ORIGINAL ARTICLE

Postoperative Mortality and Morbidity in French Patients Undergoing Colorectal Surgery

Results of a Prospective Multicenter Study

Arnaud Alves, MD, PhD; Yves Panis, MD, PhD; Pierre Mathieu, MD; Georges Mantion, MD; Fabrice Kwiatkowski, MD; Karem Slim, MD; for the Association Française de Chirurgie

Hypothesis: Better knowledge of independent risk factors might decrease mortality and morbidity rates following colorectal surgery.

Design: Prospective multicenter study.

Interventions: From June to September 2002, consecutive patients undergoing open or laparoscopic surgery (electively or on an emergent basis) for colorectal cancers or diverticular disease were prospectively included. Exclusion criteria were colectomy for other causes (eg, inflammatory bowel diseases, benign polyps). The structured sheet of data collection included more than 200 items on all perioperative data concerning the patient, the disease, and the operating surgeons. Postoperative mortality and morbidity were defined as in-hospital death and complications.

Results: Among 1421 patients, the in-hospital death rate was 3.4% and the overall morbidity rate was 35%. Four independent preoperative risk factors of mortality were found: emergency surgery, loss of more than 10% of weight, neurological comorbidity, and age older than 70 years. Six independent risk factors of morbidity were found: age older than 70 years, neurologic comorbidity, hypoalbuminemia, cardiorespiratory comorbidity, long duration of operation, and peritoneal contamination.

Conclusion: Colorectal resection in France is associated with a 3.4% mortality rate and a 35% morbidity rate. Knowledge of the risk factors could help surgeons manage cases.

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Knowledge of the true frequency of both mortality and morbidity is crucial in planning health care and research and identifying risk factors. Despite improvement in surgical technique, bowel preparation, and prophylactic antibiotics, colorectal surgery was associated with a 5% to 6% mortality rate and a 20% to 40% morbidity rate.[1-3] However, most studies about outcomes after potential colorectal resection have been retrospective analyses from highly specialized centers and often lack detailed information on how preoperative variables affected morbidity and mortality risks. Furthermore, few data have been reported so far from population-based studies that would more accurately reflect the situation in nonspecialized centers over time. To our knowledge, only 5 prospective studies,[4-8] including more than 1000 patients, have recently reported either mortality or morbidity rates for colorectal surgery. Except for 1 study,[7] no multivariate logistic regression analyses for both mortality and morbidity were performed. Furthermore, no study reported inhospital stay.

See Invited Critique at end of article

In evidence-based medicine, knowledge of the estimated risk associated with an operation might be an important factor to consider when a surgeon and patient consider surgery. Thus, the aim of this national prospective multicenter study was 2-fold:

- To assess in a French population-based study the mortality and morbidity rates following colorectal surgery
- To identify the risks factors for both mortality and morbidity

METHODS

All members of the Association Française de Chirurgie (French Association for Surgery)

Author Affiliations: Department of Digestive Surgery, Hôpital Lariboisière, Paris, France (Drs Alves and Panis); Department of Digestive Surgery, Hôpital Jean Minjoz, Besançon, France (Drs Mathieu and Mantion); Department of Statistics, Centre Jean Perrin, (Dr Kwiatkowski) and Department of Digestive Surgery, Hôtel-Dieu (Dr Slim), Clermont-Ferrand, France.

were encouraged to participate in a prospective multicenter study exploring both mortality and morbidity after colorectal surgery during a 4-month period (from June to September 2002). All consecutive patients undergoing open or laparoscopic surgery (electively or on an emergent basis) for colorectal cancers or diverticular disease were included from all centers. Exclusion criteria were colectomy for other causes (eg, inflammatory bowel diseases, benign polyps). The structured sheet of data collection included more than 200 items on all perioperative data (**Figure**).

All patients were followed up during 3 months. Both postoperative mortality and morbidity were defined as in-hospital death and specific complications, respectively. Postoperative morbidity conditions are presented in the Figure.

Statistical analyses used a χ^2 test, Mann-Whitney *U* test, *t* test, analysis of variance, Kruskal-Wallis H test, and a Pearson correlation or Spearman rank correlation when appropriate. Multivariate logistic regression analyses were also performed to find the main independent factors for postoperative mortality and morbidity. Relative risk (RR) was calculated for each significant variable. Values are expressed as mean±SD. Statistical significance was stated for $P<.05$. Data collection and statistical analyses were done using SEM software (SEM Software, Clermont-Ferrand, France).[9]

The Hospital Features
University or General Hospital or Private Clinic
Number of Patients Included per Hospital

The Patient Features
Sex; Age; Weight; Size; Body Mass Index (obesity if >30 and underweight if weight loss of more than 10% within the past 6 mo)
Blood Pressure (mm Hg); **Pulse** (beats/min); **Score of the American Society of Anesthesiologists (ASA Class); Glasgow Coma Scale Score**
Diabetes Mellitus; Recent Steroid Treatment; Prior Laparoscopy or Laparotomy
Cardiopulmonary Comorbidity (including myocardial infarction, atrial fibrillation, chronic obstructive pulmonary disease, smoking history, cardiac medications, results of both electrocardiogram and chest radiograph)
Neurologic Comorbidity (including stroke syndrome and functional status)
Gastrointestinal Comorbidity (including alcohol history, chronic liver disease, Child-Pugh classification)

The Biological Data
Hematologic (including hemoglobin, white blood cell count, platelet count, prothrombin time)
Serum Steal Level of glycemia, urea, creatinine, sodium, potassium, bilirubin, aspartate aminotransferase, alanine aminotransferase, γ-glutamyltransferase, alkaline phosphatase, albumin

The Disease Features
Colorectal Cancer: location; neoadjuvant chemotherapy and radiotherapy; complications (including obstruction, tumoral or diastatic perforation, hemorrhage); tumor staging according to TNM classification
Diverticular Disease: previous episode of diverticulitis (number, treatment of each episode); complicated diverticulitis (abscess, fistula, obstruction, hemorrhage, perforation); Hinchey score

The Surgical Procedure
Urgent or Elective Procedure; Type of Bowel Preparation; Type of Anesthesia; Type of Prophylactic Antibiotics; Laparoscopy or Laparotomy Procedure
Intraoperative Abscess; Disseminated Cancer (liver, peritoneal metastases); **Intraperitoneal Contamination**
Type of Colorectal Resection (right, left, total colectomy, proctectomy, total mesorectal excision, Hartmann procedure, abdominoperineal resection); **Associated Procedures** (including other organ resections)
Intestinal Anastomosis (manual vs stapled, location of the anastomosis ileocolic, ileorectal, colocolic, colorectal, ileoanal, coloanal); **Colonic or Ileal J Pouch; Protective Stoma; Abdominal Drainage**
Duration of Operation; Blood Loss; Amount of Homologous Blood Transfused

The Postoperative Findings
Mortality: date and etiology
Morbidity: superficial wound infection, deep wound infection, wound dehiscence, pneumonia, clinical anastomotic dehiscence, intra-abdominal abscess, prolonged ileus, anastomotic hemorrhage, bleeding requiring blood transfusion, cardiac arrest, myocardial infarction, pulmonary embolism, pneumonia, pulmonary edema, failure to wean from the ventilator 48 h after operation, progressive renal insufficiency, renal failure requiring dialysis, urinary tract infection, stroke syndrome, deep vein thrombophlebitis, systemic sepsis
Reintervention: type of procedure performed

Figure. The structured sheet of data collection for the study.

RESULTS

Of the 1426 patients who had operations in 81 participating centers, 5 were excluded because data were not available. Thus, 1421 patients were included in the final analysis of both postoperative mortality and morbidity. The mean±SD inclusion number per center was 17.6±12.8 patients within 4 months (range, 1-58 patients). A total of 690 patients (49%) were treated in teaching (university) hospitals, 463 (33%) in general hospitals, and 268 (18%) in private clinics. A total of 997 patients (70%) had colorectal cancer, and 424 (30%) had diverticular disease. Elective surgery was performed for 1152 patients (81%), and emergency surgery was performed for 269 patients (19%). A total of 652 patients (46%) were older than 69.9 years. Surgical procedures included right colectomy (n=300), left colectomy (n=644), total colectomy (n=74), proctectomy with total mesorectal excision (n=200), abdominoperineal resection (n=67), Hartmann procedure (n=105), and colostomy alone (n=31).

POSTOPERATIVE MORTALITY

Forty-eight patients died during their hospitalization, resulting in an in-hospital postoperative mortality rate of 3.4%. Forty-two patients died by day 30, a 2.9% 30-day mortality rate.

Causes of in-hospital deaths were septic shock (n=11), terminal cancer (n=6), cardiac failure (n=5), bronchopneumonia (n=4), acute respiratory distress (n=4), myocardial infarction (n=3), multivisceral failure (n=3), gastrointestinal hemorrhage (n=2), stroke syndrome (n=2), miscellaneous (n=4), and unknown (n=4).

Univariate analysis showed 28 variables associated with a higher risk of in-hospital mortality (**Table 1**). Multivariate analysis found 4 independent factors significantly associated with a higher mortality rate: urgent surgery (RR, 4.41), loss of body weight greater than 10% (RR, 3.85), neurologic comorbidity (RR, 3.43), and age older than 70 years (RR, 2.15). **Table 2** presents the variations of mortality rates and RRs according to the lack of these factors or the presence of 1 or more factors. The risk of death was low when there was only 1 or no factor; it was 9% when 2 factors were present, nearly 20% when 3 factors were present, and as high as 50% when all 4 factors were present.

POSTOPERATIVE MORBIDITY

Postoperative morbidity was observed in 495 patients (35%). Complications rates were as follows: wound, 9.6% (including wound dehiscence, wound infection, wound hematoma); clinical anastomotic dehiscence, 4.4% (of which half underwent reoperation); postoperative hemorrhage, 4.5%; stoma complications, 8.6%; prolonged ileus, 5.3%; cardiorespiratory tract, 10.7%; urinary tract, 7.7%; venous thrombosis, 1.2%; neuropsychiatric tract, 2%; postoperative gastrointestinal tract, 1.3%; and miscellaneous, 1.3%. Reoperation was necessary in 27 patients (2%).

Univariate analysis showed 29 variables associated with a higher risk of postoperative morbidity (**Table 3**). Mul-

Table 1. Factors Associated With Significant Postoperative Mortality After Colorectal Resection: Univariate and Multivariate Analysis*

Variables	Patients Who Died (n = 48)	Patients Who Survived (n = 1373)	Univariate Analysis *P* Value	Multivariate Analysis *P* Value	Multivariate Analysis OR (95% CI)
Age >70 y	35	617	<.001	.02	2.2 (1.1-4.3)
Mean ± SD body mass index, kg/m²	24 ± 4	25 ± 5	.005		
Mean Glasgow Coma Scale score	14	15	<.004		
Mean ± SD ASA grade	3 ± 1	2	<.001		
Underweight	17	139	<.001	.001	3.2 (1.6-6.2)
Cardiopulmonary comorbidity	34	707	<.004		
Neurologic comorbidity	16	115	<.001	.001	3.5 (1.8-7.0)
Mean ± SD hemoglobin, g/dL	11 ± 2	13 ± 2	<.001		
Mean ± SD γ-glutamyltransferase, U/L	161 ± 322	54 ± 89	<.001		
Mean ± SD alkaline phosphatase, U/L	176 ± 227	97 ± 77	<.005		
Mean ± SD serum albumin level, g/dL	29 ± 6	36 ± 9	<.001		
Colorectal cancer					
Emergency	15	134	<.001		
Obstruction	4	73	<.001		
Tumoral perforation	1	8	<.001		
T4	17	170	<.001		
No prophylactic antibiotics	3	18	<.03		
No bowel preparation	27	223	<.001		
Emergency surgical procedures	30	230	<.001	.001	4.3 (2.3-8.1)
Laparotomy procedure	47	1096	<.001		
Intraoperative abscess	12	131	<.002		
Peritoneal metastases	6	59	<.02		
Peritoneal contamination	11	80	<.001		
Left colectomy	11	633	<.002		
Colostomy alone	5	26	<.001		
Hartmann procedure	15	90	<.001		
Mean ± SD duration of operation, min	131 ± 53	173 ± 83	<.001		
No intestinal anastomoses	19	203	<.001		
Postoperative surgical complications	18	246	<.001		

Abbreviations: ASA, American Society of Anesthesiologists; CI, confidence interval; OR, odds ratio.
*Unless otherwise indicated, values are numbers of patients.

Table 2. Variation of the Mortality Rate According to the Absence or Presence of 4 Independent Risk Factors

No. of Factors	No. of Deaths	No. of Survivors	Mortality, %	Odds Ratio (95% CI)
0	3	577	0.5	1
1	11	546	2	3.8 (1.2-12.4)
2	20	203	9	17.3 (7.3-41.4)
3	9	47	16	31.1 (13.6-70.9)
4	5	5	50	96.7 (49.6-188.5)

Abbreviation: CI, confidence interval.

tivariate analysis found 6 independent factors significantly associated with a higher postoperative morbidity rate: age older than 70 years (RR, 1.02), neurologic comorbidity (RR, 1.58), hypoalbuminemia (RR, 0.55), cardiorespiratory comorbidity (RR, 1.50), mean operation time more than 120 minutes (RR, 1.00), and peritoneal contamination (RR, 1.59).

Mean±SD hospital stay was 17±13 days. It was significantly lower after elective surgery than after emergent surgery (16±13 vs 20±13 days; $P<.001$) and after colectomy for diverticular disease than after colectomy for cancer (15±12 vs 18±13 days; $P<.001$). Hospital stay was also significantly lower after colectomy performed in a private center than after colectomy performed in other centers (15±10 vs 17±14 vs 17±13 days; $P=.02$).

COMMENT

To our knowledge, this is the first French prospective multicenter study of more than 1400 patients that evaluated postoperative mortality and morbidity after colorectal surgery. This large prospective database provided the opportunity to review the results of large numbers of events over a short period of time and to determine trends. After elective or emergency colorectal surgery for colorectal cancer or diverticular disease, postoperative mortality and morbidity rates were 3.4% and 35%, respectively. These results compare favorably with reported postoperative mortality ranging from 2% to 9% and postoperative morbidity ranging from 18% to 37% (**Table 4**).[1-8,10-16] However, these data are difficult to interpret because of weaknesses in the study design. Among 14 recent studies,[1-8,11-16] including more than 1000 consecutive patients who underwent colorectal resection, only 5 were prospective.[4-8]

Although our mortality rate appears low compared with the literature, our morbidity rate was higher than in other

Table 3. Factors Associated With Significant Postoperative Morbidity After Colorectal Resection: Univariate and Multivariate Analysis*

Variables	Patients With Complications (n = 495)	Patients With No Complications (n = 926)	Univariate Analysis *P* Value	Multivariate Analysis *P* Value	Multivariate Analysis OR (95% CI)
Mean ± SD age, y	70 ± 13	65 ± 14	<.001	.001	1.5 (1.2-1.9)
Mean ± SD body mass index, kg/m^2	25 ± 5	25 ± 4	<.03		
Mean ± SD Glasgow Coma Scale score	14.8 ± 0.6	14.9 ± 0.4	<.001		
Mean ± SD ASA grade	2.2 ± 0.8	1.9 ± 0.7	<.001		
Diabetes mellitus	80	97	<.002		
Cardiopulmonary comorbidity	315	426	<.001	.03	1.7 (1.4-2.2)
Neurologic comorbidity	63	68	<.001	.001	1.6 (1.1-2.4)
Cirrhosis	3	11	<.002		
Mean ± SD hemoglobin, g/dL	12 ± 2	13 ± 2	<.03		
Mean ± SD γ-glutamyltransferase, U/L	67 ± 120	51 ± 87	<.03		
Mean ± SD alkaline phosphatase, U/L	107 ± 104	95 ± 75	<.05		
Mean ± SD serum albumin level, (g/dL)	35 ± 10	37 ± 8	<.001	.001	1.8 (1.3-2.6)
Colorectal cancer	374	623	<.001		
Tumoral perforation	19	11	<.005		
Previous episode of diverticulitis	85	250	<.001		
No bowel preparation	104	146	<.03		
Emergency surgical procedures	120	140	<.001	.04	1.9 (1.2-3.0)
Laparotomy procedure	427	716	<.003		
Intraoperative abscess	62	77	<.02		
Peritoneal contamination	53	38	<.001		
Left colectomy	186	458	<.001		
Hartmann procedure	55	50	<.001		
Perioperative transfusion	60	60	<.001		
Duration of operation, min	185	165	<.001	.04	1.3 (1.0-1.8)
Mean ± SD blood loss	317 ± 299	232 ± 272	<.001		
No intestinal anastomoses	103	119	<.001		
Protective stoma	67	106	<.04		

Abbreviations: ASA, American Society of Anesthesiologists; CI, confidence interval; OR, odds ratio.
*Unless otherwise indicated, values are numbers of patients.

Table 4. Outcomes After Colorectal Surgery in Recent Studies

Source	Years	No. of Patients	Mean ± SD Age, y	Cancer, %	Urgent, %	Mortality, %	Morbidity, %	Mean ± SD In-Hospital Stay, d
Prystowsky et al[3]	1994-1997	15 427	65 ± 16	46.9	30.2	4.4	24.2	11 ± 8
Ondrula et al[10]	1985-1990	825	NA	59	18.9	5.1	NA	NA
Fielding et al[11]	NA	1466	NA	100	34.6	9	13*	NA
Longo et al[7]	1991-1995	5853	68 (19-100)	100	15	5.7	28	NA
Tekkis et al[4]	1998-2001	1017	NA	65.8	21	7.5	NA	NA
Mella et al[5]	1992-1993	3221	NA	32	17.1	7.6	NA	NA
Semmens et al[12]	1988-1995	4794	67 ± 12	70	23.3	4.2	12.3*	16 ± 12
Ansari et al[1]	1987-1996	11 036	65 ± 15	67.5	38	6.5	24.6	18 ± 15
Khuri et al[8]	1991-1993	13 310	66 ± 11	NA	18.6	6.9	NA	NA
Harmon et al[2]	1992-1996	9739	69 ± 12	81.3	42.2	3.5	NA	11.5
Vignali et al[13]	1989-1995	1014	59 ± 16	53	NA	1.6	18.4	9 ± 5
Bokey et al[14]	1971-1991	1089	NA	NA	10.8	3.6	37.2	NA
Köckerling† et al[6]	1995-1998	1143	61	45.2	NA	1.57	22.3	NA
Detry et al[15]	1979-1992	1000	63	71.5	NA	2.2	19.9	12 (5-65)
Ko et al[16]	1996	22 408	70 ± 12	100	34	3	NA	NA
Present study	2002	1421	67 ± 14	70.2	19	3	35	17 ± 13

Abbreviation: NA, not available.
*Septic complications including anastomotic leak and intra-abdominal abscess.
†Laparoscopic rectal resection.

studies. Two reasons could explain this higher rate of postoperative morbidity. First, this multicenter study reflected more accurately the situation observed in our population-based study, in which patients had operations not only in teaching hospitals but also in nonspecialized hospitals. Second, our prospective study allowed us to completely register overall postoperative complications.

To our knowledge, only 9 recent studies in the literature[1-4,6,7,15,16] have used multivariate logistic regression analyses to determine the independent risk factors of postoperative mortality. In our study, no relationship was observed between patient outcomes and the surgeon or hospital features (eg, training, certification, experience, and volume of activity). Results concerning the possible relation between volume and outcome in colorectal surgery are controversial. Prystowsky et al[3] found that the patient's outcome improved with the surgeon's certification and experience. Harmon et al[2] observed that higher surgeon volume was associated with significant improvement regardless of the hospital volume. However, medium-volume surgeons achieved results equivalent to those of high-volume surgeons when they operated in high- or medium-volume hospitals. We concluded that hospital volume can serve as a surrogate for surgeon volume for achieving excellent outcomes in colorectal resection. As others did,[2-4,10,15] we observed that ages equal to or older than 70 years (46% of our patients) were significantly associated with an increased mortality rate. Furthermore, in our study, the risk of death doubled by decade in patients older than 50 years. Except in 2 studies,[2,3] we and others found that sex was not associated with a higher mortality rate. Comorbidities, including cardiorespiratory,[3,10] neurologic,[7] liver diseases,[7] corticosteroid,[7,10] diabetes mellitus,[10] and prior radiotherapy,[10] have been reported in several studies as independent risk factors for postoperative mortality. In our study, only neurologic comorbidity (including stroke syndrome and functional status) was an independent risk factor for immediate mortality rate. Although not observed in our study, an American Society of Anesthesiologists score higher than 2 represented another independent risk factor of mortality in 2 studies.[7,15] Malnutrition is a risk factor of postoperative mortality. Malnutrition may be evaluated either by a weight loss of more than 10% within the past 6 months, as our study did, or by serum albumin level, as Longo et al did.[7] Gibbs et al[17] reported that serum albumin level was a strong predictor of mortality, and it is the best prognostic indicator of nutritional status. In our study, weight loss was 1 of the 4 independent risk factors for mortality and hypoalbuminemia 1 of the risk factors of morbidity. Our results emphasized the need for careful preoperative assessment of nutritional status before colectomy. A recent prospective randomized study reported that the administration of a supplemented diet before and after surgery was beneficial to outcomes for patients with cancer who were malnourished and undergoing major elective surgery. Perioperative treatment with immunonutrition seemed to be the best strategy to reduce complications and length of hospital stay.[18]

Beside the patient characteristics and among the features of surgical procedure, urgent surgery was associated in almost all of the studies with a significantly increased mortality rate. On the other side, no significant difference was observed according to the nature of the disease (colorectal cancer vs diverticular disease), the extent of colorectal resection, and the type of intestinal anastomoses. A recent study showed that laparoscopic colorectal surgery was not associated with a higher rate of postoperative mortality.[6] Our univariate analysis showed that laparotomy was associated with a significantly increased rate of mortality. This increased mortality rate after laparotomy could be explained in part by the fact that most of the patients operated on through laparoscopy were operated on electively and for diverticulitis. However, most of the high-risk patients who had emergency operations for colorectal carcinoma were operated on through laparotomy. Furthermore, multivariate analysis failed to show any benefit effect of laparoscopy, probably because of the low number of patients. Thus, laparoscopy cannot be considered a factor of reduced mortality in colorectal surgery. Unlike 3 studies,[1,7,10] our study did not find that surgical complications such as anastomotic dehiscence were associated with significantly increased mortality. Whereas anastomotic dehiscence following colorectal surgery represented the first etiology of deaths, accounting for 20% to 33% of all of the deaths,[19] 6 patients (12%) died with an anastomotic leakage in our study. Most of the postoperative deaths were also caused by postoperative medical complications, including cardiorespiratory and cerebrovascular complications.

Very few studies have used multivariate logistic regression analyses to determine the independent risk factors of postoperative morbidity.[3,7] In our study, multivariate analysis showed 6 independent risk factors of postoperative morbidity. Four factors depend on the patient's characteristics (age older than 70 years, neurologic comorbidity, cardiorespiratory comorbidity, hypoalbuminemia) and 2 factors on the surgical procedure (long duration of operation and fecal contamination). Elderly patients and associated comorbidities (eg, cardiorespiratory, neurologic disorders) were also reported by 2 other studies. Only Prystowsky et al[3] observed that the surgeon's training, certification, and experience were associated with a reduced complication rate. For several authors, serum albumin level is the best prognostic indicator of nutritional status because of its ability to detect protein-energy malnutrition, which is not necessarily accompanied by lower body weight and might not be clinically recognizable. Thus, Gibbs et al[17] have observed among 54 125 major noncardiac surgery cases that a decrease in serum albumin from a concentration greater than 46 g/dL to less than 21 g/dL was associated with an increase in morbidity rates from 10% to 65%. Furthermore, albumin level was a better predictor of some types of morbidity, particularly sepsis and major infections, than other types.

Unlike Longo et al,[7] we did not observe any other biologic parameters significantly associated with an increased morbidity or mortality rate after colectomy. Among surgical procedures, laparoscopy seems to reduce postoperative morbidity after colorectal surgery. Whereas laparoscopy significantly reduced postoperative morbidity on univariate analysis, multivariate analysis failed to confirm its beneficial effect.

In summary, our population-based prospective study showed that in France, colorectal resection was associated with a 3.4% mortality rate and a 35% morbidity rate. Four independent risk factors, including age older than 70 years, neurologic comorbidity, underweight, and emergency surgery, significantly increased postoperative mortality. The risk of death was low when there was 1 or no risk factor; it was 9% when 2 factors were present, nearly 20% when 3 factors were present, and as high as 50% when all 4 factors were present. Furthermore, our study found 6 independent factors of postoperative morbidity: age older than 70 years, neurologic comorbidity, cardiorespiratory comorbidity, hypoalbuminemia, peritoneal contamination, and operations lasting longer than 120 minutes. Finally, this prospective study suggested the consistent association between the poor status of the patient and a poor outcome. As suggested by other studies, attending to perioperative nutrition could reduce both mortality and morbidity rates.

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Correspondence: Yves Panis, MD, PhD, Department of Digestive Surgery, Hôpital Lariboisière, 2 rue Ambroise Paré, 75475 Paris CEDEX 10, France (yves.panis@lrb.ap-hop-paris.fr).

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