Nutritional assistance by software improves surgical outcomes of elective colorectal surgery

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Abstract: Objective: Analysis of 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 support. Material and Methods: 485 patients were treated between January 2000 and January 2013 with colorectal resection. Outcomes (mortality, morbidity according to Clavien classification (CC), length of hospital stay, type of colorectal disease) in a group of patients that received nutrition support through software (SG), were compared to those in a previous series, control group (CG) with conventional nutrition support. Results: There were 59.6% men and the median age of the population was 68.2 (19-95) years, with no difference between the two groups. There were significantly more malnourished patients in the SG group (SG 63.8% vs 45.2% GC, p<0.0001). The overall mortality was 2.1% lower in the SG group, but without significant difference (SG 0.7% vs 2.7% GC).
There were more severe stage III-IV complications according to CC in the SG group (SG 10.7% vs 17% NS); with significantly greater collections (SG 8% vs 16.9% GC p=0.015) and greater anastomotic leaks (SG 4% vs 13.9% GC p <0.001). The median hospital stay was lower in the SG group (SG 12 vs 15 days, p=0.049). Conclusion the proposed software could contribute to optimizing the strategy of nutritional support in hospitalized patients.
Nutritional assistance by software improves surgical outcomes of elective colorectal surgery.

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ABSTRACT

Objective: Analysis of 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. Material and Methods: 485 patients were treated between January 2000 and January 2013 with colorectal resection. Outcomes (mortality, morbidity according to Clavien classification (CC), length of hospital stay, type of colorectal disease) in a group of patients that received nutrition support through software (SG), were compared to those in a previous series, control group (CG) with conventional nutrition support. Results: There were 59.6% men and the median age of the population was 68.2 (19-95) years, with no difference between the two groups. There were significantly more malnourished patients in the SG group (SG 63.8% vs 45.2% GC; p<0.0001). The overall mortality was 2.1% lower in the SG group, but without significant difference (SG 0.7% vs 2.7% GC). There were more severe stage III-IV complications according to CC in the SG group (SG 10.7GC vs17% NS); with significantly greater collections (SG 8% vs 16.9% GC p=0.015) and greater anastomotic leaks (SG 4%vs13.9% GC p <0.001). The median hospital stay was lower in the SG group (SG 12 vs 15 days, p=0.049). Conclusion: the proposed software could contribute to optimizing the strategy of nutritional support in hospitalized patients.

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INTRODUCTION:

The reported prevalence of malnutrition in patients admitted for gastrointestinal surgery is 28-30\%\textsuperscript{1,2}. Despite improvements in surgical technique, bowel preparation, and antibiotic prophylaxis, colorectal surgery is still associated with 5 to 6\% mortality and 20 to 40\% morbidity rate\textsuperscript{3-6}. Patients’ nutritional status is recognized as a major determinant of postoperative mortality and morbidity\textsuperscript{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\textsuperscript{8} and the preoperative treatment such as radio-chemotherapy in case of rectal adenocarcinoma\textsuperscript{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\textsuperscript{9}, most studies indicate that perioperative nutritional support should be restricted to patients with severe malnutrition\textsuperscript{10}. However, some of these studies include both colorectal and gastric surgery\textsuperscript{10,11}. Moreover, patients’ poor nutritional status is often underestimated before surgery\textsuperscript{12,13}. The aim of the present study was to analyze the impact on postoperative morbidity and mortality of the systematic use of a software to manage preoperative and postoperative nutritional requirements in patients undergoing colorectal surgery.

MATERIAL AND METHODS

Study design

From January 2010 to December 2013 a software\textsuperscript{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\textsuperscript{13} resulted in a more effective diagnosis and treatment of altered nutritional status in patients candidates to elective colorectal surgery (software group). We used a control group of patients undergoing elective colorectal surgery in our department between January 2000 and December 2013 (conventional group). Patients of the software group were compared to patients of the conventional group 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 vs laparotomy; colonic resection, rectal resection, abdominal sacral resection), duration of surgery, blood transfusion and histopathological findings for comparability of groups postoperative morbidity and mortality, and length of hospital stay.

Nutritional assessment and support
In the conventional group (336 patients) nutritional assessment was performed following usual recommendation. Malnutrition risk was assessed based on the Malnutrition Screening Tool (MST) and serum albumin levels according to the Stratton’s study. The MST is a quick and simple nutritional screening tool based on weight loss (table 1) and serum albumin below 3.5 g/dL. Patients were subsequently classified in three malnutrition risk categories (low, medium and high risk). This evaluation was performed before surgery in all patients of the control group. 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 peripheral nutrition (PPN) was used for 5 days before surgery.

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

In the intervention group (149 patients) we used the software 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, 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 Harris and Benedict formula and corrected by a coefficient ranging from 1.2 to 2, according to patient’s activity, severity of the disease and of 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, nutritional complements or a balanced diet 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 dietician.
from postoperative day three and subsequently every 3 days until discharge. Patients were discharged when food intake was more than 60% of the daily requirements and clinical and biological parameters returned to normal.

**Perioperative care**

Single-shot antibiotic prophylaxis was routinely given (750 mg cefuroxime) at induction of general anesthesia and repeated intra-operatively if surgery lasted for more than two hours. The decision to perform colonic resection by laparotomy or laparoscopy was left up to the operating surgeon. The three 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 (50UI/kg per day) for deep vein thrombosis prophylaxis after surgery and continued for four weeks thereafter. The decision to start patients on 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 four weeks after discharge by the operating surgeon in the outpatient clinic.

The international Clavien-Dindo Classification for complications was used\(^\text{16}\). 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 post-operative complication, while food intake was more than 60% of the daily requirements and clinical and biological parameters returned to normal.

**Statistical Analysis:** Statistical analysis was performed using IBM SPSS Statistics version 20 (IBM SPSS Inc., Chicago, IL, USA). Continuous variables are expressed as means ±SD or as median with range (min, max), and categorical variables are reported as count and percentages. Comparisons of means values between two groups were performed using student t-test or Mann-Whitney U. Comparisons of percentages were performed using Chi-Square test (or Fisher’s exact test, as appropriate). Predictive factors of severe complications (grade 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 OR were expressed with 95% confidence intervals. All the tests were two-sided. The statistical significance was defined as p<.05.
RESULTS

1-General characteristics of the population and co-morbidities (table 1)

A total of 485 patients were included of whom 336 patients belonged to the conventional group (CG) and 149 to the software group (SG). The overall median age was 68.2 years (19-95) without difference between the two groups. There was no difference between the two groups regarding gender, ASA score, comorbidities, performance status and body mass index. There were significantly more malnourished patients, especially those with severe malnutrition, in the SG compared to the CG (15.4% vs 4.2 % p<0.0001; respectively).

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

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

3-Nutritional support in the two groups:

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

4- Post operative complications (table 3)

Mortality was significantly lower in the SG (0.7% vs 2.7% p=0.296). There were significantly less severe post-operative complications in the SG (10.7% vs 17% p=0.097). Deep abdominal collections and anastomotic leaks were significantly lower in the SG (4% vs 13.9% p<0.001 and 8% vs 16.9% p=0.015 respectively). The overall median hospital stay was significantly shorter in the SG (12 vs 15 days p=0.015). Overall definitive stoma was 5.7% without difference between two groups (SG 6.7% vs 5.3% CG p=0.534).

5- Predictive factors of severe complications – (table 4-5)
Predictive factors of severe complications were analyzed by univariate and multivariate statistical analyses. Included variables were clinical data (age, gender, malnutrition), type of surgery, pathological 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 software use and no laparoscopy vs laparoscopy without software use; software use and no laparoscopy and software use with laparoscopy), clinical data (age, gender, malnutrition), type of surgery, pathological findings (malignant, benign and inflammatory disease). Type of surgery and software use associated to laparoscopy were independent prognostic factors of severe complications (table 5).

**DISCUSSION**

The present study clearly demonstrates that the systematic use of a software to evaluate the nutritional status and the consequent nutritional support, compared to conventional methods, improved post-operative 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. Moreover it has been shown that preoperative nutritional support in severe malnourished patients significantly decreased morbidity and mortality rates as well as the length of hospital stay.

There have been significant benefits demonstrated with pre-operative administration of immune enhancing nutrition (IEN) in some high-quality trials in this recent review of literature. 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 pre-operative and post-operative surgery. A 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. In this study IEN was used in patients who underwent elective colorectal surgery, whether malnourished or not.

These two works underline the importance of preoperative IEN to decrease post-operative complications rates. However, the importance of specific nutritional support for malnourished patients implies preoperative diagnosis and specific pre-operative and post-operative managment.
Most of 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\textsuperscript{7,10,23-25}.

Recently we showed that malnutrition was misevaluated in more than two third of cases when standard methods of evaluation were used, while the software allowed a significantly more effective identification of patients with altered nutritional status\textsuperscript{13}. This erroneous assessment may affect the response to treatment and increase adverse effects\textsuperscript{12}. Otherwise automated parenteral nutrition management by a software improved the accuracy of prescription\textsuperscript{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 severe malnourished patients and more rectal resections in the SG.

This study has several biases including its retrospective nature and the fact that the two groups of patients were not parallel. Indeed, the laparoscopic approach was significantly more used 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 significantly severe postoperative morbidity. However, these data have to be confirmed in a randomized prospective study.

Only a few series showed that an appropriate preoperative nutritional support results in a decreased hospital stay\textsuperscript{7,10}. These studies indicate that the correction of the 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 improve the nutritional support in patients undergoing major elective abdominal surgery and reduce consequently the rate postoperative complications and mortality as well as the duration of hospital stay.
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## Table 1: General characteristics and comorbidities between control group and software group

|                          | Control group (CG) N=336 | Software group (SG) N=149 | Overall population N= 485 |
|--------------------------|---------------------------|---------------------------|---------------------------|
| **Gender**               |                           |                           |                           |
| men                      | 201 (59.8%)               | 88 (59.1%)                | 289 (59.6%)               | 0.875 |
| women                    | 135 (40.2%)               | 61 (40.9%)                | 196 (40.4%)               |       |
| **Age**                  |                           |                           |                           |
| Median (range)           | 67.9 (19-95)              | 68.6 (23-93)              | 68.2 (19-95)              | 0.252 |
| **ASA score**            |                           |                           |                           |
| 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**   |                           |                           |                           |
| 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**        |                           |                           |                           |
| 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**          |                           |                           |                           |
| moderate                 | 152 (45.2%)               | 95 (63.8%)                | 247 (50.9%)               | <0.0001 |
| severe                   | 14 (4.2%)                 | 23 (15.4%)                | 37 (7.6%)                 | <0.0001 |
Table 2: Comparison for the Clinical characteristic between Control group and Software group

| Symptoms                                      | Control group (CG) N=336 | Nutrition group | p value |
|------------------------------------------------|--------------------------|-----------------|---------|
| Proctorrhagia                                  | 111 (33%)                | 63 (42.3%)      | 0.051   |
| Occlusion                                      | 55 (16.4%)               | 15 (10.1%)      | 0.072   |
| Diarrhea                                       | 45 (13.4%)               | 8 (5.4%)        | **0.009** |
| Deterioration of général condition             | 104 (30.9%)              | 44 (29.7%)      | 0.858   |
| Characteristics of colorectal pathology       |                          |                 |         |
| Colorectal cancer                              | 255 (75.9%)              | 105 (70.5%)     |         |
| • Diverticulosis/Polyp                         | 31 (9.2%)                | 25 (16.8%)      | **0.0540** |
| • **Colon** inflammation (diverticulitis or acute colitis for inflammatory bowel disease) IBD | 50 (14.9%)               | 19 (12.8%)      |         |
| Colorectal cancer                              | 255 (75.9%)              | 105 (70.5%)     |         |
| • Diverticulosis/Polyp                         | 31 (9.2%)                | 25 (16.8%)      | **0.0540** |
| • **Colon** inflammation (diverticulitis or acute colitis for inflammatory bowel disease) IBD | 50 (14.9%)               | 19 (12.8%)      |         |
Table 3: Comparison of Operative data between Control group and Software group

| Operative data                           | Control group | Software group | Global N= 485 | p value |
|------------------------------------------|---------------|----------------|---------------|---------|
|                                           | (CG) N=336    | (SG) N=149     |               |         |
| Type of surgery                          |               |                |               |         |
| 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*                      | 9 (2.7%)      | 11 (7.4%)      | 20 (4.1%)     |         |
| Open surgery                             |               |                |               | <0.001  |
| Colectomy                                | 274 (81.5%)   | 62 (41.6%)     | 333 (68.6%)   |         |
| Protectomy                               | 56 (16.6%)/  | 80 (53.7%) /  | 136 (28%)     |         |
| Converted laparoscopy                    | 6 (1.8%)      | 7 (4.7%)       | 13 (2.6%)     |         |
| Stomia                                   |               |                |               |         |
| 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   |
| Post operative complications             | 105 (31.2%)   | 42 (28.2%)     | 147 (30.3%)   | 0.522   |
| Mortality                                | 9 (2.7%)      | 1 (0.7%)       | 10 (2.1%)     | 0.296   |
| Stage I-II                               | 49 (14.6%)    | 25 (16.7%)     | 74 (15.2%)    | 0.583   |
| Stage III-IV                             | 56 (17%)      | 16 (10.7%)     | 72 (14.8%)    | 0.097   |
| Anastomotic leakage                      | 47 (13.9%)    | 6 (4%)         | 53 (10.9%)    | <0.001  |
| Re-laparotomy                            | 36 (10.7%)    | 10 (6.7%)      | 46 (9.5%)     | 0.182   |
| Local collection Drainage                | 18 (5.3%)     | 4 (2.6%)       | 22 (4.5%)     | 0.241   |
| Collections                              | 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
*Combined resection consisted to two or more organs resection
Table 4: Multivariate analysis of predictive factors for severe complications (Clavien III-IV) between Control group and Software group

|                          | Severe Complications N=72 | No Complications N=329 | Odd Ratio | Confidence Interval | P value |
|--------------------------|---------------------------|------------------------|-----------|---------------------|---------|
| Age ( mean years)        | 65±14                     | 65±15                  | 1         | [0.9-1.1]           | 0.773   |
| Gender                   |                           |                        |           |                     |         |
| Male                     | 40 (55.6%)                | 200 (60.8%)            | 1.2       | [0.7-2.1]           | 0.391   |
| Female                   | 32 (44.4%)                | 129 (39.2%)            |           |                     |         |
| Denutrition              | 39 (54.2%)                | 161 (45.8%)            | 1.2       | [0.7-2.1]           | 0.430   |
| No denutrition           | 33 (45.8%)                | 168 (51.1%)            |           |                     |         |
| Type of surgery          |                           |                        |           |                     |         |
| 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%)               |           |                     |         |
| Others                   | 12 (3.6%)                 | 5 (6.9%)               |           |                     |         |
| Type of tumor            |                           |                        |           |                     |         |
| 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
Table 5: Multivariate analysis of predictive factors of severe complications (Clavien III-IV) between Control group and Software group

|                              | Odd Ratio | Confidence Interval | P     |
|------------------------------|-----------|---------------------|-------|
| Age (mean years)             | 1         | [0.9-1.0]           | 0.497 |
| Gender M/F                   | 1.2       | [0.7-2.2]           | 0.347 |
| Denutrition: yes vs 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 |