The correlation of nutrition risk index, nutrition risk score, and bioimpedance analysis with postoperative complications in patients undergoing gastrointestinal surgery

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Background. *Malnutrition in gastrointestinal (GI) surgery is associated with increased morbidity. Therefore, careful screening remains crucial to identify patients at risk for malnutrition and consequently postoperative complications. The aim of this study was to evaluate the ability of 3 established score systems to identify patients at risk of developing postoperative complications in GI surgery and to assess the correlation among the score systems.*
Methods. *We evaluated prospectively 200 patients admitted for elective GI surgery using (1) nutrition risk index, (2) nutrition risk score, and (3) bioelectrical impedance analysis. Complications were assessed using a standardized complication classification. The findings of the score systems were correlated with the incidence and severity of complications. Parametric and nonparametric correlation analysis was performed among the different score systems.*
Results. *All 3 score systems correlated significantly with the incidence and severity of postoperative complications and the duration of hospital stay. Using multiple regression analysis, only nutrition risk score and malignancy remained prognostic factors for the development of complications with odds ratios of 4.2 (*P *= .024) and 5.6 (*P *< .001), respectively. The correlation between nutrition risk score and nutrition risk index was only moderate (Pearson coefficient = 0.54). Bioelectrical impedance analysis displayed only weak to trivial correlation to the nutrition risk index (0.32) and nutrition risk score (0.19), respectively.*
Conclusion. *The nutrition risk score, nutrition risk index, and bioimpedance analysis correlate with the incidence and severity of perioperative complications in GI surgery. The nutrition risk score was the best score in predicting patients who will develop complications in this study population. The correlation between the individual scores was only moderate, and therefore, they do not necessarily identify the same patients. (Surgery 2009;145:519-26.)*

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MALNUTRITION is an important risk factor for perioperative morbidity and mortality. The reported prevalence of malnutrition in gastrointestinal (GI) surgery patients ranges from 30% to 50%.[1-3] Perioperative nutritional support in malnourished patients decreases postoperative complications such as wound infections and sepsis.[2,4-6] A proper assessment of the nutritional status in GI surgery patients is therefore highly desired.[7-9] Different screening tools have been developed to identify patients who may benefit from nutritional support therapy. Most of these scores have not been validated with respect to clinical outcome as recognized by the American Society for Parenteral and Enteral Nutrition.[10]

The nutritional status in patients with GI disorders is determined by the consequences of starvation as well as by the metabolic stress from the underlying disease. The loss of lean body mass is thought to be a crucial event.[11] A comprehensive nutritional assessment should evaluate the protein and energy balance, body composition, and the extent of metabolic stress that would be caused

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by a surgical intervention. A variety of anamnestic scores,[12,13] anthropometric studies,[14] biochemical serum markers,[15] and electrophysiologic studies[16] is used currently for screening, but none of these tools have been accepted universally. The most popular screening tools often focus on a single aspect of nutritional status, and it remains unclear whether different scores provide consistent data. An ideal test for the preoperative assessment of the nutritional status should be able to quantify the severity of malnutrition and the depletion of lean body mass. Furthermore, the same test should be able to monitor nutrition therapy in the postoperative course.

Anamnestic scores are easy to perform and have been shown to be valuable in identifying patients at risk to develop postoperative complications.[9,17] The nutrition risk score (NRS) is a simple, safe, and inexpensive tool that assesses nutrition intake as well as the extent of stress associated with the underlying disease.[13] The nutrition risk index (NRI), which is based on the serum albumin concentration, and weight loss has been shown to identify patients at risk for postoperative complications.[4,18] Its value, however, is limited by non-nutritional factors that affect albumin synthesis and the fact that the score does not account for specific, disease-related nutritional risk, such as cancer. Bioelectrical impedance analysis (BIA), which measures the impedance to an alternating current in the body, can quantify body compartments, such as lean body mass, body cell mass, and body fat, and thereby is indicative of nutritional status. Many studies have shown the clinical and prognostic value of BIA.[19-24] The BIA uses regression equations to calculate body compartments, such as body cell mass and lean body mass, and has some shortcomings in patients with altered hydration status. The phase angle (PA) is derived directly from the electrical resistance and reactance from the BIA and does not rely on regression equations. Therefore, using PA as an indicator of body cell mass and nutritional status eliminates a large source of random error from the BIA analysis. Various clinical trials have assessed the validity of the PA as an indicator of nutritional status and have showed its correlation with survival and morbidity.[16,19,25-27]

Unfortunately, limited data are available about the correlation of these scores with clinical outcomes in patients who undergo GI surgery.[9,16,28] Most current studies are hampered by the lack of a standardized classification of complications. Furthermore, few, prospective data are available to assess the correlation of the different scores in selected patient groups, such as patients who undergo GI surgery,[19,29] and the value of the scores regarding their ability to identify the same patients remains unclear.

To address these shortcomings, we evaluated the ability of 3 different screening scores to predict the incidence and severity of postoperative complications in patients who undergo elective GI surgery using an objective classification of postoperative complications. In addition, we assessed the correlation among the different scores and their ability to identify the same population of patients.

MATERIALS AND METHODS

Patients. In all, 200 consecutive patients admitted for elective GI surgery in our unit underwent a prospective, nutritional risk screening during a period of 5 months. The screening was performed preoperatively within the first 24 h after admission. All patients provided written consent for data collection and publication. No specific nutritional intervention was implemented according to the score results in these patients.

Nutritional assessment. The NRS and NRI were performed according to Reilly and Buzby.[13,30,31] In brief, the NRS includes 5 different components: body mass index (BMI), weight loss, appetite, dysphagia, and severity of disease. A standardized questionnaire was used to obtain information on changes of body weight, feeding habits, preexisting comorbidities, and severity of the GI disease according the recommendations.[13] The patient's height and body weight were measured using a calibrated scale to calculate the individual BMI. The NRI is a simple equation that uses serum albumin and recent weight loss: NRI = $(1.489 \times \text{serum albumin [g/L]}) + (41.7 \times \text{current weight/usual weight})$. BIA was performed using a single-frequency body impedance analyzer portable plethysmograph (Akern, Turin, Italy) that applies 800 μA current at a frequency of 50 kHz. The electrodes were placed on wrist and ankle on the patient's right side. The examination was performed according to the standards of the National Institutes of Health.[32] The PA was calculated from the measured reactance and resistance. Estimates of fat-free mass, extracellular mass, and body cell mass were obtained using the software Bodygram 1.1.2. PA was used for the correlation analysis, because PA represents the relative contribution of reactance and resistance, is obtained directly from the measured values, and does not rely on regression equations, which eliminates a large source of random error. Serum albumin concentrations were determined using a standard bromcresol green test[33] to calculate the NRI. Blood samples were taken routinely at admission, before intravenous

Table I. Parameters of the different nutritional risk scores

Score	*Parameters*
NRS	BMI, weight loss, appetite, ability to eat, disease
NRI	Recent weight loss and serum albumin concentration
PA	Calculated directly from reactance and resistance from bioimpedance analysis

fluid application was started. A short overview of the different scores is given in Table I.

Definition of malnutrition. For the NRS, patients were classified at low (no malnutrition), moderate, or high risk of malnutrition according to the cutoff points proposed by Reilly.[13] The scale is as follows: 0–3 points = low risk; 4–6 points = moderate risk; and 7–15 points = high risk. The cutoff points suggested by Buzby et al[30] were used to define malnutrition for the NRI. Patients with a score above 97.5% were classified as well nourished, between 83.5% and 97.5% as moderately malnourished, and below 83.5% as severely malnourished. From the BIA, we used PA values below 6° as an indicator for malnutrition as suggested by Mushnick,[34] Nagano,[25] and Barbosa.[19]

Assessment of complications. A standardized classification of postoperative complications was used to monitor morbidity and mortality.[35] The grading of the severity of complications is based on the therapy used to correct a specific complication. In brief, grade 1 complications include minor deteriorations from the normal postoperative course without the need of any specific treatment. Grade 2 complications can be treated solely by drugs, blood transfusion, and physiotherapy. Grade 3 complications require interventional or operative treatment. Grade 4 complications are life-threatening complications that require intensive care unit management. Grade 5 is defined as the death of the patient. If a patient had more than 1 complication, then only the greatest ranked complication was used for the analysis.

Statistical analysis. Statistical analysis was performed using SPSS (SPSS Inc., Chicago, IL). Results are given as the median and range. A comparison of complication rates within well-nourished and malnourished patients was performed using the Pearson Chi-square test. A multiple logistic regression analysis was performed to compute the odds ratios for different variables. An analysis of variance (ANOVA) was used to compare the mean duration of stay in patients with or without nutritional risk. Parametric and nonparametric correlation analysis (Pearson and Spearman rho) was performed between NRS, NRI, and PA. The values for the area under the curve (AUC) were calculated using receiver operator characteristic (ROC) curves analysis. P values less than .05 were considered as statistically significant.

RESULTS

Patient characteristics. Included in this study were 102 men and 98 women with a median age of 49 years (range, 18–85) who underwent complete preoperative nutritional risk assessment. The median height was 1.7 m (range, 1.4–1.9), the median weight was 78 kg (range, 39–185), and the median BMI was 27.3 kg/m^2 (range, 15–64). The median serum albumin concentration was 41 g/L (range, 21–51). Thirty-five (17.5%) patients underwent operation for cancer. The remaining 165 (82.5%) patients underwent operation for various benign diseases. The median duration of stay was 6 days (range, 1–39).

What is the prevalence of nutritional risk in GI surgery patients using different nutritional risk scores? The prevalence of malnutrition according to the NRS was 11% (22/200). The NRI identified 30 malnourished patients (15%). A total of 40 (20%) malnourished patients were detected by using NRI and NRS together. BIA identified 57 patients (28.5%) with a PA less than 6°, which indicates an increased nutritional risk.

The incidence of nutritional risk defined by NRS was greater ($P < .001$) in cancer patients (34% at nutritional risk) compared with patients with benign disease (6% at nutritional risk). Similar results were found for NRI and PA; the incidence of patients at nutritional risk in cancer patients was 37% versus 10% (defined by NRI; $P < .001$) and 54% versus 23% (defined by PA; $P < .001$), respectively. In aged patients (>70 years), we did not observe an increased nutritional risk according to NRS or NRI, whereas the proportion of patients with a decreased PA was greater in aged patients (66% in aged versus 22% in patients younger than 70 years; $P < .001$).

Can the different scores predict postoperative complications? In all, 50 patients (25%) experienced postoperative complications. Many complications were of infectious origin (60%), which included 16 surgical site infections, 4 pneumonias, 5 urinary tract infections, 3 sepsis, and 2 intraperitoneal abscesses. Although infections made major contributions to the overall morbidity, most infectious complications were classified as grades 1 and 2. Apart from infectious complications, there were

Table II. The incidence and correlation of malnutrition and complications according to NRI, NRS, and BIA

		Total	*No complications*	*Complications*	P *value*
NRI	No malnutrition	170	134	36	.004
	Moderate malnutrition	26	15	11	
	Severe malnutrition	4	1	3	
NRS	Low risk for malnutrition	178	142	36	<.001
	Moderate risk for malnutrition	17	8	9	
	High risk for malnutrition	5	0	5	
PA	≥6°	143	117	26	<.001
	<6°	57	33	24	

Different screening systems NRI, NRS, and BIA expressed by PA, with a PA less than 6° as an indicator for nutritional risk. The Pearson Chi-square test has been used to assess the correlation among complications and the different degrees of nutritional risk.

Table III. Correlation of complication grade and different screening systems

		NRS		*NRI*		*PA*	
Complication grade	n/%	*Low risk for malnutrition*	*At risk for malnutrition*	*No malnutrition*	*Malnutrition*	*≥6°*	*<6°*
No complication	150/75	142	8	134	16	117	33
1	5/2.5	3	2	4	1	3	2
2	23/11.5	21	2	19	4	11	12
3	13/6.5	7	6	8	5	8	5
4	9/4.5	5	4	5	4	4	5
Total	200/100	178	22	170	30	143	57
P value		<.001		.007		.011	

The complication grade is defined by the Dindo classification,[35] NRS, NRI; moderate and severe malnutrition is defined as malnutrition. Values less than 6° for the PA were used as an indicator for nutritional risk. The Pearson Chi-square test has been used to assess the correlation between the complication grades and the nutritional risk according to the different screening systems.

5 postoperative hemorrhages, 4 anastomotic leakages, 3 abdominal wound dehiscence, 3 pulmonary embolisms, 2 patients who developed diarrhea, and 1 patient each with hepatic encephalopathy, myocardial infarction, and deep venous thrombosis. The grading of the complications according to their severity included 5 patients with a grade 1 complication, 23 with a grade 2, 13 with a grade 3, and 9 with a grade 4. No grade 5 complication was reported (death).

We found a strong correlation between the incidence of postoperative complications and nutritional risk as defined by NRI, NRS, and decreased PA. All patients who were defined at high risk of malnutrition by the NRS developed a postoperative complication. Details and numbers are given in Table II.

Furthermore, complications of patients at nutritional risk defined by NRS, NRI, and decreased PA were more severe and required more interventions or reoperations. For example with the NRS system, the incidence of severe complications (grades 3–5) in patients at risk was 45% versus 7% in patients without nutritional risk ($P < .001$). The absolute numbers of complication grades and nutritional risk including statistics are given in Table III.

To adjust for confounding factors, we used multiple logistic regression analysis and computed odds ratios to develop postoperative complications for different variables. The odds ratio to develop a postoperative complication was 4.2 in patients at nutritional risk (defined by NRS) and 5.6 in patients who suffered from a malignant disease. Age (>70 years), serum albumin concentrations, BMI, decreased PA, and malnutrition according to NRI were not statistically significant factors in the multiple regression analysis (Table IV). A detailed analysis of the patients showed that patients who were defined at nutritional risk by only 1 scoring system (NRI, NRS, or PA [$n = 75$]) did not have

Table IV. Multiple logistic regression analysis: odds ratios for developing complications

	OR (95% CI)	P *value*
PA ≥6°	1.6 (0.7–3.8)	.292
NRI (malnourished)	1.7 (0.4–8.1)	.481
NRS (at risk)	4.2 (1.2–14.8)	.024
Age >70 years	2.4 (0.9–6.8)	.091
Malignant disease	5.6 (2.2–14.3)	<.001
Albumin*	0.9 (0.8–1.1)	.337
BMI*	1.0 (1.0–1.1)	.298

CI, Confidence interval; *OR*, odds ratio.
*The ORs for "albumin" and "BMI" are for each increase in score unit, whereas all other variables are categorical.

a different complication rate compared with each score alone (43% for all 3 vs 64% NRS alone vs 47% NRI alone). We analyzed whether a patient was at a risk to develop complications if he/she fulfilled the criteria for any assessment. Only a few patients fulfilled these criteria, and they did not have a greater incidence of complications (56%).

What is the impact of nutritional risk on the duration of hospital stay? We tested the impact of an increased nutritional risk on the duration of hospital stay. Although patients without nutritional risk had a mean hospital stay of 7.2 days, patients at moderate or even high nutritional risk defined by NRS had a prolonged duration of hospital stay of 12.2 days and 18 days, respectively ($P < .001$). Similar findings were obtained by NRI and PA (Table V). Cancer patients exhibited an increased nutritional risk, but in addition, mean hospital stay was prolonged compared with patients with benign diseases (11.9 days vs 7.0 days; $P < .001$).

What is the correlation of the different scores in GI surgery patients? A total of 174 of 200 patients were given the same classification (at nutritional risk/no nutritional risk) by NRS and NRI. The remaining 26 patients were classified differently. Therefore, the overall accuracy of NRS and NRI was 87%. The sensitivity and specificity of NRI to detect malnourished patients defined by NRS was 64% and 90%, respectively. This approach resulted in a positive predictive value of 44% and a negative predictive value of 95%. The correlation between the NRS, NRI, and PA was much weaker, as indicated by the Pearson correlation analysis (Table VI). Overall, the raw scores did not have a strong correlation. The best correlation was found between NRS and NRI. The Pearson correlation coefficient was 0.54, which can be considered as moderate. In contrast, the PA displayed only weak (0.32) to trivial (0.19) correlation with NRI and NRS. Other parameters obtained by BIA (fat-free mass, body cell mass, and extracellular mass) did not correlate well with the other scores (data not shown). Because of the large sample size, all correlations were statistically significant; however, the strength of the relationship is not conclusive. Correlations were also assessed using Spearman's rho correlation analysis, which resulted in similar findings (data not shown).

Receiver operator characteristic curves were calculated to determine the value of NRI, NRS, and PA to predict patients who will develop complications. NRS displayed a fair diagnostic value with an AUC of 0.69. The AUC of NRI and PA was only 0.34 and 0.36, whereas 0.5 is equivalent to random classification; an AUC of 1.0 would reflect an ideal test.

DISCUSSION

A successful outcome after surgery is highly dependent on the incidence and severity of postoperative complications. Although malnutrition is a well-recognized risk factor, its prevalence and severity is often underestimated. Many nutrition risk scores for screening purposes are available, but none is generally accepted as the gold standard. So far, it remains unclear which scores are of value to predict nutrition-related complications in GI surgery and whether they can identify the same patient groups.

We applied prospectively 3 different scores to a cohort of consecutive GI surgery patients and found a strong correlation between the nutrition risk screening scores NRS, NRI, and BIA and the incidence of postoperative morbidity using a validated classification system of surgical complications. In addition, patients at nutritional risk experienced more severe complications compared with nonrisk patients, which resulted in more reoperations and a prolonged hospital stay. The correlation between the individual scores, however, was only moderate.

We observed a high rate of patients at nutritional risk (20%) in our cohort, which is in accordance to other studies that report malnutrition rates between 24% and 38%.[9,29,36] As expected, the prevalence of malnutrition in patients with malignant diseases was greater than in patients with benign diseases. In patients who underwent an operation for GI cancer, the reported prevalence of malnutrition is similar to our results.[36,37]

The incidence of postoperative complications was as great as 64% in patients at nutritional risk compared with 20% in patients with no detected risk defined by NRS. We observed similar results

Table V. The correlation of NRS, PA, NRI, and duration of stay

		Total (n)	*Duration of stay (SD)*	P *value*
NRI	No malnutrition	170	7.2 (6.0)	.001
	Moderate malnutrition	26	11.0 (7.6)	
	Severe malnutrition	4	14.8 (5.7)	
NRS	Low risk for malnutrition	178	7.2 (5.9)	<.001
	Moderate risk for malnutrition	17	12.2 (7.7)	
	High risk for malnutrition	5	18.0 (2.7)	
PA	≥ 6°	143	6.9 (5.6)	<.001
	< 6°	57	10.4 (7.4)	

SD, Standard deviation.
ANOVA. The duration of stay is given in days (mean and SD).

for NRI and decreased PA. The high incidence of postoperative complications in malnourished patients has been described by others.[4,16,19,28,38,39] In addition, we could show for the first time that in patients with nutritional risk, the complications were more severe and resulted in more reoperations. This finding is an important observation and provides 1 explanation for the increased duration of stay in malnourished patients, which is consistent with the results of other studies.[9,11,40-43] Using a multiple regression analysis, only malignancy and nutritional risk, defined by NRS, remained significant prognostic factors for the development of complications. This observation suggests that the NRS is the preferred screening test in this study population and indicates the limitations of BIA and the NRI.

Many studies addressed different screening tools and their ability to identify malnourished patients and patients who are at nutritional risk. In contrast, only a few studies compared different screening tools to investigate their correlation and reliability.[17,29,44] Therefore, we assessed the correlation between the different scores in identifying the same patient population. The NRI, which is characterized by serum albumin concentration and weight loss, correlated only moderately with the NRS; 87% of the patients were classified correctly. These results are comparable with the study of Corish et al,[17] who compared the NRS and NRI in nonsurgical patients. Although serum albumin has been used as a tool to evaluate nutritional status in the past, its serum concentration is dependent strongly on hepatic protein synthesis and patient's metabolic activity. Therefore, serum albumin concentrations are not always reliable indicators of nutritional status, particularly in marasmic and critically ill patients.[45] The NRS is an anamnestic score, which was developed to identify malnourished patients as well as patients at risk for malnutrition. The NRS includes the severity of the disease and is very similar to the Subjective Global Assessment Score and the recently developed Nutrition Risk Score 2002.[13,46] The advantage of the NRS over the NRI is that it accounts for patients with recent changes of eating habits and disease-related nutritional risk. Because the NRS, like the NRS 2002, assesses weight loss and functional ability, it is more accurate in identifying high-risk patients than anthropometrics alone. The NRS displayed the strongest correlation with postoperative complications and was the only score that remained a significant prognostic factor in the multivariate analysis. Whether this score can stratify patients, who will improve their clinical outcome with preoperative and/or postoperative nutrition support therapy, remains to be proven in an interventional trial.

Table VI. Parametric Pearson correlation analysis of NRI, NRS, and PA

	NRI	*NRS*	*PA*
NRI	1	0.536*	0.321*
NRS	0.536*	1	0.186*
PA	0.321*	0.186*	1

*Correlation is significant at the .01 level (2-tailed).

BIA has provided prominent results to predict clinical outcome and duration of hospital stay.[11,22,47] Barbosa et al[16] assessed the correlation among BIA, Subjective Global Assessment Score, and perioperative complications. BIA and Subjective Global Assessment Score correlated with the incidence of perioperative morbidity; however, the same group investigated the correlation between BIA and other nutritional risk scores and found only a poor reliability of the scores in identifying the same patient populations.[19] These findings were confirmed by our results that showed only a poor correlation between BIA (PA) and the other nutritional risk scores from NRS and NRI. Nevertheless, many authors have used PA to assess nutritional risk to eliminate the shortcomings of the regression equations from BIA and have shown that PA correlates with morbidity and mortality rates in different patient groups,[11,16,21,26,34,48] which was again confirmed by our results. Furthermore, BIA findings have been shown to correlate with the duration of hospital stay.[24] In contrast, Cox-Reijven et al[49] validated the findings of BIA in patients with GI disease. Fluid compartments were measured by dilution methods, which may be considered the gold standard. The vector approach described by Piccoli et al[50] failed to identify depleted patients. This group concluded that the impedance vector method is not sensitive enough to screen patients for clinical depletion. Although the impedance vector approach might not yet be suitable as a screening method for malnutrition, BIA provides important information about electrophysiologic changes and body composition. A better understanding of the physical phenomena is needed to comprehend the exact biologic importance of BIA parameters and their confounding factors under various disease conditions. BIA might be helpful particularly in the assessment of the depleted obese patients,[51,52] which represents a growing population in the western world.

In conclusion, the prevalence of patients at nutritional risk who undergo GI surgery is high. Nutritional risk as defined by the NRS, NRI, and BIA correlates with the incidence and severity of perioperative complications. The best correlation in this study population was observed with the NRS. The correlation among the different nutritional risk scores is only moderate, and they do not necessarily identify the same patients.

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