Int Surg 2019;**104:**431–438
DOI: 10.9738/INTSURG-D-16-00214.1

Nutritional Assistance by Software Improves Surgical Outcomes of Elective Colorectal Surgery

Mehdi Ouaissi[1,2], Jacques di Costanzo[3], Laurence Boiron[4], Regis Hankard[5], Théophile Guilbaud[4], Diane Mege[4], Aurelie Maignan[4], Caroline Rossi[4], Cecilia Frasconi[4], Remy Le Huu Nho[4], Loundou Anderson[6], Nicolas Pirro[4], Antonio Iannelli[2,7], Igor Sielezneff[4]

[1]*Department of Digestive and Colorectal Surgery, Trousseau Hospital, Chambrès les Tours, France*

[2]*Atelier Provençal d'écriture médicale, Marseille, France*

[3]*Department of Nutrition, European Hospital, Marseille, France*

[4]*Department of Digestive and Visceral Surgery, Timone Hospital, Assistance Publique des Hopitaux de Marseille, Marseille, France*

[5]*Department of Nutrition, Bretonneau Hospital, Tours, France*

[6]*Department of Public Health and Biostatistics, Faculty of Medicine, Aix Marseille University, Assistance Publique des Hôpitaux de Marseille, Marseille, France*

[7]*Digestive Unit, Archet 2 Hospital, University Hospital of Nice, Nice, France*

University of Nice Sophia-Antipolis, Nice, France

Objective: The present study analyzes nutrition support in a group of patients undergoing colorectal surgery managed by nutritional requirement software compared to a group of consecutive patients undergoing colorectal surgery with conventional nutrition

Materials and Methods: A total of 485 patients were treated between January 2000 and January 2013 with colorectal resection. Outcomes (mortality, morbidity according to Clavien classification, length of hospital stay, type of colorectal disease) in a group of patients who

Corresponding author: Mehdi Ouaïssi, MD, PhD, Department of Digestive and Colorectal Surgery, Trousseau Hospital, Avenue de la République, 37170 Chambrès les Tours, France.
Tel.: 02 47 47 18 28; Fax: 02 47 47 59 37; E-mail: ouaissi_mehdi@hotmail.com

received nutrition support through software (SG) were compared to those in a previous series, control group (CG) with conventional nutrition support

Results: Of the patients, 59.6% were men and the median age of the population was 68.2 years (range, 19–95 years), with no difference between the 2 groups. There were significantly more malnourished patients in the SG group (SG 63.8% versus 45.2% CG; $P < 0.0001$). The overall mortality was 2.1% lower in the SG group, but without a significant difference (SG 0.7% versus 2.7% CG). There were more severe stage III to IV complications according to Clavien classification in the SG group (SG 10.7 GC versus 17% NS), with significantly greater collections (SG 8% versus 16.9% CG; $P = 0.015$) and greater anastomotic leaks (SG 4% versus 13.9% CG; $P < 0.001$). The median hospital stay was lower in the SG group (SG 12 days versus 15 days CG; $P = 0.049$).

Conclusion: The proposed software could contribute to optimizing the strategy of nutritional support in hospitalized patients.

Key words: Malnourished patient – Colorectal surgery – Nutritional support

The reported prevalence of malnutrition in patients admitted for gastrointestinal surgery is 28-% to 30%.[1,2] Despite improvements in surgical technique, bowel preparation, and antibiotic prophylaxis, colorectal surgery is still associated with a 5% to 6% mortality and a 20% to 40% morbidity rate.[3–6] Patients' nutritional status is recognized as a major determinant of postoperative mortality and morbidity.[7] Several factors may contribute to impair patients' nutritional status, including those related to the colorectal disease, either malignant or benign, such as Crohn disease, or rectitis,[8] and the preoperative treatment, such as radiochemotherapy in cases of rectal adenocarcinoma.[2] Although it is recognized that for optimal rehabilitation and wound healing after surgery the body needs to be in an anabolic state before surgery,[9] most studies indicate that perioperative nutritional support should be restricted to patients with severe malnutrition.[10] However, some of these studies include both colorectal and gastric surgery.[10,11] Moreover, patients' poor nutritional status is often underestimated before surgery.[12,13] The aim of the present study was to analyze the impact on postoperative morbidity and mortality of the systematic use of a piece of software to manage preoperative and postoperative nutritional requirements in patients undergoing colorectal surgery.

Materials and Methods

Study design

From January 2010 to December 2013 software[13] was systematically used to evaluate and eventually treat altered nutritional status in all patients undergoing elective colorectal surgery in our department. Our hypothesis was that the use of the software[13] would result in a more effective diagnosis and treatment of altered nutritional status in patients who are candidates to elective colorectal surgery (software group). We used a control group (CG) of patients undergoing elective colorectal surgery in our department between January 2000 and December 2013 (conventional group). Patients in the software group (SG) were compared to patients of the CG with respect to mortality, morbidity rates, and length of hospital stay.

Information was retrospectively retrieved from a prospectively held database, including demographics, type of disease (inflammatory bowel disease, benign tumor, adenocarcinoma), ASA score, distance of the tumor from the anus at colonoscopy, type of surgery (laparoscopy versus laparotomy; colonic resection; rectal resection; abdominal sacral resection), duration of surgery, blood transfusion, and histopathologic findings for comparability of groups' postoperative morbidity and mortality, and length of hospital stay.

Nutritional assessment and support

In the CG (336 patients) nutritional assessment was performed following usual recommendations. Malnutrition risk was assessed based on the Malnutrition Screening Tool and serum albumin levels according to the study by Stratton *et al*.[1] The Malnutrition Screening Tool is a quick and simple nutritional screening tool based on weight loss

Table 1 General characteristics and comorbidities between the CG and the SG

	CG (n = 336)	SG (n = 149)	Overall population (N = 485)	*P* value
Sex, n (%)				
Men	201 (59.8)	88 (59.1)	289 (59.6)	0.875
Women	135 (40.2)	61 (40.9)	196 (40.4)	
Age, y, median (range)	67.9 (19–95)	68.6 (23–93)	68.2 (19–95)	0.252
ASA score, n (%)				
1–2	291 (86.9)	130 (87.2)	421 (86.8)	0.885
3–4	45 (13.3)	19 (12.7)	64 (13.2)	
Performance status, n (%)				
0	217 (64.6)	101 (67.7)	318 (65.5)	0.777
1	93 (27.7)	37 (24.8)	130 (26.8)	
2	21 (6.3)	11 (7.3)	32 (6.6)	
3	5 (1.5)	0	5 (1)	
Comorbidities, n (%)				
Diabetes	48 (14.2)	19 (12.9)	67 (13.8)	0.775
Coronary disease	64 (19)	18 (12.1)	82 (16.9)	0.066
Hypertension	126 (37.5)	69 (46.4)	195 (40.2)	0.071
Denutrition characteristics				
Body mass index, median (range)	24 (15–39)	24.9 (14–47)	24.5 (14–47)	0.088
Denutrition, n (%)	152 (45.2)	95 (63.8)	247 (50.9)	**<0.0001**
Moderate	138 (41.1)	72 (48.3)	210 (43.3)	0.1370
Severe	14 (4.2)	23 (15.4)	37 (7.6)	**<0.0001**

(Table 1) and serum albumin level below 3.5 g/dL. Patients were subsequently classified in 3 malnutrition risk categories (low, medium, and high risk). This evaluation was performed before surgery in all patients of the CG. When a patient was recognized as having high malnutrition risk before surgery, he or she was encouraged to eat through oral or enteral feeding as tolerated. When the patient's food intake was less than 18 kcal per kilogram of body weight through oral or enteral feeding, the complementary parenteral peripheric nutrition was used for 5 days before surgery.

Postoperatively, patients whose intake did not cover at least 60% of their nutritional needs within 1 week after surgery had complementary oral, enteral, or PNN nutritional support.

In the intervention group (149 patients) we used the software[13] in order to evaluate and treat malnutrition. The software was designed with respect to the recent proposals of the Agence Nationale d'Accréditation et d'Evaluation en Santé and within the Programme National Nutrition et Santé.[9,14,15]

The following parameters were entered for each patient: body weight and height, loss of weight expressed as percent of usual body weight, and duration of weight loss. Body mass index, Nutritional Risk Index, and subsequently the risk of malnutrition were calculated. According to these data, the software was able to calculate the level of patient's needs (Total Energy Expenditure, calculated from Resting Energy Expenditure, according to the Harris and Benedict formula and corrected by a coefficient ranging from 1.2 to 2, according to the patient's activity, severity of the disease, and type of surgery). The needs in water, electrolytes, vitamins, and trace elements were finally calculated. The software propositions were as follows: in cases of mild or moderate malnutrition, a balanced diet or nutritional complements were proposed for prescription; in case of severe malnutrition, the software proposed, depending on the functional state of the gastrointestinal tract, enteral nutrition or parenteral nutritional support, or total parenteral nutrition. The software also proposed the most appropriate nutritional mixture according to the patient's needs.

Postoperatively, systematic PNN was given to severely malnourished patients who had preoperative nutritional support according to the software recommendations. Patients without preoperative malnutrition and those with mild or moderate malnutrition had oral, enteral, or PNN complementary nutritional support calculated by the software correlated to an evaluation of their food intake by a dietician. Patients were evaluated by a dietitian from postoperative day 3 and subsequently every 3 days until discharge. Patients were discharged when food intake was more than 60% of the daily requirements and clinical and biologic parameters returned to normal.

Perioperative care

Single-shot antibiotic prophylaxis was routinely given (750 mg of cefuroxime) at induction of general anesthesia and repeated intraoperatively if surgery lasted for more than 2 hours. The decision to perform colonic resection by laparotomy or laparoscopy was left up to the operating surgeon. The 3 operating surgeons involved in this study were experts in both laparoscopic and open colorectal surgery. Conversion to open surgery was defined as the need to perform an abdominal incision larger than 7 cm.

Postoperative care

All patients received low–molecular weight heparin (50 IU/kg per day) for deep vein thrombosis prophylaxis after surgery and continued for 4 weeks thereafter. The decision to start patients on an oral diet after surgery was left to the operating surgeon and was based on the restoration of bowel sounds, passage of flatus and/or stool. Patients were systematically reviewed 4 weeks after discharge by the operating surgeon in the outpatient clinic.

The international Clavien-Dindo Classification for complications was used.[16] Mortality was defined as any death occurring within 90 days of surgery or any time during hospital stay.

The length of hospital stay was calculated as the time from the day of surgery to the day of discharge. Discharge status included discharge home with or without assistance or discharge to a nursing facility. Patients were discharged, in the absence of any documented postoperative complication, while food intake was more than 60% of the daily requirements and clinical and biologic parameters returned to normal.

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics version 20 (IBM SPSS Inc, Chicago, Illinois). Continuous variables are expressed as means ± SD or as median with range (minimum, maximum), and categoric variables are reported as count and percentages. Comparisons of means values between 2 groups were performed using Student *t*-test or Mann-Whitney *U*. Comparisons of percentages were performed using χ^2 test (or Fisher exact test, as appropriate). Predictive factors of severe complications (grades III–IV) were analyzed by multivariate statistical analysis. Significant variables at the 0.15 level in univariate analysis were introduced in the multivariate logistic regression model. Univariate and multivariate Cox proportional hazard regression models were used to estimate the hazard ratio (OR). The ORs were expressed with 95% confidence intervals. All the tests were 2-sided. The statistical significance was defined as $P < 0.05$.

Results

General characteristics of the population and comorbidities

A total of 485 patients were included, of whom 336 patients belonged to the CG and 149 to the SG (Table 1). The overall median age was 68.2 years (range, 19–95 years) without differences between the 2 groups. There was no difference between the 2 groups regarding sex, American Society of Anesthesiologists (ASA) score, comorbidities, performance status, and body mass index. There were significantly more malnourished patients, especially those with severe malnutrition, in the SG compared with the CG (15.4% versus 4.2%; $P < 0.0001$; respectively).

Clinical presentation and characteristics of the colorectal tumor and surgery (Tables 1 and 2)

Diarrhea was significantly less frequent in the SG (5.4% versus 13.4%; $P = 0.009$). Colorectal cancer, benign tumor, and inflammatory bowel disease colitis or diverticulitis were respectively 74.2%, 11.5%, and 14.2%, without differences between the 2 groups. Colectomy and rectal surgery (proctectomy and abdominal amputation) were 70.9%, and 21.1%, without differences between the 2 groups. However, the rectal resection rate was greater in the SG than in the CG (28.2% versus 23.5%; $P = 0.306$). Laparoscopy was significantly more frequent in the SG (41.6% versus 16.6%; $P < 0.001$).

Nutritional support in the two groups

Patients in the CG had had an average nutritional support between 15 and 20 kcal/kg/d (17 ± 2), with 6 to 8 g of nitrogen (7 ± 2), with a calorie to nitrogen ratio of 80 to 100 (90 ± 5). Patients in the SG group had an average nutritional support according to the software recommendations of 20 to 30 kcal/kg/day (25 ± 5), with 8 to 10 g of nitrogen (9 ± 2), with a calorie to nitrogen ratio of 120 to 150 (130 ± 5).

Table 2 Comparison for the clinical characteristics between the CG and the SG

Symptoms	Nutrition group, n (%)			*P* value
	CG (n = 336)	SG (n = 149)	Global (N = 485)	
Proctorrhagia	111 (33)	63 (42.3)	174 (35.9)	0.051
Occlusion	55 (16.4)	15 (10.1)	70 (14.5)	0.072
Diarrhea	45 (13.4)	8 (5.4)	53 (10.9)	**0.009**
Deterioration of general condition	104 (30.9)	44 (29.7)	148 (30.7)	0.858
Characteristics of colorectal pathology				
Colorectal cancer	255 (75.9)	105 (70.5)	360 (74.2)	0.0540
Diverticulosis/polyp	31 (9.2)	25 (16.8)	56 (11.5)	
Colon inflammation (diverticulitis or acute colitis for inflammatory bowel disease)	50 (14.9)	19 (12.8)	69 (14.2)	

Postoperative complications (Table 3)

Mortality was significantly lower in the SG (0.7% versus 2.7%; $P = 0.296$). There were significantly fewer severe postoperative complications in the SG (10.7% versus 17%; $P = 0.097$). Deep abdominal collections and anastomotic leaks were significantly lower in the SG (4% versus 13.9%, $P < 0.001$; and 8% versus 16.9%, $P = 0.015$, respectively). The overall median hospital stay was significantly shorter in the SG (12 versus 15 days; $P = 0.015$). Overall definitive stoma was 5.7%, without differences between 2 groups (SG 6.7% versus 5.3% CG; $P = 0.534$).

Predictive factors of severe complications – (Tables 4 and 5)

Predictive factors of severe complications were analyzed by univariate and multivariate statistical analyses. Included variables were clinical data (age, sex, malnutrition), type of surgery, pathologic findings (malignant, benign, and inflammatory), and the use of the software or not. Multivariate analysis showed that both types of surgery and software use were independent prognostic factors of severe complications. Covariate analysis showed a significant correlation between software use and laparoscopy ($P = 0.0001$; Table 4). A second multivariate analysis with new variables (no soft-

Table 3 Comparison of operative data between the CG and the SG

Operative data	CG (n = 336)	SG (n = 149)	Global (N = 485)	*P* value
Type of surgery, n (%)				
Colectomy	248 (73.8)	96 (64.4)	344 (70.9)	0.051
Protectomy	67 (19.9)	35 (23.5)	102 (21.1)	
ASR	12 (3.6)	7 (4.7)	19 (3.9)	
Combined resection[a]	9 (2.7)	11 (7.4)	20 (4.1)	
Open surgery, n (%)	274 (81.5)	62 (41.6)	333 (68.6)	<0.001
Laparoscopy, n (%)	56 (16.6)	80 (53.7)	136 (28)	
Converted laparoscopy	6 (1.8)	7 (4.7)	13 (2.6)	
stomia, n (%)				
Protective ileostomy	74 (22)	25 (16.7)	99 (20.4)	0.222
Definitive stomia	18 (5.3)	10 (6.7)	28 (5.7)	0.534
Postoperative complications, n (%)	105 (31.2)	42 (28.2)	147 (30.3)	0.522
Mortality, n (%)	9 (2.7)	1 (0.7)	10 (2.1)	0.296
Stages I–II, n (%)	49 (14.6)	25 (16.7)	74 (15.2)	0.583
Stages III–IV, n (%)	56 (17)	16 (10.7)	72 (14.8)	0.097
Anastomotic leakage, n (%)	47 (13.9)	6 (4)	53 (10.9)	**<0.001**
Relaparotomy, n (%)	36 (10.7)	10 (6.7)	46 (9.5)	0.182
Local collection drainage, n (%)	18 (5.3)	4 (2.6)	22 (4.5)	0.241
Collections, n (%)	57 (16.9)	12 (8)	69 (14.2)	**0.015**
Median length of hospital stay (range)	15 (1–120)	12 (2–67)	13 (1–120)	**0.049**

ASR, abdominal sacral resection.

[a]Combined resection consisted of resection of 2 or more organs.

Table 4 Multivariate analysis of predictive factors for severe complications (Clavien III–IV) between the CG and the SG

	Severe complications (n = 72)	No complications (n = 329)	OR (confidence interval)	*P* value
Age, mean, y	65 ± 14	65 ± 15	1 (0.9–1.1)	0.773
Sex, n (%)				
Male	40 (55.6)	200 (60.8)	1.2 (0.7–2.1)	0.391
Female	32 (44.4)	129 (39.2)		
Denutrition, n (%)	39 (54.2)	161 (45.8)	1.2 (0.7–2.1)	0.430
No denutrition, n (%)	33 (45.8)	168 (51.1)		
Type of surgery, n (%)				
Colectomy	41 (56.9)	240 (72.9)	2.2 (1.2–4)	**0.009**
Proctectomy	22 (30.6)	64 (19.5)		
APR	13 (4)	4 (5.6)		
Other	12 (3.6)	5 (6.9)		
Type of tumor, n (%)				
Colorectal cancer	53 (73.6)	249 (75.7)	1.1 (0.6–2.2)	0.640
Benign	6 (8.3)	39 (11.9)		
Inflammatory	13 (18.1)	41 (12.5)		
Nutritional software	37 (51.4)	189 (57.4)	2 (1.1–3.7)	**0.032**

APR, abdominoperineal resection.

ware use and no laparoscopy versus laparoscopy without software use; software use and no laparoscopy and software use with laparoscopy), clinical data (age, sex, malnutrition), type of surgery, and pathologic findings (malignant, benign, and inflammatory disease) was done. Type of surgery and software use associated with laparoscopy were independent prognostic factors of severe complications (Table 5).

Discussion

The present study clearly demonstrates that the systematic use of a piece of software to evaluate the nutritional status and consequent nutritional support, compared with conventional methods, improved postoperative outcomes in terms of reduced morbidity and length of stay.

Surgery, like any injury to the body, elicits a series of reactions, including release of stress hormones and soluble mediators of inflammation that may have a major impact on body metabolism. Altered nutritional status is associated with increased postoperative morbidity and mortality after elective surgery.[17–20] Moreover, it has been shown that preoperative nutritional support in severely malnourished patients significantly decreased morbidity and mortality rates as well as length of hospital stay.[7]

There have been significant benefits demonstrated with preoperative administration of immune-enhancing nutrition (IEN) in some high-quality trials in a recent review of the litterature.[21] However this review included different heterogeneous studies with different grades of malnourished patients (severe and moderate) and different types of surgery (major or minor, gastric and/or colorectal surgery, etc). In a summary, IEN was definitely important for all patients who underwent digestive surgery, but management of malnourished patients could clearly benefit from specific nutritional support in preoperative and postoperative surgery. A

Table 5 Multivariate analysis of predictive factors of severe complications (Clavien III–IV) between the CG and the SG

	OR (confidence interval)	*P* value
Age, mean, y	1 (0.9–1.0)	0.497
Sex, M/F	1.2 (0.7–2.2)	0.347
Denutrition, yes versus no	1.2 (0.7–2.1)	0.430
Type of surgery	2.1 (1.2–4)	**0.044**
Type of tumor	1.2 (0.6–2.3)	0.556
Without nutritional software use/without laparoscopy	2 (1.1–3.7)	**0.061**
Without nutritional software use/laparoscopy	0.6 (0.3–1.4)	0.278
Nutritional software use/without laparoscopy	0.9 (0.4–2.2)	0.963
Nutritional software use/laparoscopy	0.3 (0.1–0.7)	**0.010**

recent study demonstrates decrease in hospital length of stay, likely related to fewer complications, and supports the use of IEN as a quality improvement measure in elective colorectal surgery.[22] In this study IEN was used in patients who underwent elective colorectal surgery, whether malnourished or not.

These 2 works underline the importance of preoperative IEN to decrease postoperative complication rates. However, the importance of specific nutritional support for malnourished patients implies preoperative diagnosis and specific preoperative and postoperative managment.[21,22]

Most surgical series analyzing the impact of preoperative malnutrition on surgical outcome included different diseases, of variable severity affecting different digestive organs. On the contrary, our series was focused on a subgroup of patients with colorectal diseases.[7,10,23–25]

Recently we showed that malnutrition was misevaluated in more than two thirds of cases when standard methods of evaluation were used, whereas the software allowed a significantly more effective identification of patients with altered nutritional status.[13] This erroneous assessment may affect the response to treatment and increase adverse effects.[12] Otherwise automated parenteral nutrition management by the software improved the accuracy of prescription.[26,27]

The study shows that the standardized preoperative nutritional management with the software decreases significantly the occurrence of anastomotic leaks and intra-abdominal collections. Interestingly, the benefic effect of the systematic use of the software persisted in spite of the fact that there were more severely malnourished patients and more rectal resections in the SG.

This study has several biases, including its retrospective nature and the fact that the 2 groups of patients were not parallel. Indeed, the laparoscopic approach was used significantly more often in the SG, corresponding to the deep diffusion of the laparoscopic technique in the last years. Indeed, in covariate analysis there was a significant correlation between software use and laparoscopy, and in a second multivariate analysis both the software and laparoscopy decreased severe postoperative morbidity significantly. However, these data have to be confirmed in a randomized prospective study.

Only a few series have showed that an appropriate preoperative nutritional support results in a decreased hospital stay.[7,10] These studies indicate that the correction of preoperative malnutrition in patients undergoing surgery decreases the postoperative inflammatory response. Indeed, in the present study the postoperative nutritional status was monitored by the use of software up to discharge.

Conclusion

The use of the proposed software may contribute to improving nutritional support in patients undergoing major elective abdominal surgery and may consequently reduce the rate of postoperative complications and mortality as well as the duration of hospital stay.

Acknowledgments

None of the authors have conflicts of interest. This work was supported by institutional funding from Aix-Marseille University (Marseille, France) and ARCDO-PACA. The authors are also grateful to Dr Frederic Vancouver and to Anderson Loundou for her meticulous reading and statistical analysis of the manuscript.

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