Original Research

The Influence of Nutritional Status on Complications after Major Intraabdominal Surgery

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Objective: Currently most nutritional assessment techniques are based on their ability to predict clinical outcomes. However, the validity of any of these techniques to truly measure "nutritional risk" has not been proved. We have therefore prospectively assessed the prognostic value of two nutritional assessment techniques and nonnutritional factors in determining outcome after major abdominal surgery.

Methods: At admission and discharge, 100 patients undergoing major abdominal surgery were assessed on the following items: Subjective Global Assessment, Nutritional Risk Index, anthropometric measurements, serum total protein, serum albumin, lymphocyte count, total serum cholesterol. Patients were monitored for postoperative complications until death or discharge.

Results: At admission, 44% of the patients were malnourished according to the Subjective Global Assessment, while 61% of the patients were malnourished according to the Nutritional Risk Index. At discharge, these numbers were 67% and 82%, respectively. Higher death rates were found in the malnourished groups. The risk of complication was increased in malnourished patients with both assessment techniques. The odds ratios for the association between malnutrition and complications varied between 1.926 and 9.854 with both assessments. The presence of cancer in the patient was predictive for complication.

Conclusions: Malnutrition is a marker of bad outcomes. Both Subjective Global Assessment and Nutritional Risk Index nutrition tests are predictive for malnutrition and postoperative complications in patients undergoing major abdominal surgery.

INTRODUCTION

Pre-existing malnutrition has been shown to be a major clinical problem in surgical patients [1]. Malnutrition has been correlated with longer hospital stays, nutrition-related complications during and after hospitalization, and other adverse outcomes [2–6]. The ability to use nutrition assessment to predict clinical outcome can be problematic, because the interaction between malnutrition and other factors that influence outcome makes it difficult to isolate any putative contribution from malnutrition alone. For example, illness and injury can affect tissue metabolism and accelerate loss of tissue function and mass. Inadequate protein and energy intake can also lead to alterations in intermediary metabolism, tissue function and body composition. Therefore the presence of "malnutrition" can contribute to a poor clinical outcome or may simply be associated with poor outcome, if the disease itself affects markers of nutritional status [7].

Recognition of specific prognostic factors might lead to interventions or increased postoperative surveillance that would improve outcome. Most current nutritional assessment techniques are based on their ability to predict clinical outcome. However, the validity of any of these techniques to truly measure nutritional risk has not been proven [8]. We have therefore prospectively assessed the prognostic value of two nutritional assessment techniques and nonnutritional factors in determining outcome after major abdominal surgery.

MATERIALS AND METHODS

After obtaining institutional approval, 100 consenting patients who were scheduled for major intra-abdominal surgery

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were enrolled in this study. We assessed nutritional status and laboratory parameters of nutrition in patients at admission and discharge. No nutrition support team was active in the wards. The decision to initiate nutritional support was made by the primary surgeon on clinical grounds alone.

Nutritional Measurements

Two methods were applied for nutritional assessment. The first method Subjective Global Assessment (SGA), is a clinical score. It was performed by a trained independent physician using a standard form including food intake and complaints such as vomiting, diarrhea, and loss of weight. This information is used to classify patients into one of three categories of nutritional status: A: well nourished, B: moderately malnourished or C: severely malnourished [9]. The second method, Nutritional Risk Index (NRI), is a simple equation that uses serum albumin and recent weight loss. NRI $=$ (1.489 $\times$ serum albumin, g/L) $+$ 41.7 $\times$ (present weight/usual weight). A NRI $>$ 100 indicates that the patient is not malnourished, 97.5–100 indicates mild malnourishment, 83.5–$<$97.5 indicates moderate malnourishment and $<$83.5 indicates severe malnourishment [10].

Height was recorded from case notes where available or measured with a stadiometer. Weight was measured with either mechanical scales or bathroom scales. Height and weight were used to determine body mass index (BMI) (weight (kg)/height (m^2)). Weight change over the six months before hospital admission was estimated by patients and expressed as a percentage of previous weight. Triceps and other skin-fold thicknesses measure subcutaneous fat and are an indication of body fat stores. Triceps skin-fold thickness (TSF) is measured with a skin caliper on the posterior upper arm midway between the acromion and olecranon process. A skin-fold of 4 to 8 mm suggests borderline fat stores, and a thickness of 3 mm or less indicates severe depletion. Midarm circumference (MAC) was measured using a non-stretch plastic tape, midway between the acromion and olecranon of the non-dominant arm. A measurement of 15 cm or less indicates severe depletion of muscle mass. Both MAC and TSF were used to calculate midarm muscle circumference (MAMC) according to the following formula: MAMC (cm) $=$ MAC (cm) $-$ (TSF (mm) $\times$ 0.3142). Midarm muscle circumference estimates muscle mass or lean tissue stores [11]. A fasting blood sample was obtained to measure complete blood count, albumin, total protein, alanine amino transferase (ALT), aspartate amino transferase (AST), total cholesterol and C-reactive protein (CRP). The lymphocyte count was calculated from the total, and the differential white count was obtained by an automated analyzer.

Postoperative Complications

Physicians and nurses were instructed to record all new complications in the patients' files. The presence, type and severity of the complications that occurred after admissions were derived from the patients' files after discharge. Rigid objective criteria were established defining each complication to avoid subjective observer bias. The presence or absence of cancer was recorded. For multiple diagnoses, the diagnosis that was the reason for admission was chosen.

Statistical Methods

The data was analyzed using the Statistical Program for Social Science (SPSS) for Windows (release 10.0). One-way analysis of variance, followed by the Bonferroni correction, was used to compare means, while the χ^2 test was used to compare proportions. Spearman rank correlation coefficients were calculated for association between change in nutritional status and complication. The odds ratio (OR) was used to measure for the development of complications. Multivariate logistic regression analysis of complications used variables with p less than 0.05 in univariate analysis. A backwards stepwise method was used with variables retained in the model if their logistic likelihood ratio p value was less than 0.05.

RESULTS

One hundred patients were enrolled in the study. Diagnoses of the patients are displayed in Table 1. Most of the patients had been admitted for gastrointestinal surgery. Twenty patients were hospitalized for acute conditions. At admission, 44% of the patients were malnourished according to the SGA, 61% of the patients according to the NRI. Weight loss and ALT were significantly higher in the severe malnourished group than in the well nourished group according to the SGA. TSF, BMI and albumin level were lower in the severely malnourished group with same method. Hospital stay was longer in the malnourished groups, but this was not statistically significant (Table 2). According to the NRI, most of the anthropometric data and the

Table 1. Diagnoses of patients

	Number
Pancreatic cancer	10
Gastric cancer	4
Rectum cancer	6
Colonic cancer	14
Ovarian cancer	10
Cervix cancer	3
Vulvar cancer	2
Endometrial cancer	5
Colonic perforation	7
Small bowel perforation	3
Rectal prolapse	4
Bowel obstruction	8
Choleolithiasis	18
Crohn's disease	2
Pheochromecytoma	2
Liver laceration	2
Total	100

Table 2. Patients' characteristics, anthropometrics and laboratory data at admission according to the SGA

	A (n = 56)	B (n = 30)	C (n = 14)
Age	59.4 ± 13.6	64.3 ± 17.7	66.9 ± 9.5
Weight loss %	1.7 ± 2.4	10.9 ± 4.6	16.1 ± 10.4*$^{\alpha}$
TSF (mm)	28.3 ± 5.4	25.8 ± 4.1	25.1 ± 8.6*$^{\alpha}$
MAMC (cm)	18.5 ± 3.9	16.5 ± 2.9	17.8 ± 5.5
BMI (kg/m^2)	27.4 ± 5.4	24.4 ± 4.9*	20.8 ± 4.0*
Albumin (g/dL)	3.8 ± 0.6	3.5 ± 0.6	3.1 ± 0.6*
Lymphocyte	1900 ± 1224	3639 ± 1970*	2115 ± 1182*$^{\alpha}$
AST	47.1 ± 84.6	52.3 ± 71.4	99.4 ± 66.1
ALT	34.2 ± 45.8	59.5 ± 102.5	166.9 ± 185.2*$^{\alpha}$
Total cholesterol	177.4 ± 34.8	168.9 ± 40.3	170.7 ± 53.8
C-reactive protein	6.8 ± 10.9	4.1 ± 4.3	4.2 ± 6.1
Length of stay	13.0 ± 6.1	22.2 ± 15.4*	17.0 ± 3.6

* $p < 0.01$ compared with well nourished group (A).
$^{\alpha}$ $p < 0.01$ compared with moderately malnourished group (B).
SGA = subjective global assessment, BMI = body mass index, TSF = triceps skin-fold, MAMC = midarm muscle circumference, AST = aspartate amino transferase, ALT = alanine amino transferase.

albumin level were lower in the severe malnourished group (Table 3). At discharge, malnutrition rates were 67% and 82% according to the SGA and NRI, respectively. Both tests showed significant increase in malnutrition rate at discharge ($p < 0.01$). According to the SGA, 47% of the patients were moderately malnourished, 20% of the patients were severely malnourished at discharge. Thirty-seven of the patients' nutritional status was recategorised: 33 patients' status being deteriorated and four patients' status being well according to the SGA at discharge. On the other hand, malnutrition rates were found 6% (mild), 31% (moderate) and 45% (severe) with NRI at discharge. Twenty-seven patients moved from the well nourished group to the malnourished groups with NRI at discharge. Nineteen patients were more malnourished at discharge than at admission with NRI. No correlation was found between change in nutritional status and complication with both nutritional tests.

Postoperative complications were found in 36 patients. Twenty six patients had more than one complication (Table 4). Twelve patients died during their hospital stay. Higher death rates were found in the malnourished groups (Table 5). Every patient that died was malnourished. No well nourished patient died. A significantly higher number of complications were seen in malnourished groups than in the well nourished group. Also, the mean number of complications was significantly lower in the well nourished group (Table 5). There were seven trauma patients. Three of those were in the anemia complicated group. Five of those did not receive any transfusion after the day of the operation. There were a total of 12 patients that were transfused. All sepsis patients were malnourished: two of those were moderately malnourished, and four of those were severely malnourished with both assessments at admission. According to the SGA, 82% of the patients who were diagnosed with pneumonia were malnourished at admission: 66% were moderately malnourished, 18% were severely malnourished. Nine of the 12 pneumonia patients were malnourished: five of those moderately malnourished, three severely malnourished. A power analysis for the χ^2 test was done. Our results provide an 80% ($\alpha = 0.05$) power for detecting significant difference in complication rates between well nourished and malnourished groups using both assessment methods. The risk of complication increased in malnourished patients and cancer patients with both assessment methods. The odds ratios for the association between malnutrition and the occurrence of complications are shown in Table 6.

DISCUSSION

Consistent with prior studies, this investigation demonstrates that more than 40% of the surgical patients are malnourished. It also shows that there is a strong association between

Table 3. Patients' characteristics, anthropometrics and laboratory data at admission according to the NRI

	None (n = 39)	Mild (n = 6)	Moderate (n = 36)	Severe (n = 19)
Age	60.4 ± 14.1	61.7 ± 16.8	64.2 ± 13.7	60.7 ± 17.6
Weight loss %	2.8 ± 3.3	2.0 ± 3.1	7.6 ± 7.6*	13.6 ± 8.6*$^{\alpha\$}$
TSF (mm)	27.4 ± 7.1	28.7 ± 4.6	29.6 ± 6.7	21.4 ± 5.8*$^{\$}$
MAMC (cm)	17.6 ± 3.1	21.6 ± 4.9	18.7 ± 5.2	15.5 ± 2.8$^{\alpha\$}$
BMI (kg/m^2)	26.4 ± 5.6	24.5 ± 1.3	27.3 ± 5.6	20.9 ± 3.5*$^{\$}$
Albumin (g/dL)	4.3 ± 0.2	3.7 ± 0.3*	3.5 ± 0.4*	2.6 ± 0.3*$^{\alpha\$}$
Lymphocyte	2358 ± 1309	2211 ± 1931	1862 ± 1026	3837 ± 2401*$^{\$}$
AST	22.9 ± 17.0	128.6 ± 62.6*	71.1 ± 104.1*	72.0 ± 86.0
ALT	22.7 ± 31.4	177.7 ± 124.5*	54.3 ± 62.9$^{\alpha}$	111.9 ± 185.5*
Total cholesterol	188.2 ± 35.5	187.7 ± 28.0	166.8 ± 40.5	141.6 ± 31.7*
C-reactive protein	8.2 ± 12.8	0.6 ± 0.5	3.6 ± 3.2	7.1 ± 7.3
Length of stay	13.7 ± 6.3	13.0 ± 5.8	18.0 ± 11.7	19.4 ± 14.3

* $p < 0.01$ compared with well nourished group.
$^{\alpha}$ $p < 0.01$ compared with mild malnourished group.
$^{\$}$ $p < 0.01$ compared with moderate malnourished group.
NRI = nutritional risk index, BMI = body mass index, TSF = triceps skin-fold, MAMC = midarm muscle circumference, AST = aspartate amino transferase, ALT = alanine amino transferase.

Table 4. Postoperative complications in 100 patients*

Type	Definition	Number
Death	Occurring within hospital	12
Wound infection	Inflammation/purulent discharge ± positive swab culture	8
Pneumonia	New shadowing on chest X-ray, purulent sputum ± positive culture	12
Atelectasis	Confirmed on CXR in the absence of signs of pulmonary infection	1
Pulmonary complications	Other than 3 and 4	2
Anemia	Needing transfusion after day of operation	8
Sepsis	Positive culture with systemic inflammatory response syndrome criteria	6
Intra-abdominal abscess	Intra-abdominal purulent collection requiring operative drainage	6
Cardiac arrhythmia	Any arrhythmia (not existent before operation)	15
Miscellaneous	Any other unexpected event requiring treatment or intervention	43

* Complication was found in 36 patients. Twenty six patients had more than one complication.

malnutrition and postoperative complications according to the both nutrition assessment techniques. The presence of cancer was an important predictor for the risk of complication.

Surgical complications occur frequently. One large study documented at least one complication in 17% of surgical patients [12]. Because of the increased risk of morbidity and mortality in malnourished surgical patients, there has been much research to define the clinical and laboratory parameters for evaluating a patient's nutritional status. How to identify the patients at risk? Many indices and scoring systems have been developed to predict a patient's nutritional risk, but no single scoring system is used as a standard. A weight loss of more than five percent in one month or of 10 percent or more over six months, a serum albumin of less than 3.2 g/dL and a total lymphocyte of less than 3.000/mm^3 (3×10^9/L) can signify an increased risk of postoperative complications [13,14].

In 1936, Studley documented that, in patients operated on for chronic peptic ulcers, if preoperative weight loss was 20% or more the complications including mortality were 33.5%, compared with 3.5% in those who had lost less weight [15]. In another prospective study of patients undergoing elective surgery involving resection of a portion of the upper GI tract, patients with weight loss alone >10% fared no worse than control subjects without weight loss. However those patients with >10% weight loss with some evidence of physiologic impairment (defined by abnormal serum protein levels, maximal inspiratory pressure, hand grip dynamometry or body composition) sustained a significantly higher incidence of major complications [16]. In our study, as in Windsor's study, weight loss alone wasn't a specific predictor, but when used in the scoring systems (SGA and NRI), the scoring systems were predictive for postoperative complications.

Albumin is commonly thought of as a good indicator of nutritional status and visceral proteins. In 54,215 patients undergoing major noncardiac operations, a serum albumin less than 21 g/L was associated with a morbidity rate of 65% and a mortality rate of 29%. Albumin level was a better predictor of some type of morbidity, particularly sepsis and major infections, than many other preoperative patient characteristics [17]. A more recent study has shown that serum albumin (OR: 1.9, CI: 1.2–2.9) and cholesterol (OR: 2.0, CI: 1.3–3.0) levels have an inverse and highly significant relationship with nosocomial infection in general surgery patients [18]. In this study albumin didn't reach statistical significance for the risk of complication (OR: 0.919, CI: 0.845–1.000, $p = 0.05$). It was thought that the reason for this was that the sample size was not large enough for significance.

Subjective Global Assessment is used primarily by clinicians to assess nutritional status in hospitalized patients. It uses physical findings and four areas of medical history: change in weight over the previous two weeks and six months, change in dietary intake, gastrointestinal symptoms and functional capacity [9]. This technique has good interrater agreement [9], good sensitivity and specificity [19] and predicts nutrition-related complications in certain populations, including surgical patients [3,7]. Combining SGA with some of the traditional markers of nutritional status increased the ability to identify patients who developed complications from 82% to 90%. This also increased the percentage of patients identified as malnourished, but who did not develop a postoperative complication,

Table 5. Number of complications and deaths during the hospital stay in patients admitted to the hospital according to the SGA and NRI

	SGA			NRI			
	A (n = 56)	B (n = 30)	C (n = 14)	None (n = 39)	Mild (n = 6)	Moderate (n = 36)	Severe (n = 19)
Death (%)*	0	6 (20%)	6 (42%)	0	0	4 (11%)	8 (42%)
Complications (patient)*	13 (23%)	15 (50%)	8 (57%)	8 (20%)	2 (33%)	16 (44%)	10 (52%)
Complication/patient*	26/56 (0.46)	43/30 (1.43)	32/14 (2.28)	10/39 (0.25)	6/6 (1)	46/36 (1.27)	38/19 (2)

* $p < 0.01$ between groups in the same assessment.

Table 6. Odds ratios (with 95 CIs) for risk of complications

	OR	95% CI	*p*
BMI	1.001	1.000–1.002	0.89
Albumin	0.919	0.845–1.000	0.05
Ca	4.232	1.317–13.594	0.015
SGA (B)	3.308	1.283–8.528	0.013
SGA (C)	4.410	1.293–15.042	0.018
NRI mild	1.926	0.274–13.513	0.51
NRI moderate	3.525	1.071–11.599	0.038
NRI severe	9.854	1.768–54.922	0.009

from 25% to 30% [7]. The NRI is derived from the serum albumin concentration and the ratio of actual to usual weight with the equation. This index was used in the Veterans Administration Cooperative Study that evaluated the effect of perioperative nutritional support [10]. The odds ratios for the risk of complications in malnourished compared with well nourished patients were reported as 1.7 for SGA and 1.6 for NRI [7]. In this study, we found that the odds ratios for the incidence of any complication in malnourished patients compared with well nourished patients during hospitalization were 3.308–4.410 (moderate and severe malnourished) for the SGA and 1.926–9.854 (from mild to severe) for NRI.

The presence of cancer was reported as an independent risk factor for malnutrition [20]. Studies reported that all the nutritional parameters reflected a significant deterioration as the stages of cancer progressed; also, the frequency of postoperative complications was the highest in high stage cancer patients [21]. In our study, there was an increased postoperative complication rate with the presence of cancer.

Nutritional status also worsens during the course of hospitalization in multiple patient populations [1,22]. There are many reasons for this, e.g., having to fast for investigations, unpalatable foods, nausea, depression or feeding difficulties. Consistent with previous studies, in our study patients' malnutrition rates were higher at discharge than at admission.

Several criticisms of this study should be addressed. First, the group of patients was very heterogeneous, and it might have been preferable to study patients with one disease in detail. We deliberately studied this heterogeneous population because our aim was to study the relationship between nutritional status and complications in surgical patients. If a correlation could be shown in this population, it would have strengthened the need for treatment of malnutrition. Second, one might say malnutrition is not the cause of complication, but that both malnutrition and complications are the result of the underlying disease or other factors. Malnutrition and underlying disease are inextricably interwoven, and only in unusual circumstances, such as self-imposed malnutrition like anorexia nervosa, is malnutrition clearly separable from other disease. In fact, in a recent consensus report on nutrition support in clinical practice, it was concluded that all current nutrition assessment techniques are affected by illness and injury and that their validity independently to measure nutritional risk has not been proven [8]. We used NRI and SGA for assessment. The Nutritional Risk Index uses serum albumin concentrations, which are influenced by nutritional status but also by inflammatory stress due to a disease. However, SGA is not influenced by serum proteins. On the other hand, NRI uses some laboratory examination; it needs laboratory charge also, but SGA uses only clinical examination which can easily be done in several minutes. One might say SGA is a more cost effective means of assessing nutritional risk than NRI.

CONCLUSION

In conclusion, our study demonstrates malnutrition is a marker of bad outcomes. Both the SGA and NRI nutrition tests are predictive for malnutrition and postoperative complications in patients undergoing major abdominal surgery. The presence of cancer also was predictive for postoperative complications. Anthropometrics and other laboratory variables weren't predictive for complications. Nutritional assessment of the critically ill patient anticipating a major operation is crucial, as the deterioration of nutritional status is a key factor in surgical outcome.

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