal training to complete.

Cereda et al. (2006) compared NRI and GNRI to albumin and prealbumin in elderly patients admitted to a long-term care facility in Como, Italy. Faramarzi et al.

(2013) screened colorectal cancer patients using albumin, NRI and PG-SGA, while Meireles et al. (2012) screened hospitalized surgical patients using three screening tools and anthropometric measures (fat mass index, body cell mass, and standardized phase angle). Cereda et al. (2006) found NRI and GNRI to have similar reliability using Pearson's linear correlation coefficients of 0.98 and 0.95 respectively, in comparison to the objective measures of albumin and prealbumin. Faramarzi et al. (2013) found NRI to have a sensitivity, specificity and kappa value of 66%, 60% and 0.27 when compared to PG-SGA. Using SGA as the gold standard, Meireles et al. (2012) found NRS-2002 and NRI had kappa coefficient values of 0.49 and 0.26 respectively. Based on their statistical analysis, the authors suggested a combination of subjective and objective measures, but did not recommend a specific screening tool (Cereda et al., 2006; Faramarzi et al., 2013; & Meireles et al., 2012). Cereda et al. (2006) further suggested the need for long-term prospective studies which evaluate the nutritional status of the elderly using multiple subjective screening tools and objective measures.

Objective Measures Recommended for Practice

Almeida et al. (2011) conducted their study on 300 adult surgical patients admitted to the hospital. They used the Subjective Global Assessment (SGA) as the gold standard nutritional screening method and compared it to three subjective screening tools, BMI and percentage weight loss. They found MUST and NRS-2002 to be the most concordant with SGA (Almeida et al., 2011). The sensitivity of MUST and NRS-2002 were 85% and 80%, while the specificities were 89% and 93% respectively. The sensitivity and specificity of percentage weight loss were also higher at 89% and 93% respectively. Compared to the subjective measures, percentage weight loss was more cost effective and less time consuming (Almeida et al., 2011). The authors concluded that percentage weight loss screening on admission should be mandatory in routine practice at the very least, in order to increase outcome driven nutrition management (Almeida et al., 2011).

Practice Implications

Early identification and treatment of malnutrition may help decrease hospital costs, inpatient LOS and readmission rates. The costs of HF alone are high. The presence of a complication such as malnutrition can increase healthcare costs and the length of hospital stays dramatically. The NRI has demonstrated evidence of reliability and validity in the hospitalized, cancer, elderly, and HF patient populations. Best results are seen when a subjective tool is used in combination with anthropometric (BMI and % weight loss) and laboratory measures (serum albumin and prealbumin) to identify those at risk for malnutrition. Implementation of subjective screening tools on admission in combination with anthropometric measures may help assist providers in identifying multiple patient populations at risk for malnutrition.

There are major gaps in the literature in regards to consistency among nutrition screening tools in multiple populations. There are conflicting data in research today as to which nutritional screening tool is the most valid and reliable across various clinical settings and in different patient populations. The elderly, cancer and hospitalized patients were the most common populations in which NRI was evaluated; however, in those studies, researchers mainly evaluated NRI and SGA.

Two of the ten studies recommended the use of NRI alone while the others which found NRI useful, also recommended other screening tools. In the two studies which evaluated NRI and HF patients, the tool was not compared to other subjective screening tools, only objective and anthropometrics measures. It would be helpful to see NRI compared to other similar screening tools to determine the most reliable in HF patients. Overall, there needs to be more studies in which a variety of tools are used in accordance with biometric nutritional screening parameters such as laboratory data and body measurements in order to determine the most accurate and reliable screening tool.

Conclusion

This literature review revealed a lack of studies in which multiple tools evaluated the nutritional status of HF patients. Of the two studies reviewed that pertained to HF patients, one study compared NRI to traditional nutritional biomarkers, while the second used NRI to evaluate HF patient outcomes. Multiple subjective screening tools need to be studied within this population to better identify malnutrition among HF patients. No one tool has been proven as the gold standard of nutrition assessment, making it necessary to evaluate multiple tools in the HF population.

Table 1 Review of the NRI Literature

Author and Year	Study Design and Purpose	Sample and Demographics	Nutrition Screening Methods	Results	Conclusions	Limitations
Al-Najjar, & Clark: 2012	Retrospective cohort study over six years at a community CHF clinic. Evaluate nutrition screening methods and their application to HF patients.	Five hundred thirty eight outpatients; mean age 71 ± 9.9; 76% male; all with left ventricular systolic dysfunction	Nutritional Risk Index (NRI), BMI and various laboratory variables (albumin, hemoglobin, white blood count, platelets, creatinine, potassium)	Prevalence according to NRI: 23% moderate, 2.8% being severe. NRI correlation coefficient: **BMI** 0.87, **hemoglobin** 0.19, and **age** -0.24 ($p < 0.001$)	Increased age and decreased BMI and hemoglobin were associated with increased incidence of malnutrition. NRI was a helpful prognostic marker in patients with HF in an outpatient setting. There is a need for a large randomized controlled trials using NRI to evaluate malnutrition effects on mortality.	Large study population but did not take into account changes in medical therapy for patients when determining malnutrition prevalence. The patient population was a convenience sample and included a large number of males compared to females, 76% and 24% respectively. They also did not compare NRI to other methods of nutritional analysis in determining prevalence of malnutrition in the HF population.

Table 1 (continued)

Author and Year	Study Design and Purpose	Sample and Demographics	Nutrition Screening Methods	Results	Conclusions	Limitations
Almeida, Correia, Camilo, & Ravasco: 2011	Prospective cross-sectional study, over eight months with all data collection by a single research dietitian to determine nutritional status	Three hundred surgical hospitalized patients; ages 43 - 77; 44% male; 46% cancer patients	BMI, recent % weight loss, Nutrition Risk Screening 2002 (NRS 2002), Malnutrition Universal Screening Tool (MUST), NRI, Subjective Global Assessment (SGA)	Compared to SGA the Sensitivity, Specificity, positive predictive value (PPV), negative predictive value (NPV): **NRS 2002** - 80%, 89%, 87%, 100%; **MUST** - 85%, 93%, 89%, 99%; **NRI** - 29%, 27%, 24%, 27%; **BMI** - 43%, 39%, 35%, 31%; **% wt loss** - 89%, 93%, 81%, 89%	NRS 2002 and MUST are the most concordant, valid and reliable tools to detect nutrition risk in surgical patients. >5% weight loss over six months was reliable and valid. Percent weight loss estimation should be mandatory in routine practice to increase outcome driven nutrition management.	MUST and NRI were made into two categories for the purpose of the study, but each were originally developed into three and four categories. Made two categories in order to determine comparisons, but only two categories could affect the results.

Table 1 (continued)

Author and Year	Study Design and Purpose	Sample and Demographics	Nutrition Screening Methods	Results	Conclusions	Limitations
Aziz, Javed, Pratep, Musat, Nader, Pulimi, Alivar, Herzog & Kukin: 2011	Controlled population study to assess the incidence of malnutrition and outcomes of adults admitted with acute decompensated HF	One thousand one hundred patients with acute decompensated HF; **No risk** mean age 68 ± 14yrs, 51% male; **mild risk** mean age 72 ± 14yrs, 51% male; **moderate ris**k 72 ± 14yrs, 59% male; **severe risk** mean age 68 ± 15yrs, 56% male	Serum albumin and NRI	NRI risk: none 666 (60%), mild 63 (6%), moderate 213 (19%), severe 168 (15%). Values for mod/severe risk: **readmission rates** 52%/68%; **LOS** 10/10.9 days; **mortality rates** 15%/19% ($p < 0.001$). Average albumin: no risk 3.9, mild risk 3.4, mod risk 3.2, severe 2.6	NRI scores correlated with the lower serum albumin levels. NRI is better prognostic indicator of morbidity and mortality in HF patients than BMI or albumin alone. Recommend NRI to further stratify these patients for nutrition depletion assessment. Need more trials to determine if nutrition therapy is helpful to improve outcomes in HF patients.	Could not calculate periodic NRI scores in patients after admission to the hospital. This could have helped evaluate nutritional status throughout the hospital stay which may have affected patient outcomes.

Table 1 (continued)

Author and Year	Study Design and Purpose	Sample and Demographics	Nutrition Screening Methods	Results	Conclusions	Limitations
Cereda, Limonta, Pusani, & Vanotti: 2006	Retrospective analysis to compare traditional malnutrition markers and screening tools to determine malnutrition risk of elderly admitted to a long-term care unit	One hundred seventy seven elderly patients; 38% male; mean age 80 ± 8.6 yrs	Albumin, prealbumin, Geriatric Nutritional Risk Index (GNRI) and NRI	Nutrition risk: **GNRI** - mod 14.2%, severe 3.5%; **NRI** - mod 33.8%, severe 3.9%. Pearson's linear correlation coefficient: **albumin** - GNRI 0.95; NRI 0.98; **prealbumin** - GNRI 0.52, NRI 0.52	Concluded that a prospective study comparing the two tools would be beneficial given their similar reliability and agreement to traditional markers in elderly patients admitted with an acute illness. GNRI and NRI showed significant correlations with all other biochemical markers of nutrition status.	Sample included patients picked for convenience and resided in a long-term care setting. Those patients are usually less likely to be at nutritional risk as opposed to those in the hospital who are acutely ill. The study was retrospective and collected data could be incorrect.

Table 1 (continued)

Author and Year	Study Design and Purpose	Sample and Demographics	Nutrition Screening Methods	Results	Conclusions	Limitations
Faramarzi, Mahdavi, Mohammad-Zadeh, & Nasirimotlagh: 2013	Prospective study to validate NRI against patient-generated subjective global assessment (PG-SGA), in adult colorectal cancer patients before radiotherapy. All data collected by one nutritionist.	Fifty two patients; mean age 54 years ± 16.8 yrs; 77% male.	Anthropometric data, albumin, NRI, PG-SGA	Prevalence of malnutrition: **SGA** 33% moderate, 19% severe; **NRI** 35% mod, 10% severe. When compared to the SGA, NRI sensitivity 66%, specificity 60%, PPV 64%, NPV 62%, kappa 0.267	NRI had lower sensitivity and specificity than SGA in assessing nutritional status of cancer patients. Each tool has its own advantages and disadvantages (cost and ease of use). Best nutrition assessment is a combination of anthropometric measures and subjective scoring systems.	Small sample size and convenience of inclusion. NRI tool uses albumin, while SGA is based on weight history, dietary intake, diagnosis and physical assessment. Albumin may be affected by disease state and inflammation, making NRI results less accurate.

Table 1 (continued)

Author and Year	Study Design and Purpose	Sample and Demographics	Nutrition Screening Methods	Results	Conclusions	Limitations
Kyle, Kossovsky, Karsegard & Pichard: 2006	Population study to test the sensitivity and specificity of three screening tools compared to SGA, to assess the association between nutritional risk and hospital LOS over a three month period.	Nine hundred ninety five adult medical and surgical patients; 53% male; mean age 50.5 ± 21.9 (< 10d LOS), 65.4 ± 18.7 (> 11d LOS)	NRI, MUST, NRS-2002, SGA	Moderate/severe nutritional risk: **SGA** 39%, **NRI** 25%, **NRS-2002** 28%, **MUST** 37%. Compared to SGA, sensitivity, specificity, PPV, NPV, kappa: **NRI** 43.1%, 89.3%, 76.2%, 66.3%, 0.24; **MUST** 61.2%, 78.6%, 64.6%, 76.1%, 0.26; **NRS-2002** 62%, 93.1%, 85.1%, 79.4%, 0.48	Significant association between LOS and moderate to severe malnutritional status among all tools. NRS-2002 had higher sensitivity and specificity compared to SGA than NRI and MUST. The authors recommended using the NRS-2002, MUST and SGA on admission to screen patients for malnutrition.	SGA does not allow for categorization of mild malnutrition and focuses on chronic not acute malnutrition. Screeners should have been better trained on the screening tools before implementing the study. LOS was studied as an outcome parameter, but many other factors influence LOS, not just malnutrition, which were not assessed in this study.

Table 1 (continued)

Author and Year	Study Design and Purpose	Sample and Demographics	Nutrition Screening Methods	Results	Conclusions	Limitations
Meireles, Wazlawik, Bastos, & Garcia: 2012	Cross-sectional study to assess the relationship between nutritional risk tools and parameters derived from bioelectrical impedance analysis with SGA over 6 months.	One hundred twenty four hospitalized surgical patients; mean age 52.26 ± 14.95 yrs; 56.5% female; 33.1% > 60 yrs	SGA, NRS 2002, NRI, Fat-Free Mass Index (FFMI), Fat Mass Index (FMI), body cell mass (%BCM), standardized phase angle (SPA)	Nutritional risk: **NRS 2002** 19.3%; **NRI** 69.5%; **FFMI** 12.9%; **FMI** 8.1%; **%BCM** 46.8%; **SPA** 4.8%. Agreement between SGA and screening parameters (k coefficient): **NRS** 0.490; **NRI** 0.256; **FFMI** 0.342; **FMI** 0.190; **%BCM** -0.085; **SPA** 0.038	NRS 2002 showed the best agreement with SGA. Highest malnutrition prevalence seen with NRI. The best malnutrition indicator is a combination of anthropometric measures with subjective screening tools.	Sample size could have been larger. The BMI cut off was 34. Obese patients can be very malnourished and should have been included in the study.

Table 1 (continued)

Author and Year	Study Design and Purpose	Sample and Demographics	Nutrition Screening Methods	Results	Conclusions	Limitations
Poulia, Yannakoulia, Karageorgou, Gamaletsou, Panagiotakos, Sipsas, & Zampelas: 2012	Prospective study to evaluate the efficacy of tools to predict malnutrition in elderly patients admitted to the hospital in Athens, Greece over nine months.	Two hundred forty eight elderly patients > 60 years; mean age 75.2 ± 8.5yrs; 52% male; admitted for neurologic syndrome, fever, blood disease, rheumatologic disease, malignancy, hemorrhage, diabetes, GI, kidney or respiratory disease	NRI, GNRI, SGA, MUST, mini nutritional assessment – screening form (MNA-SF), and NRS-2002	Compared to true nutritional status (combined index), sensitivity, specificity, PPV, NPV, kappa: **NRI** - 71.7%, 48.8%, 85.4%, 29.3%, 0.550; **GNRI** - 66%, 92.1%, 94.6%, 56.45%, 0.465; **SGA** - 84.3%, 91.4%, 95.2%, 74.3%, 0.707; **MUST** - 87.3%, 76.8%, 88.4%, 75%, 0.638; **MNA-SF** - 98.1%, 50%, 79.9%, 93.2%, 0.545; **NRS 2002** - 99.4%, 6.1%, 68.2%, 83.3%, 0.088	The NRI was higher in sensitivity and PPV than the other tools, but scored lower in specificity and NPV. MUST and MNA-SF were the most valid. MUST and SGA showed better agreement with the combined index. The researchers concluded that the combination of objective and subjective diagnostic tools that are easy to use are the best for nutritional screening.	Some patients had to have the questionnaires translated for them and results then had to be translated again, making for some miscommunication among patients and researchers. Some patients estimated height and weight instead of being accurately measured by researchers and in 4.8% of patients, anthropometric measurements were not available. These variations in accuracy of measurements could affect calculations and results.

Table 1 (continued)

Author and Year	Study Design and Purpose	Sample and Demographics	Nutrition Screening Methods	Results	Conclusions	Limitations
Tu, Chien, & Chou: 2012	Prospective study to assess the nutritional status of patients with colorectal cancer before and after surgery in Taiwan over two years.	Forty five colorectal cancer patients; mean age 62.1 yrs ± 11.5; 56% male	Anthropometric measures, biochemical markers, MUST, NRI, & SGA	Compared to prealbumin, sensitivity, specificity, PPV, NPV, kappa: **MUST** - 64%, 60%, 66.7%, 57.1%, 0.239; **NRI** - 80.9%, 70.8%, 70.8%, 80.9%, 0.51; **SGA** - 72.4%, 81.2%, 87.5%, 69.1%, 0.50	Overall the NRI had the highest sensitivity and second highest specificity when compared to prealbumin than MUST and SGA. The MUST and NRI were comparable measures, easy to administer and require minimal training to complete, compared to the SGA. MUST is best to use.	Small sample size and convenience of inclusion

Table 1 (continued)

Author and Year	Study Design and Purpose	Sample and Demographics	Nutrition Screening Methods	Results	Conclusions	Limitations
Vicente, Barao, Silva, & Forones: 2013	Cross-sectional study to evaluate nutritional screening methods used to screen patients seen in an oncology clinic in Sao Paulo during an 18 month period.	137 colorectal (n=116) and gastric (n=21) cancer patients divided into two groups; group one undergoing treatment for cancer, mean age 60.2 ± 12.2yrs, 48% male; group two patients post tumor removal undergoing follow-up treatment, mean age 61.3 ± 11.6 yrs, 45.2% male	BMI, albumin, SGA, NRI, MUST and the Malnutrition Screening Tool (MST)	Compared to SGA; **Grp 1** sensitivity, specificity: **BMI** - 10%, 100%; **albumin** - 30%, 92%; **NRI** - 68%, 64%; **MST** - 52%, 84%; **MUST** - 72%, 49%. **Grp 2** sensitivity, specificity: **BMI** - 15.3%, 100%; **albumin** - 15.3%, 93.8%; **NRI** - 55.8%, 83.6%; **MST** - 61.5%, 91.8%; **MUST** - 84%, 73.4%.	MUST was the most sensitive tool for screening nutrition, but with a lower specificity. NRI had a lower sensitivity but a higher specificity. Overall the subjective tools showed a higher sensitivity but lower specificity then objective measures. MUST and SGA in combination are better for identifying nutritional risk.	Although the sample size was large, it included a small number of patients with gastric cancer, only 15% of the study population. The authors noted inconsistency with other studies in the number of malnutrition patients compared to other studies in similar populations. This was attributed to the patients not being hospitalized and in fairly good health.

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Manuscript 3

Evaluating Nutritional Risk in Heart Failure Patients Using Four Screening Tools: A Retrospective Chart Audit

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Abstract

The purpose of this project was to test the performance of albumin, NRI and MUST screening tools in comparison to the standardized measure of prealbumin among HF patients admitted to the University of Kentucky Chandler Medical Center. Inclusion criteria included all HF patients with the 428 diagnostic code, admitted from January 1, - December 31, 2013, ages 18 and older, with all laboratory values available specified in the data collection tool (Appendix A). A retrospective electronic medical record (EMR) review was performed for 100 patients who met the inclusion criteria. All data were collected through the University of Kentucky's secure network via the EMR program Sunrise Clinical Manager. Serum albumin, prealbumin, MUST and NRI found 79, 85, 53 and 92 patients to be at nutritional risk, respectively. The NRI tool compared better with prealbumin than albumin and MUST, when screening for malnutrition in HF patients. The sensitivity of NRI compared to prealbumin was 92.9%. The results of this study provide evidence that NRI in combination with laboratory measures may be beneficial in identifying malnutrition among HF patients. There is still a need for further research into effective screening methods among this population.

Evaluating Nutritional Risk in Heart Failure Patients Using Four Screening Tools: A Retrospective Chart Audit

Malnutrition incidence among hospitalized inpatients is prevalent at a rate of 23% (Gout, Barker, & Crowe, 2009). According to the most current nationally-representative data describing U.S. hospital discharges, malnourished patients spent an average of 12.6 days in the hospital compared to 4.4 days for other patients (Corkins et al., 2014). With an increased hospital length of stay, the average hospital cost will triple for those patients, rising from $9,485 to $26,944 (Corkins et al., 2014). Visceral proteins such as albumin and prealbumin are useful markers to detect malnutrition in adults and the elderly (Sergi et al., 2006). Traditionally albumin has been the most commonly used indicator, with prealbumin increasing in popularity in the recent years (Beck & Rosenthal, 2002). Prealbumin is the most sensitive indicator for protein synthesis because it contains one of the highest ratios of essential and nonessential amino acids compared to any protein in the body (Beck & Rosenthal, 2002). Normal levels for albumin and prealbumin are 3.3-4.8g/dL and 16-35mg/dL respectively (Beck & Rosenthal, 2002). Serum albumin has a half-life of 20 days and can be affected by hydration status and renal function. The half-life of prealbumin is two days and is not typically affected by hydration status, renal or liver function. Prealbumin levels will decrease if a patient is consuming 60% or less of their required daily protein intake (Le Moullac, Gouache, & Bleiberg-Daniel, 1992). Once adequate supplementation of proteins is restored, increased prealbumin synthesis will typically occur within 2-4 days (Le Moullac et al., 1992). Low levels of albumin and prealbumin are associated with a low body mass index (BMI) and a poor nutritional status (Sergi et al., 2006). In HF patients, renal insufficiency is common and can lead to false elevation of serum albumin and prealbumin; therefore, malnutrition cannot be ruled out if these levels are on the lower end of normal (Sergi et al., 2006).

An estimated 5.1 million Americans have HF (Centers for Disease Control, 2013). Malnutrition prevalence among HF patients is as high as 66% based on serum albumin levels and the presence of less than 90% ideal body weight (Aziz et al., 2011; Nicol et al., 2002). Malnutrition in HF patients may be caused by hepatic and gastrointestinal (GI) congestion due to elevated right sided heart pressures, resulting in anorexia, malabsorption, dyspepsia, and protein wasting enteropathy (Nicol et al., 2002). These changes may lead to the patient feeling full and satisfied due to hepatic and GI congestion rather than consuming a full meal (Nicol et al., 2002). Cardiac cachexia (CC) is the presence of severe malnutrition in HF patients which can be associated with advanced myocardial dysfunction, poor prognosis and decreased survival (Moughrabi & Evangelista, 2007). The definition of CC is "unintentional nonedematous weight loss greater than 6% of a patient's previous weight over a period of six months regardless of BMI, and in the absence of other primary cachectic states such as cancer, thyroid disease and severe liver disease" (Moughrabi & Evangelista, 2007, p. 101).

Changes in weight are not always an accurate measure of nutritional status given the fluid volume overload often present in HF (Araujo, Lourenco, Rocha-Gonocalves, Ferreira, & Bettencourt, 2011). Nutritional markers among patients with CC were assessed, and prealbumin, albumin, hemoglobin, lymphocyte count and triglycerides levels were significantly lower compared to healthy HF patients (Araujo et al., 2011). Based on multivariate logistic regression analysis, prealbumin was the only laboratory marker independently associated with CC occurrence through an odds ratio of 1.08 and 95% confidence interval 1.01-1.17 ($p<0.001$; Araujo et al., 2011).

Laboratory values of albumin and prealbumin are useful in identifying malnutrition in the general and HF populations, but they have a few limitations in their accuracy. Albumin concentrations can be affected by hydration, renal function, and the presence of infection or inflammation (Beck & Rosenthal, 2002). Prealbumin can decrease in the post-surgical phase, in the presence of inflammation, and in conditions associated with protein malnutrition (e.g., malignancy, cirrhosis and zinc deficiency; Beck & Rosenthal, 2002). Overall, prealbumin is a better nutrition laboratory marker of acute changes in nutritional status, while albumin more accurately identifies chronic malnutrition. Aside from prealbumin and albumin, there is currently a lack of literature that compares other laboratory trends and trends in co-morbidities among malnourished HF patients.

Subjective nutritional screening tools can be easy, rapid and inexpensive methods of identifying malnutrition risk and prevalence among patients. There are a number of screening tools available, but there are few studies which identify the best methods to measure malnutrition and its severity in the HF population. However, two subjective screening tools have shown some promise among this population, the Malnutrition Universal Screening Tool (MUST) and the Nutritional Risk Index (NRI). In two studies, multiple screening tools were tested in cardiac surgery patients and the MUST was reported as being the most sensitive in detecting malnutrition (Lomivorotov et al, 2012; Venrooij et al., 2011). In comparison to the Subjective Global Assessment (SGA) screening tool, MUST had a sensitivity of 97.9 and specificity of 87.1 (Lomivorotov et al., 2012). The MUST was also the only tool to be significantly associated with post-operative complications following open heart surgery according to multivariate logistic regression analysis (odds ratio 1.5; 95% confidence interval 1.1 – 2.4; p=0.02). Researchers recommended MUST in screening cardiac surgery patients, but also indicated more research needs to be conducted among HF patients to determine the most reliable tool (Lomivorotov et al, 2012; Venrooij et al., 2011).

Two studies compared NRI to a traditional nutrition biomarker, albumin, to determine its reliability in identifying malnutrition among HF patients (Al-Najjar & Clark, 2012; Aziz et al., 2011). When evaluating NRI and other nutritional screening parameters as predictors of outcomes and mortality, NRI was a useful prognostic marker in outpatients with HF (Al-Najjar & Clark, 2012). According to statistical analysis, NRI was a univariable predictor of mortality (chi-square 25, p <0.001), and an independent predictor of outcome in multivariable analysis (chi-square 12, p <0.001; A-Najjar & Clark, 2012). In another study, NRI was found to be the most significant predictor of all-cause mortality and readmission rates associated with episodes of acute decompensated HF (Aziz et al., 2011). Using Cox's hazard regression models, NRI had a univariate odds ratio of 3.03, and a 95% confidence interval of 3.22-3.94 with p < 0.0001; a multivariate odds ratio of 3.1, and a 95% confidence interval of 2.34-4.22 with p <0.0001 (Aziz et al., 2011). The authors suggested further research be conducted using NRI in the HF population to determine malnutrition prevalence and its effects on morbidity and mortality (Al-Najjar & Clark, 2012; Aziz et al., 2011). Implementing the use of NRI or MUST on admission for HF patients may help identify the presence of malnutrition earlier so that the malnourished may be referred to a dietitian for appropriate nutritional intervention earlier. Noting the negative impacts of malnutrition on the patient, early recognition and management may help decrease hospital lengths of stay, readmission rates and associated healthcare costs.

Description of Practice Inquiry Project

This practice inquiry project, through a retrospective EMR review, evaluated the presence of malnutrition in 100 HF patients admitted to the University of Kentucky Chandler Medical Center between January 1, and December 31, 2013.

Goals and Objectives

The objectives of this project were to (i) evaluate HF patients for the presence of malnutrition using four screening measures (i.e., albumin, prealbumin, Nutritional Risk Index and Malnutrition Universal Screening Tool), and (ii) determine laboratory and co-morbidity trends among malnourished patients. Based on these objectives, the primary goal of this project was to test the performance of albumin, NRI and MUST in comparison to prealbumin, among HF patients admitted to the University of Kentucky Chandler Medical Center.

Methods

Human subject and research approval procedures

Once the project proposal was developed an expedited proposal was then submitted and approved by the hospital's Institutional Review Board (IRB). Noting the project was a retrospective EMR review, patient consent was waived in compliance with IRB regulations.

Study Setting

The study was conducted at the University of Kentucky Chandler Medical Center, which is an 875-bed level 1 trauma center located in central Kentucky.

Study Design and Selection of Participants

A retrospective EMR review was performed. Inclusion criteria encompassed all HF patients with the 428 diagnostic code, admitted from January 1, - December 31, 2013, ages 18 and older, with all laboratory values available specified in the data collection tool (Appendix A). The HF core measures coordinator provided a list of HF patients with medical record numbers in order to obtain 100 patients who met the inclusion criteria. A convenience sample was obtained of the first 100 patients from every HF diagnostic code (428.0, 428.2, 428.3, and 428.4) who had all laboratory values available in their EMR. The master list consisted of the medical record numbers for the 100 patients, who were randomly assigned a study number.

In order to collect specific data via the EMR, a total of 100 patient records were reviewed using the master list of medical record numbers. All data were collected through the University of Kentucky's secure network through the EMR program, Sunrise Clinical Manager, which requires an active username and password to access. The collected data included the following: demographics (gender, age, and ethnicity), admitted unit (intensive care, telemetry, or progressive), HF diagnostic code, percent ejection fraction (% EF), anthropometric measures (height, weight, BMI), presence of unexplained weight loss, presence of acute illness or no nutritional intake >5 days, dietitian consult, day of first dietitian note, intensive care unit (ICU) length of stay (LOS), hospital LOS, diet order on admission, and dietary intake. Laboratory measures, which included B-type natriuretic peptide (BNP), glomerular filtration rate (GFR), glucose, HgbA1c, creatinine, albumin, and prealbumin, were obtained from the initial set of labs acquired within the first 24 hours of admission. If the laboratory value wasn't available within the first 24 hours, the first available value was then used. Height, weight, BMI and presence of recent weight loss were obtained from the adult patient profile, which every patient must have completed within 24 hours of admission. Ejection fraction was collected from results of the first echocardiogram conducted on admission. The orders and documents sections of the patient's EMR provided admission orders which indicated to which unit the patient was admitted, transfer orders if the patient was moved throughout their hospital stay, diet order, if a dietitian was consulted and when the first nutrition note was documented.

Outcome Measure

For the purpose of this study, malnutrition or non-nutritional risk will be classified as follows for each screening tool: the non-nutritional risk group will have albumin > 3.2g/dL, prealbumin ≥ 11mg/dL, NRI score of ≥ 82.1, and a MUST score of 0; the nutritionally at risk group will have albumin ≤ 3.2g/dL, prealbumin ≤ 10.9mg/dL, NRI ≤ 82, and a MUST score of ≥ 1.

Instruments

Nutritional risk based on serum prealbumin can be classified into four categories: normal is 16.0 – 35.0mg/dL, increased risk is 11.0 – 15.9mg/dL, significant risk 5.0 – 10.9mg/dl, and poor prognosis with < 5.0mg/dL (Prealbumin in Nutritional Care Consensus Group, 1995). When the serum albumin level is ≤ 3.2g/dL a patient is at an increased risk of being malnourished (Beck & Rosenthal, 2002).

The NRI was developed by the Veterans' Affairs Total Parenteral Nutrition Cooperative Study Group to determine nutritional risk in the postsurgical patient population (Al-Najjar & Clark, 2012). The NRI uses the patient's serum albumin, and the ratio of current body weight to ideal body weight to predict a patient's malnutrition status. The score is calculated as follows: 1.5 x serum albumin + 41.7 x current weight/ideal body weight. A score of > 100 means there is no evidence of malnutrition, 97.5 – 100 indicates mild malnutrition, 83.5 – 97.5 means moderate malnutrition, and < 83.5 signifies severe malnutrition (Al-Najjar & Clark, 2012).

The MUST was originally developed by the Malnutrition Advisory Group for the British Association of Parenteral and Enteral Nutrition (Elia, 2010). MUST is a five-step tool that is easy to use and usually takes 3-5 minutes to complete. It evaluates BMI score, recent weight loss, and acute disease, then assigns an overall numerical risk (Elia, 2010). A score of 0 = low risk, 1 = medium risk, and ≥ 2 = high risk. Based on the MUST score appropriate management guidelines are provided. A score of 0 requires no intervention. Patients with a score of 1 require close dietary intake monitoring to evaluate for necessary supplements. A score of 2 or more requires immediate nutritional evaluation by a dietitian.

Data Analysis

Data analysis was performed using SPSS ® v. 21.0 (SPSS Inc., Chicago, IL).

Descriptive statistics. Data on patient age, gender, ethnicity, anthropometric measurements, blood biochemical parameters, ICU and hospital LOS were analyzed using descriptive statistics. In order to determine trends among patient demographics and blood biochemical measures among the malnourished groups, descriptive statistics were also computed using SPSS.

Consistency analysis. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and confidence intervals (95%) were conducted to compare the performance of serum albumin, MUST and NRI in comparison to serum prealbumin levels. In the following equations, *a* represents test positive true cases; *b* represents test positive not cases; *c* represents test negative true cases; and *d* represents test negative not cases:

Sensitivity (Sn) = $a / (a+c)$ Specificity (Sp) = $b / (b+d)$

PPV = $a / (a+b)$ NPV = $d / (d+c)$

$$95\%\ CI\ (Sn) = Sn \pm 1.96 \sqrt{}\ [Sn(1\text{-}Sn)] / a + c$$

$$95\%\ CI\ (Sp) = Sp \pm 1.96 \sqrt{}\ [Sp(1\text{-}Sp)] / b + d$$

Results

Characteristics of the Study Population

The demographics of the participants are presented in Table 1. The mean age was 62.8 ± 11.5 years, with 53% males involved in the study. The majority of patients were diagnosed with systolic HF (49%), followed by diastolic HF (26%), then unspecified congestive HF (23%), and finally combined diastolic and systolic HF (2%). A normal EF% of > 55 was seen in 32% of patients, while 68% had a decreased EF% (< 55). Seventy one patients were admitted to a telemetry unit, while eight went to a progressive floor, and 21 were admitted to the ICU. Nineteen patients admitted to telemetry or progressive floors were transferred into the ICU at some point during their hospital admission. For all patients, the mean hospital LOS was 16 days (± 31). For those who were in the ICU, fifteen patients stayed for 1 – 5 days, twelve remained for 6 – 10 days, and thirteen stayed for > 10 days.

Aspects of Blood and Biochemical Parameters

Table 2 outlines the range of blood biochemical measures for all patients in the study. The mean glucose level was 147mg/dL, while the mean albumin and prealbumin levels were 2.8g/dL and 11.1mg/dL respectively. One patient had a normal BNP level, indicating no signs of fluid volume overload upon admission, and eight patients showed very little signs. The rest of the study population all showed some signs of fluid volume overload associated with decompensated HF upon admission; seven patients indicated mild decompensated HF, seven moderate, with 77 showing severe signs of unstable HF upon admission. Thirty five patients had normal kidney function on admission with creatinine levels less than 1.2mg/dL, while 65 showed signs of renal insufficiency with levels > 1.2mg/dL. The GFR, another marker for renal function, was normal for 32 patients (> 60%), and abnormal for 68 patients (< 60%). A three month average of blood glucose levels, HgA1c, was reported for all patients and indicates a patient's risk for developing diabetes mellitus. Based on those HgbA1c levels, 42 patients had normal glucose levels over the last three months, with 26 indicating they were at risk for diabetes and 32 were diabetic.

Malnutrition Prevalence

Analysis showed a range of malnutrition prevalence based on each screening measure. Table 3 shows the prevalence of malnutrition among HF patients, based on each tool's malnutrition classifications and the limits set by this study. Analysis of serum albumin levels revealed 21 patients were not at nutritional risk and 79 were at risk.

Serum prealbumin levels suggested 15 patients had no nutritional risk, 34 had a low nutritional risk, 46 were at moderate risk, and five at high risk. Analysis using MUST indicated 47 patients were not at nutritional risk, while 15 were at a low risk and 38 at a high risk. Results of the NRI analysis indicated six patients had no nutritional risk, two had a low risk, three had a moderate nutritional risk, and 89 were at a high risk. Based on the study cut off limits for nutritional risk albumin, prealbumin, MUST and NRI found 79, 85, 53 and 92 patients to be at risk, respectively.

Characteristics of Malnourished Patients

Tables 4 and 5 provide the trends for malnourished patients with respect to patient characteristics, and laboratory and biochemical measures. The mean ages for malnourished patients according to each method were MUST 64.5 years, NRI 63.3 years, prealbumin 63.2 years, and albumin 63.5 years (Table 4). Of the malnourished patients identified by MUST, 27 (50.9%) were female and 26 male. For NRI 40 (43.5%) malnourished patients were female and 52 male. Prealbumin identified 39 (45.9%) female and 46 male patients, while albumin found 35 (44.3%) female and 44 male patients. Dietitian consults on admission for those identified as malnourished were ordered for 32 patients recognized by MUST, 39 patients per NRI, 41 based on prealbumin, and 36 identified by albumin. Some patients were seen by a dietitian, regardless if a consult was placed for routine screening, hospital length of stay or ICU admission. Based on each tool, the number of identified malnourished patients seen by a dietitian were as follows: MUST 48 (90.6%), NRI 67 (72.8%), prealbumin 47 (81%), and albumin 59 (74.7%).

When analyzing hospital LOS for each screening method, MUST showed that malnourished patients remained in the hospital for a mean of 21.1 days, while NRI suggested they stayed 16.4 days, prealbumin indicated a mean of 16.9 days, and albumin indicated malnourished patients stayed for 16.3 days. The mean EF for those malnourished based on MUST, NRI, prealbumin, and albumin were 35.1%, 36.6%, 38.2%, and 39.7% respectively. The mean creatinine values for malnourished patients were 1.5mg/dL according to MUST and NRI, while prealbumin and albumin observed a mean of 1.6mg/dL. Renal function based on GFR was reduced for 33 (62.3%) patients according to MUST, 63 (68.5%) per NRI, 58 (68.2%) according to prealbumin, and 54(68.4%) patients with albumin.

Comparison of Nutrition Screening Methods

Tables 6 shows the sensitivity, specificity, PPV and NPV values for each tool compared to prealbumin, and Table 7 compares MUST to NRI. Sensitivity of a screening tool suggests sensitiveness to a certain factor (Lalkhen & McCluskey, 2008). In this study, test sensitivity was the proportion of at nutritional risk cases as diagnosed by albumin, prealbumin, MUST and NRI. Specificity identifies the patients who are not at nutritional risk and are classified appropriately (Lalkhen & McCluskey, 2008). A high sensitivity may provide more false positives, or patients falsely identified as malnourished, while a high specificity may give many false negatives. This means more patients who are not malnourished may be classified as malnourished and may be subject to extra treatment or testing. Conversely with a lower sensitivity and higher specificity, malnourished patients may be misclassified as not malnourished and thus will not receive appropriate treatment. For the purpose of this study, a higher sensitivity and a lower specificity was desired.

MUST, NRI and albumin compared to prealbumin. In comparison to prealbumin as a screening parameter, MUST revealed 49 true positive cases, four false positives, 11 true negatives and 36 false negatives. There were 79 true positives, 13 false positives, two true negatives and six false negatives with NRI. Serum albumin levels showed 72 true positives, seven false positives, eight true negatives, and 13 false negatives when compared to prealbumin as a screening parameter. The sensitivity of MUST was 57.6% with a specificity of 73.3%, PPV 92.5%, and NPV of 23.4%. For NRI, the sensitivity, specificity, PPV and NPV were 92.9%, 13.3%, 85.7%, and 25.0% respectively. The sensitivity of albumin was 85.0%, with a specificity of 53.3%, PPV of 91.1% and NPV of 38.1%.

MUST compared to NRI. When comparing the two subjective screening tools with NRI as the reference method, MUST had 50 true positives, three false positives, five true negatives, and 42 false negatives. The sensitivity, specificity, PPV and NPV of MUST were 54.3%, 62.5%, 94.3%, and 10.6% respectively.

Discussion

This project was designed to compare nutritional screening measures and evaluate trends among malnourished HF patients. The results showed malnutrition prevalence to be 53 - 92% based on the four screening tools. The prevalence among albumin, prealbumin and NRI were similar, but MUST identified the fewest patients as malnourished at 53%. The high incidence of malnutrition is not consistent with the prevalence of 66% seen in the study conducted by Aziz et al. (2011). This may be attributed to an increased prevalence of inflammation and infection seen in this population, which was not evaluated in this study.

Malnutrition prevalence in male HF patients ranged from 49 - 57%, which is pretty similar to the prevalence of 66% seen in other studies (Aziz et al., 2011). The average LOS for malnourished patients in this study ranged from 16 – 22 days, which appears to be much higher than those seen in other studies. For example, Aziz et al. (2011) found the average hospital LOS to be 7 – 11 days for malnourished. The larger range seen in this study may be attributed to a few outlying patients who had extremely long lengths of stay ranging from 70 – 278 days. For patients who were in the ICU, 25 – 39% remained for ≤ 10 days, while 11 – 23% stayed for > 10 days. There were no studies which measured ICU LOS, but rather focused solely on hospital LOS.

In terms of renal function, in this study 62 – 68% had a decreased GFR rate, and elevated creatinine values averaging 1.5 – 1.6mg/dL. These measures of renal function indicate that most of the malnourished patients experienced some sort of renal dysfunction in addition to their HF. The average glucose values ranged from 134 – 156mg/dL, while the mean HgbA1c levels were 6.0 – 6.5%. These elevated glucose and HgbA1c levels indicated most of the population was diabetic or at risk for becoming diabetic. Upon admission BNP levels were collected for patients included in this study. Based on those values 91% of the entire study population showed mild to severe decompensated HF associated with fluid volume overload on admission to the hospital (Table 2). Decompensated HF can worsen a patient's prognosis and outcomes, and lead to more hospital readmissions and cardiac cachexia (Araujo et al., 2011). The presence of other comorbidities in addition to malnutrition and HF may also lead to worse outcomes and a poor prognosis for these HF patients. Other studies that measured specific laboratory values did not mention trends among the malnourished, so there is little data available to determine patterns among the malnourished HF patient population.

Once patients are identified as malnourished or at risk for malnutrition, the next step is providing appropriate treatment in order to correct the condition. Part of that step is taking a multidisciplinary approach and involving a dietitian in the patient care plan. Based on the results of this study, only 45 dietitian consults were placed at admission for all the patients, but 74 patients were seen at some point during their admission by a dietitian. When looking at patients identified as malnourished by the screening tools, 42 – 60% received a consult on admission and 73 – 91% were actually evaluated by a dietitian. The low number of consults on admission for the malnourished patients is concerning because even though a majority of those patients were eventually seen by an RD, that first nutritional evaluation may have been delayed by a few days or even a week. This delay in evaluation may lead to worsening malnutrition, a poor prognosis, and increased morbidity and mortality.

In comparison to prealbumin, MUST found 36 false negatives, while NRI and albumin only found six and thirteen respectively. When compared to NRI, MUST found 42 false negatives. This is concerning because 36 – 42 patients were not accurately identified by MUST when they truly were malnourished.

Ideally a perfect screening tool would have a sensitivity of 100%, but this is unrealistic. There is not a specific cut off for an adequate sensitivity range, but in general ≥ 85% sensitivity is acceptable in most of the literature (Aziz et al., 2011; Lomivorotov et al., 2012; Van Venrooij et al., 2011). For this study, in striving for a higher sensitivity, a lower specificity was acceptable in order to correctly identify the population as malnourished. When compared to prealbumin the sensitivity of MUST was 57.6%, while NRI and albumin were 92.9% and 84.7% respectively. NRI and albumin showed optimal sensitivities compared to prealbumin in identifying patients as malnourished, while MUST did not have the most favorable sensitivity. The specificities for MUST, NRI and albumin were lower at 73.3%, 13.3%, and 53.3% respectively, but given the higher sensitivities of NRI and albumin, these levels are more acceptable. These sensitivity and specificity values can be attributed to the high incidence of true positives and low false positives seen with NRI and albumin, and the moderate amount of true positives and false negatives observed with MUST. Between the two subjective screening tools, NRI performed best when compared to prealbumin given the high sensitivity level, even though the specificity of MUST was higher than NRI. When comparing MUST to NRI, the sensitivity and specificity remained less than optimal at 54.3% and 62.5% respectively. This too can be attributed to the higher number of false negatives.

Overall the higher sensitivities of NRI (92.9% and 94.9%) mean it is the better screening tool because there is a possibility that only 5-7% of patients who may be malnourished were not correctly identified. The lower sensitivities of MUST at 57.6 % and 54.3% indicate that there is a possibility that it misidentified 42-46% of patients as not being malnourished. Currently no other research is available that compares these tools to the laboratory markers of prealbumin and albumin in the HF patient population, making it difficult to identify trends among the tools.

Limitations

As is the case with all studies, this study had a few limitations. First off, the chart review was completed retrospectively, meaning all data collected are second hand information. Height, weight and BMI may be inaccurate in that some measurements may have been self-reported instead of accurately measured by the health provider. Presence of recent weight loss, which is required for the MUST calculation, relied on the admission patient profile being accurately completed by the patient's nurse. The profile information may have come from a family member of the patient who did not accurately track the patient's weight, or the patient may not recall recent weight loss over the past six months. Both the BMI and recent weight loss inconsistencies could have affected the overall MUST scores and their comparison to the other screening tools.

Another limitation is that albumin and prealbumin levels may not have been collected immediately upon admission. Prealbumin has a half-life of two days, and without adequate protein intake the value can decrease. These laboratory values may be lower than normal in the presence of infection and inflammation. Markers for inflammation and infection such as C-reactive protein and lymphocyte count were not collected in this study, which may have been the reason for the increased prevalence of malnutrition among HF patients.

Implications for Practice

Accurately identifying malnutrition in HF patients is difficult without a standardized tool with which to evaluate patients. Some subjective tools and objective measures work well in one population and not in others, such as HF patients. This study has shown that NRI compares fairly well to prealbumin as a malnutrition screening tool and that MUST was less optimal in terms of sensitivity and specificity. Implementing NRI in combination with traditional laboratory screening measures could be beneficial in identifying malnutrition in the HF population. Earlier identification of malnourished HF patients on admission could lead to quicker nutrition evaluations by dietitians and appropriate intervention. More rapid treatment of malnutrition could help improve nutritional status among HF patients and may in turn help decrease hospital costs, LOS and readmission rates.

Implications for Future Research

This project further identifies the need for a prospective study which evaluates a large cohort of HF patients with a variety of subjective and objective screening measures. Other studies may be helpful in narrowing down specific screening parameters which work well in the HF patient population. If HF patients are accurately identified as being malnourished, then other measures associated with malnutrition may be examined. Such measures include outcomes, treatment options, laboratory and comorbidity trends among the malnourished, and morbidity and mortality.

Conclusion

Heart failure is prevalent and associated with increased healthcare costs and frequent hospital readmissions. Malnutrition is associated with a significant health risk and financial burden. The development of malnutrition in the presence of HF will worsen a patient’s myocardial dysfunction, decrease survival rates and lead to a poor prognosis (Moughrabi & Evangelista, 2007). Early identification and treatment of malnutrition in HF patients may help decrease associated healthcare costs and improve outcomes. Quick, easy, inexpensive and reliable malnutrition screening methods may help identify patients more quickly and accurately in order to reverse early malnutrition. The results of this study provide evidence that NRI in combination with laboratory measures may be helpful in identifying malnutrition among HF patients. There are a number of nutritional screening tools available which are easy to use and inexpensive to implement. Further research into NRI and other screening tools among the HF population may be beneficial.

Tables

Table 1: Patient Demographics

Parameter	Mean (SD)
Age (years)	62.8 (11.5)
Hospital LOS (days)	16 (31)
	N
Gender	
Male	53
Female	47
Ethnicity	
Caucasian	77
African American	18
Other	5
BMI	
≤ 18	3
19 – 24	30
25 – 29	20
≥ 30	47
HF Diagnostic Code	
428.0 (unspecified CHF)	23
428.2 (systolic HF)	49
428.3 (diastolic HF)	26
428.4 (sys & dias HF)	2
Ejection Fraction (%)	
< 55%	68
> 55%	32
Admit to:	
Telemetry Bed	71
Progressive Bed	8
ICU	21
Hospital LOS	
2 – 5 days	38
6 – 10 days	22
11 – 15 days	10
> 15 days	30
ICU LOS	
0 days	60
1 – 5 days	15
6 – 10 days	12
> 10 days	13
Dietitian Consult	
No	55
Yes	45

Table 1 (continued)

Parameter	N
Dietitian Note	
No	26
Yes	74

Table 2: Blood Biochemical Measures

Parameter	**Mean (SD)**
Glucose (normal < 140mg/dL)	147 (83)
Albumin (normal 3.3-4.8**g/dL)**	2.8 (0.6)
Prealbumin (normal 16-35mg/dL)	11.1 (4.5)
	N
BNP (pg/mL)	
< 100 (no HF s/s)	1
100 – 300 (few HF s/s)	8
301 – 600 (mild HF)	7
601 – 900 (moderate HF s/s)	7
> 901 (severe HF s/s)	77
Creatinine (normal < 1.2mg/dL)	
≤ 1.2	35
> 1.2	65
GFR (normal > 60%)	
< 60	68
> 60	32
HgbA1c (%)	
Normal (< 5.6)	42
At Risk (5.7 – 6.5)	26
Diabetic (> 6.5)	32

BNP – B-type Natriuretic Peptide; GFR – Glomerular Filtration Rate; s/s – signs and symptoms

Table 3: Malnutrition Prevalence

Parameter	N	No Risk Total (%)	At Risk Total (%)
MUST Score		47	53
Low risk: 0	47		
Mod risk: 1	15		
High risk: ≥ 2	38		
NRI score		8	92
No risk: > 98	6		
Low risk: 92 – 98	2		
Mod. risk: 82 – 91	3		
High risk: < 82	89		
Albumin		21	79
No risk: > 3.2g/dL	21		
At risk: ≤ 3.2g/dL	79		
Prealbumin		15	85
No risk: ≥ 16mg/dL	15		
Low risk: 11 – 15.9mg/dL	34		
Mod risk: 5 – 10.9mg/dL	46		
High risk: < 5mg/dL	5		

Table 4: Malnourished Patient Demographics

Study Characteristics	% at risk: Number (%)			
	MUST (*n* = 53)	NRI (*n* = 92)	Prealbumin (*n* = 85)	Albumin (*n* = 79)
Gender				
Female	27 (50.9)	40 (43.5)	39 (45.9)	35 (44.3)
Male	26 (49.1)	52 (56.5)	46 (54.1)	44 (55.7)
Race				
Caucasian	44 (83.0)	71 (77.2)	66 (77.6)	63 (79.7)
African American	6 (11.3)	16 (17.4)	15 (17.6)	12 (15.2)
Other	3 (5.7)	5 (5.4)	4 (4.7)	4 (5.1)
Admit to:				
Telemetry	31 (58.5)	65 (70.7)	58 (68.2)	55 (69.6)
Progressive	2 (3.8)	8 (8.7)	8 (9.4)	8 (10.1)
ICU	20 (37.7)	19 (20.7)	19 (22.4)	16 (20.3)
HF Diagnostic Code				
428.0 (unspecified HF)	10 (18.9)	19 (20.7)	23 (27.1)	22 (27.8)
428.2 (systolic HF)	27 (50.9)	48 (52.2)	40 (47.1)	34 (43.0)
428.3 (diastolic HF)	14 (26.4)	23 (25.0)	20 (23.5)	21 (26.6)
428.4 (sys. & dia. HF)	2 (3.8)	2 (2.2)	2 (2.4)	2 (2.5)
ICU LOS				
0 days	20 (37.7)	55 (59.8)	50 (58.8)	50 (63.3)
1 – 5 days	12 (22.7)	14 (15.2)	13 (15.3)	12 (15.2)
6 – 10 days	9 (17.0)	11 (12.1)	9 (10.7)	8 (10.1)
> 10 days	12 (22.7)	12 (13.2)	13 (15.3)	9 (11.4)
RD Consult				
No	21 (39.6)	53 (57.6)	44 (51.8)	43 (54.4)
Yes	32 (60.4)	39 (42.4)	41 (48.2)	36 (45.6)
RD Note				
No	5 (9.4)	25 (27.2)	11 (19.0)	20 (25.3)
Yes	48 (90.6)	67 (72.8)	47 (81.0)	59 (74.7)

Table 4 (continued)

Parameter	**% at risk: Mean (SD)**			
	MUST (*n* = 53)	NRI (*n* = 92)	Prealbumin (*n* = 85)	Albumin (*n* = 79)
Age (years)	64.5 (12.2)	63.3 (11.6)	63.2 (11.6)	63.5 (11.5)
BMI	28.5 (10.9)	28.2 (6.8)	29.6 (8.9)	29.2 (8.9)
Hospital LOS (days)	22.1 (41.0)	16.4 (32.1)	16.9 (33.3)	16.3 (33.7)
EF %	35.1 (18.2)	36.6 (18.0)	38.2 (18.4)	39.7 (18.3)

Table 5: Malnourished Patient Lab and Biochemical Measures

Study Characteristics	**% at risk: Number (%)**			
	MUST (*n* = 53)	NRI (*n* = 92)	Prealbumin (*n* = 85)	Albumin (*n* = 79)
GFR (%)				
< 60	33 (62.3)	63 (68.5)	58 (68.2)	54 (68.4)
> 60	20 (37.7)	29 (31.5)	27 (31.8)	25 (31.6)
	% at risk: Mean (SD)			
	MUST (*n* = 53)	NRI (*n* = 92)	Prealbumin (*n* = 85)	Albumin (*n* = 79)
Glucose (mg/dL)	133.9 (65.4)	144.9 (80.5)	149.1 (87.1)	152.9 (90.3)
BNP (pg/mL)	7665.0 (13003.7)	7921.1 (11576.9)	8557.9 (11892.2)	7872.4 (11652.6)
Creatinine (mg/dL)	1.5 (0.8)	1.5 (0.7)	1.6 (0.7)	1.6 (0.7)
HgbA1c (%)	6.0 (1.2)	6.3 (1.4)	6.4 (1.5)	6.5 (1.6)
Albumin (g/dL)	2.8 (0.5)	2.8 (0.6)	2.8 (0.6)	2.6 (0.5)
Prealbumin (mg/dL)	9.6 (3.9)	11.0 (4.4)	9.6 (3.0)	10.3 (4.0)

Table 6: Prediction Accuracy: Albumin, MUST and NRI compared to Prealbumin

Parameter	**Sensitivity (CI)** [a]	**Specificity (CI)** [a]	**PPV** [a]	**NPV** [a]
Albumin (*n* = 100)	84.7 (77.1, 92.3)	53.3 (28.0, 78.6)	91.1	38.1
MUST (*n* = 100)	57.6 (46.5, 68.1)	73.3 (44.8, 91.1)	92.5	23.4
NRI (*n* = 100)	92.9 (84.7, 97.1)	13.3 (2.3, 41.6)	85.7	25.0

CI, Confidence Interval; PPV, Positive Predictive Value; NPV, Negative Predictive Value
[a] values are *n* (%)

Table 7: Prediction Accuracy: MUST compared to NRI

Parameter	**Sensitivity (CI)** [a]	**Specificity (CI)** [a]	**PPV** [a]	**NPV** [a]
MUST (*n* = 100)	54.3 (43.7, 64.7)	62.5 (25.9, 89.9)	94.3	10.6

CI, Confidence Interval; PPV, Positive Predictive Value; NPV, Negative Predictive Value
[a] values are *n* (%)

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Conclusion to Final DNP Capstone Report

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Conclusion

This capstone evaluates HF patients admitted to the University of Kentucky Chandler Medical Center for the presence of malnutrition. Four nutritional screening measures were used to determine the best methods that can be used by health professionals in order to accurately identify malnutrition in the HF population. This study found malnutrition prevalence among HF patients to be fairly high at a rate of 53-92%. The average hospital length of stay for malnourished patients was found to be 16-22 days. Serum albumin, prealbumin and NRI demonstrated the best ability to screen HF patients for malnutrition. Given these high rates of malnutrition, more needs to be done in order to more accurately screen patients upon hospital admission and treat them immediately. Early identification and treatment may help improve outcomes, decrease hospital lengths of stay and overall healthcare costs.

Manuscript one concluded that based on the available literature, no one tool demonstrated consistent reliability and validity in screening for malnutrition among multiple patient populations in various healthcare settings. Malnutrition can occur in many patient populations including chronic diseases such as cancer, liver failure and HF (Jensen et al., 2010). The MUST demonstrated evidence of reliability and validity in multiple patient populations such as cancer, chronic disease, the elderly, hospitalized patients and outpatients. The use of MUST in the HF patient population is not well described in the literature; however it has been used with success in other adult and elderly populations. More research needs to be conducted within the HF population to better identify a reliable and valid tool for this population.

Manuscript two revealed through a review of the literature that there is a lack of studies in which multiple tools evaluated the nutritional status of HF patients. Of the two studies reviewed that pertained to HF patients, one study compared NRI to traditional nutritional biomarkers, while the second used NRI to evaluate HF patient outcomes. Multiple subjective screening tools need to be studied within this population to better identify malnutrition among HF patients. No one tool has been proven as the gold standard of nutrition assessment, making it necessary to evaluate multiple tools in the HF population.

Manuscript three showed that NRI compared well to prealbumin, while MUST was less optimal in terms of sensitivity and specificity. Implementing NRI in combination with traditional laboratory screening measures could be beneficial in identifying malnutrition in the HF population. There are a number of nutritional screening tools available which are easy to use and inexpensive to implement. Further research into NRI and other screening tools among the HF population may be beneficial.

Overall this practice inquiry project has shown a high prevalence of malnutrition in HF patients based on four nutritional screening methods. The need of future research into effective screening tools in this population is necessary in order to accurately identify malnutrition and take action to treat it as quickly as possible. Early intervention may help increase quality of life and outcomes for HF patients.

Appendix

Appendix A: Data Collection Tool

Subject ID #	Sex (1=F 2=M)	Age (yr)	Race (1 = Caucasian, 2 = African American, 3 = other)	Admit to: (1 = ICU, 2 = tele, 3 = prog)	HF diagnostic code	% EF	Height (in)

Wt (kg)	BMI	Unexplained wt loss	Pt acutely ill or no nutritional intake >5 days	GFR	Glu cose	Hgb A1c	Creatinine	Albu min	BNP

Prealb umin	RD consult (y/n)	RD note (day #)	ICU LOS	Hosp LOS	Diet Order	Diet intake	Calculated MUST score	Calculated NRI score

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