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CLINICAL RESEARCH

Adequacy of oral intakes after cardiac surgery within an ERAS pathway: A prospective observational study

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Abstract

Background: The 2019 Enhanced Recovery After Cardiac Surgery (ERACS) guidelines presented perioperative recommendations to optimize treatment for patients undergoing cardiac surgery (CS). However, the guidelines have not established postoperative nutrition recommendations. Limited studies have analyzed oral intakes after CS, but to our knowledge, none have done so in an ERACS pathway. The main objective of this study was to evaluate the adequacy of postoperative oral intakes, including adherence to oral nutrition supplements (ONSs).

Methods: This was an observational prospective study. Postoperative oral intakes were analyzed from postoperative day (POD) 1 to 4, using direct observation of meal plates provided by the hospital. ONSs consumption was evaluated from POD2 to POD4. Adherence to other ERACS recommendations, including nutrition optimization before surgery, was recorded.

Results: Forty-three patients were included in this study. Nutrition optimization before CS was offered to three (7%) patients. Forty-one (95%) patients resumed oral intakes on POD1. Mean oral calorie and protein intakes from POD2 to POD4 were 1088 ± 437 kcal and 0.8 ± 0.3 g/kg, respectively; however, 17 (41%) patients had calorie and protein intakes ≥70% of their estimated requirements. On POD2, ONSs consumption contributed $35\% \pm 19\%$ and $38\% \pm 20\%$ of calorie and protein intake, respectively. There was a significant decrease in ONSs consumption starting on POD3.

Conclusion: Within an ERACS pathway and with the contribution of ONSs, 41% of patients achieved sufficient oral intakes within the first 4 days after CS. The optimization of ONSs adherence on postoperative oral intakes should be further studied.

Abbreviations: BMI, body mass index; CABG, coronary artery bypass graft; CNST, Canadian Nutrition Screening Tool; CPB, cardiopulmonary bypass; CS, cardiac surgery; ERACS, Enhanced Recovery After Cardiac Surgery; ERAS, Enhanced Recovery After Surgery; ESPEN, European Society for Clinical Nutrition and Metabolism; LOS, length of stay; ONSs, oral nutrition supplements; POD, postoperative day; PONV, postoperative nausea and vomiting; RD, registered dietitian; SGA, Subjective Global Assessment; SICU, surgical intensive care unit.

KEYWORDS
cardiac surgery, ERAS, malnutrition, oral intakes, oral nutrition supplements

INTRODUCTION

Enhanced Recovery After Surgery (ERAS) is an evidence-based approach that promotes perioperative care and the contribution of a multidisciplinary team. A key component of ERAS is nutrition care—namely, nutrition risk screening and optimization before surgery, followed by the prompt resumption of oral intakes after surgery.[1] However, there are disparities in the nutrition recommendations between guidelines. For instance, the recent guidelines for lower extremity vascular surgery include specific criteria for preoperative nutrition assessment and recommend the use of oral nutrition supplements (ONSs) to optimize postoperative oral intakes.[2] Those recommendations are based on the European Society for Clinical Nutrition and Metabolism (ESPEN) surgical guidelines.[3] By contrast, the 2019 ERAS guidelines for cardiac surgery (CS), titled *Guidelines for Perioperative Care in Cardiac Surgery—Enhanced Recovery After Surgery Society Recommendations*, have not established nutrition recommendation for the postoperative period. Furthermore, the recommendation concerning correction of nutrition deficiency before surgery has a low level of evidence and is primarily based on studies from other surgical fields.[4] The lack of nutrition recommendation in the ERACS guidelines has been discussed by members of the ERACS Society, who encourage research on this topic, especially for the postoperative period.[5] Therefore, the main aim of this observational study was to evaluate the adequacy of postoperative oral intakes within an ERACS pathway and, more specifically, the adherence to ONSs. The second aim was to describe the adherence to other perioperative nutrition practices recommended by the ERAS approach for CS.

METHODOLOGY

Study design

This was an observational prospective study conducted in a university-affiliated hospital specializing in cardiology in Montreal, Canada. Patients were recruited in May and June 2023. Inclusion criteria were age ≥55 years, male or female sex, and CS performed with cardiopulmonary bypass (CPB)—specifically, coronary artery bypass graft (CABG), valve repair and/or replacement, combination of CABG and valve surgery, and Bentall procedure. Exclusion criteria were other types of CS, initial admission at another hospital, inability to answer the nutrition status questionnaire before surgery, and administration of enteral or parenteral nutrition in the days before the surgery. This study was approved by the ethics committee of the Montreal Heart Institute Research Center. All patients provided written informed consent.

Patient and surgical characteristics

Patients' characteristics included age, sex, serum albumin level, duration of hospitalization before surgery, and anthropometry (weight and height measured by the nursing staff before surgery). The medical history included cardiac history (presence of valvular and coronary heart disease) and the presence of comorbidities. Surgical characteristics included the duration of CPB time, the Society of Thoracic Surgeons (STS) score or the EuroSCORE II.[6] Nutrition status assessment before surgery was determined according to the Subjective Global Assessment (SGA), originally developed by Detsky et al.[7] Assessment was performed by a registered dietitian (RD) who had clinical experience with this population. The questionnaire adapted by the Canadian Malnutrition Task Force was used.[8] Patients were classified according to three categories: well-nourished (class A), mildly/moderately malnourished (class B), or severely malnourished (class C). The SGA was administered the day before or the day of the surgery. If the surgery was postponed by >1 week, the SGA was repeated.

Clinical outcomes

Postoperative clinical outcomes included length of stay (LOS) after surgery and in the surgical intensive care unit (SICU). Readiness to discharge was applied when the hospital stay was prolonged for administrative reasons, such as delayed transportation, based on discharge criteria presented in Supporting Information S1: Table S1. Other outcomes included occurrence of paralytic ileus, delirium, and wound infection; discharge destination; readmission at 30 days; and in-hospital mortality.

Evaluation of oral calorie and protein intakes

Calorie and protein oral intakes of the three main meals were recorded from postoperative days (POD) 1–4. Postoperative food offering is described in Table 1. Briefly, patients received three light meals on POD1. On POD2, patients received a half portion of a regular diet, and regular portions started on POD3. ONSs were systematically provided to postoperative patients as three portions of 120 ml on POD2 and POD3 and then two portions of 120 ml starting on POD4 until discharge. ONSs were provided by the hospital food service and delivered with the food trays. Patients could also ask the dietetic technician to switch ONSs to enriched foods on POD2. Only intakes of patients returning to exclusive oral diet on POD1 were analyzed. Oral intakes were recorded by direct observation of the food plates provided by the hospital. For each item, including ONSs, the percentage consumed was recorded as 0%, 25%, 50%, 75%, or 100%. This method has been validated and allows for accurate estimation of intakes without overestimation.[9] Meal observations were conducted by the same person to ensure homogeneity. Snacks were not evaluated, and patients were asked to refrain from replacing hospital meals with food brought from home. If a meal observation was missed, a food recall was promptly obtained from the patient. Calorie and protein intakes were analyzed with the WinVision nutrition management software (Nutritek©), which is commonly used in local hospitals. This software has been used in a recent Canadian nutrition study to analyze oral intakes of hospitalized patients after CS.[10] This program is linked to the Canadian Nutrient File, an exhaustive nutrient database managed by Health Canada.[11] Nutrition requirements were based on the ESPEN surgical guidelines, which suggest calorie and protein targets of 25 kcal/kg and 1.5 g/kg, respectively. Actual weight was used for patients with a body mass index (BMI; calculated as weight [kg] divided by height squared [m^2]) of <25, and ideal weight was used for patients with a BMI ≥25.[3] Sufficient oral intakes for both calories and protein were established at ≥70% of estimated requirements, which represent intakes of ≥17.5 kcal/kg and 1.05 g/kg, respectively. This cutoff was selected because calorie intakes between 70% and 100% of requirements are defined as

TABLE 1 Description of five care elements following the ERAS approach and postoperative nutrition management, including diet regimen management.

Recommendation	Protocol
Preoperative	
Education	Elective patients: online educational videos, including nutrition information provided by an RD
Screening and optimization	Nutrition risk screening using the CNST and serum albumin level Referral to an RD for evaluation and optimization as needed, in person or by phone (including dietary advice, use of ONSs and/or enriched foods, etc)
Carbohydrate loading	Patients with glycated hemoglobin <7%: 400-ml drink with 50 g of maltodextrin, consumed 2 h before surgery Patients with glycated hemoglobin ≥7%, insulin-dependent diabetes, or other contraindication: fasting or water only (prescribed by the anesthesiologist)
Postoperative	
Key PONV prophylaxis	Intravenous ondansetron administration upon admission at the SICU
Extubation within 6 h of surgery	Internal protocols to ensure prompt extubation after admission in the SICU; criteria based on hemodynamic stability, level of sedation, and respiratory function
Diet regimen management	Oral intakes resume 4 h after extubation Starting POD2: 120-ml portion of ONSs (1.5 kcal/ml, high protein content) offered with meals (until discharge); can be switched to enriched food (soups and desserts) Visit of a dietetic technician on POD2 to adjust food offer (including ONSs) and encourage patients to consume their ONSs Nutrition intervention by an RD to optimize intakes, as needed Description of food offer(mean caloric and protein offer [including ONSs]): • POD1, three light meals ($\bar{x}$1100 kcal, 50 g of protein) • POD2, half portions of meals and ONSs three times per day ($\bar{x}$1800 kcal, 100 g of protein [ONSs: 540 kcal, 30 g]) • POD3, regular portions and ONSs three times a day ($\bar{x}$1950 kcal, 100 g of protein [ONSs: 540 kcal, 30 g]) • POD4 and after, regular portions and ONSs twice a day ($\bar{x}$1800 kcal, 95 g of protein [ONSs: 360 kcal, 20 g])

Abbreviations: CNST, Canadian Nutrition Screening Tool; ONSs, oral nutrition supplements; POD, postoperative day; PONV, postoperative nausea and vomiting; RD, registered dietitian; SICU, surgical intensive care unit.

normocaloric, whereas intakes below 70% are considered hypocaloric.[12] Similarly, protein intakes of >1 g/kg are defined as a high protein intake in hospitalized patients.[13] Very insufficient intakes were established at ≤50% of estimated requirements because ESPEN guidelines recommend starting nutrition therapy when intakes are below 50% in the first week after surgery.[3] On discharge day, intakes were only analyzed if the three main meals were consumed before departure. If the patient was discharged during the day, the last intake analysis was from the day before. Other nutrition outcomes investigated included postoperative intervention from an RD, such as nutrition counseling, and need for enteral or parenteral nutrition.

ERAS guideline adherence

The ERAS approach was implemented at the Montreal Heart Institute in phases throughout the last two decades. Briefly, specific protocols were gradually developed by a multidisciplinary team according to evidence-based practices and after successful pilot implementation. Starting in 2002, protocols to ensure extubation within 6 h after admission in the SICU were implemented, followed in 2008 by the creation of a postoperative pain management service leading to patient-controlled analgesia. Between 2010 and 2018, protocols facilitating postoperative mobilization were developed, allowing patients with femoral arterial line and chest tubes to be mobilized. Formal ERAS cardiac data collection was initiated in 2019 with the addition of a nurse coordinator to the ERAS team, which led to frequent quality improvement audits. In parallel, the nutrition protocols were introduced—namely, preoperative carbohydrate loading, earlier resumption of oral intakes, and systematic postoperative ONSs offer. In 2020, protocols facilitating resumption of early mobilization on POD0 and criteria allowing early discharge starting on POD3 were implemented. Finally, preoperative education classes were initiated in 2022. The main protocols in place during the data collection are presented in Supporting Information S1: Table S1.

Adherence to four recommendations from the ERACS guidelines was recorded: preoperative education, preoperative nutrition optimization, carbohydrate loading, and extubation within 6 h of surgery.[4] Furthermore, postoperative nausea and vomiting (PONV) prophylaxis was recorded, although this is not included in the ERACS guidelines, because it is an important aspect of ERAS care.[1] Description of these five preselected ERAS care elements is presented in Table 1. Briefly, preoperative education, in the form of a video that includes nutrition information by an RD, is offered to patients scheduled for elective surgery who provide an email address. At the time of data collection, these patients were asked if they remembered watching the nutrition education video before their surgery. Nutrition risk screening includes measurement of serum albumin level and the use of the Canadian Nutrition Screening Tool (CNST).[14] The presence of nutrition risk according to the CNST is based on the combination of two criteria: prolonged reduced oral intakes and recent unintended weight loss. This standardized risk screening tool was administered by a nurse or completed by the patient, either at admission or up to a few weeks before CS for patients who were scheduled for elective surgery. At our hospital, all patients are eligible for a referral to an RD for nutrition evaluation, based on low serum albumin level (<35 g/L), the CNST result, or providers' clinical judgment. Nutrition optimization can include nutrition counseling and dietary advice, such as the use of preoperative ONSs, and can be performed either by phone before admission or during hospitalization, as needed. Nutrition screening and adherence to optimization offered by an RD were recorded. Patients who received carbohydrate loading before CS, defined as the consumption of a 400-ml drink with 50 g of maltodextrin 2 h before surgery for eligible patients, as well as those who were extubated within 6 h of CS, were recorded. Finally, adequate prophylaxis of PONV was defined as the absence of nausea and vomiting, and patients who did not report these symptoms on POD1 and POD2 were recorded.

Statistical analysis

Descriptive statistics were used to describe patients' characteristics, oral intakes, and adherence to the ERAS approach for the overall population. Continuous variables were expressed as mean and SD or median and IQR, as appropriate. Categorical variables were expressed as frequencies and percentages. Continuous variables were compared using Student *t* test or Mann-Whitney test, if distributional assumptions were not met. Categorical variables were compared using chi-square test or Fisher exact test, as appropriate. The repeated-measures analysis of variance model was used to study postoperative oral intakes and ONSs consumption, across time and between sexes. Models with time, sex, and sex-by-time interaction as independent variables were used. Analyses were conducted at the 0.05 significance level and using SAS software, version 9.4 (SAS Institute).

RESULTS

Patient and surgical characteristics

Fifty patients were recruited for this study, and seven (14%) were excluded. Reasons for exclusion were the patients undergoing a surgery that did not meet the inclusion criteria ($n = 4$), the surgical procedure being postponed after the study period ($n = 1$), or the patient participating in other research projects ($n = 2$). A significant number of research projects that involve patients undergoing CS were ongoing during this study period. As a result, eight patients (of 43 [18.6%]) from our study were also recruited in the DEPOSITION ("Decreasing Postoperative Blood Loss by Topical Versus Intravenous Tranexamic Acid in Open Cardiac Surgery") protocol, a study that investigates the use of topical tranexamic acid on postoperative seizure and blood loss, compared with its usual intravenous access.[15] Those patients were still included in our study because there were no competing outcomes. Furthermore, sensitivity analyses conducted at the end of the study showed no significant difference in clinical outcomes between patients taking part in the DEPOSITION study and the other patients (SICU LOS $P = 0.12$; postoperative LOS $P = 0.53$; intubation time after surgery $P = 0.42$). Therefore, 43 patients were analyzed in the present study.

Patient and surgical characteristics are described in Table 2. Most patients (72%) were men, mean age was 69.9 ± 7.25 years, and mean BMI was 29.8 ± 5.7 kg/m^2. Half of the patients were hospitalized before surgery, on average for 6 ± 1.8 days. The most common procedure was CABG, and only four (9.3%) patients had a EuroSCORE II calculated before surgery. According to the SGA, a small proportion of patients were moderately malnourished (SGA B: 5 of 43 patients [11.6%]) before surgery, and no patients were severely malnourished.

TABLE 2 Patient and surgical characteristics.

Patient characteristics	Data
Age, mean (SD), years	69.9 (7.25)
Sex, *n* (%)	
Women	12 (28)
Men	31 (72)
Cardiac history, *n* (%)	
Coronary artery disease	30 (69.8)
Valvular heart disease	24 (55.8)
Comorbidity, *n* (%)	
Chronic obstructive pulmonary disease	4 (9.3)
Chronic kidney disease	4 (9.3)
Diabetes	18 (41.9)
Serum albumin level, mean (SD), g/L	36 (3.7)
Preoperative BMI, mean (SD)	29.8 (5.7)
Nutrition status according to the SGA, *n* (%)	
A—well-nourished	38 (88.4)
B—moderately malnourished	5 (11.6)
C—severely malnourished	0
Surgery characteristics	
Surgical procedure, *n* (%)	
CABG	20 (46.5)
Heart valve surgery (single valve)	11 (25.6)
Heart valve surgery (multiple valves)	3 (7)
Combined procedure	8 (18.6)
Bentall procedure	1 (2.3)
Elective admission for surgery, *N* (%)	22 (51)
STS score, mean (SD), percentage	1.23 (1.03)
CPB time, mean (SD) (min)	88 (48)

Abbreviations: BMI, body mass index; CABG, coronary artery bypass graft; CPB, cardiopulmonary bypass; SGA, Subjective Global Assessment; STS, Society of Thoracic Surgeons.

Clinical outcomes

Clinical outcomes are presented in Table 3. Patient discharge started on POD3, and median LOS after surgery was 4.5 days (IQR, 3.5–5.5). The postoperative LOS of five patients was adjusted with the readiness-to-discharge criteria because their discharge was postponed pending transport or referral to a convalescence private facility. Two patients died in the hospital, one during surgery and one in the SICU. Both patients were moderately malnourished (SGA B) and were classified as high risk (EuroSCORE II of 13.16% and STS score of 5.93%, respectively).

ERAS protocols adherence

Adherence to the four preselected ERAS recommendation is presented in Table 4. Ten patients remembered watching the nutrition education video; these 10 represent 45.5% of the 22 patients who were admitted for elective surgery and were therefore offered preadmission education. Adherence to carbohydrate loading, early extubation, and adequate PONV prophylaxis was applied to ≥70% of all patients. Six (of 43 [14%]) patients did not receive the carbohydrate loading because of poorly controlled diabetes. Nutrition screening using the CNST was applied to 90.7% of patients, and serum albumin level was measured in 93% of patients. Three patients (of 43 [7%]) were considered at nutrition risk according to the CNST, and two patients (of 43 [4.6%]) had a serum albumin level ≤30 g/L. Preoperative nutrition optimization was offered to three patients, all hospitalized before CS. Of those three, two

TABLE 3 Clinical outcomes.

Clinical outcomes	Data
LOS, median (IQR)	
SICU LOS, hours	41 (22–51)
Postsurgery LOS, days	4.5 (3.5–5.5)
Discharge on POD3, *n* (%)	5 (11.6)
Discharge on POD4, *n* (%)	12 (28)
Paralytic ileus, *n* (%)	1 (2.3)
Delirium, *n* (%)	2 (4.7)
Surgical wound infection, *n* (%)	4 (9.3)
Transfer to a rehabilitation facility, *n* (%)	0
30-day readmission, *n* (%)	4 (9.3)
In-hospital mortality, *n* (%)	2 (4.7)

Abbreviations: LOS, length of stay; POD, postoperative day; SICU, surgical intensive care unit.

TABLE 4 Adherence to four ERAS care elements.

	Data, *n* (%)
Preoperative	
Education (nutrition information) for elective patients ($n = 22$)	10 (45.5)
Nutrition screening and optimization ($n = 43$)	
Measurement of serum albumin level	40 (93)
Nutrition screening (CNST)	39 (90.7)
Nutrition evaluation by an RD and optimization	3 (7)
Carbohydrate loading ($n = 43$)	30 (70)
Postoperative	
Extubation within 6 h of surgery ($n = 42$)	33 (78.6)
Adequate PONV prophylaxis ($n = 41$)	
POD1	29 (70.7)
POD2	34 (83)

Abbreviations: CNST, Canadian Nutrition Screening Tool; POD, postoperative day; PONV, postoperative nausea and vomiting; RD, registered dietitian.

were referred to an RD after nutrition screening with the CNST and were also malnourished according to the SGA.

Nutrition outcomes

Forty-one patients (of 43 [95%]) returned to exclusive oral intakes starting on POD1, as one patient died during surgery and one patient required enteral nutrition for prolonged mechanical ventilation. Starting on POD2, the oral intakes of 38 patients were analyzed, with three patients being excluded from oral intake analysis. Reasons for exclusion were two patients consuming outside food instead of hospital meals and one patient being prescribed fasting for a paralytic ileus. Five patients (of 43 [11.6%]) received a postoperative nutrition intervention by an RD in addition to standard nutrition care, and no patient received parenteral nutrition.

Distribution of oral intakes is presented in Figure 1 for each day. Mean calorie and protein intakes on POD1 were significantly lower than those on every other day ($P < 0.0001$). There was no difference between calorie or protein intakes on subsequent days, although there was a trend for lower intakes on POD4 compared with those on POD2 ($P = 0.15$). On average, oral intakes from POD2 to POD4 were 1088 ± 437 kcal and 57 ± 25 g of protein, which represent $62\% \pm 24\%$ and $54\% \pm 22\%$ of patients' estimated calorie and protein requirements, respectively. When adjusted for weight, mean oral intakes from POD2 to POD4 for calories and protein were 15.6 ± 6.1 kcal/kg and 0.8 ± 0.3 g/kg, respectively. However, 17 patients (41% of patients resuming oral intakes on POD1) met

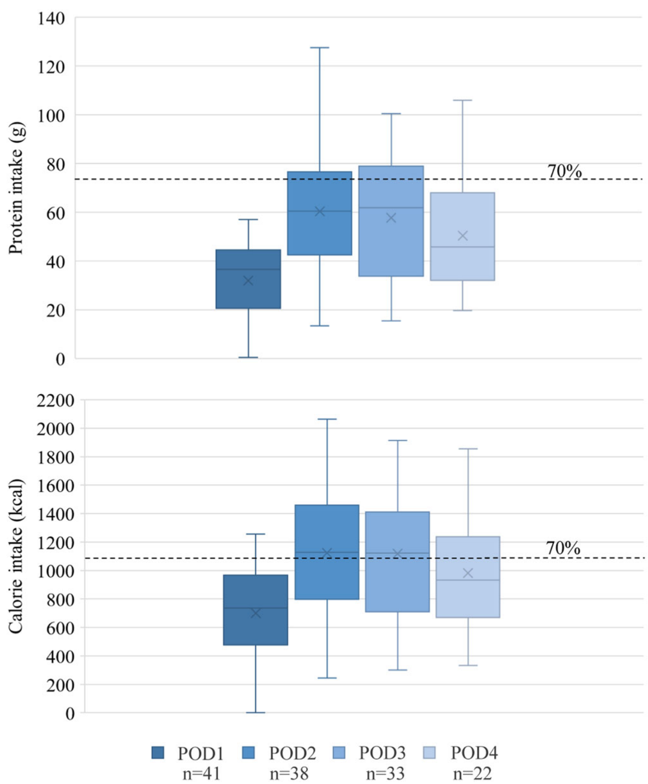

FIGURE 1 Distribution of postoperative oral intakes. Mean calorie and protein intakes on postoperative day (POD) 1 were significantly lower than on other days ($P < 0.0001$). The mean objective of oral intakes ≥70% of estimated requirements equates to 1232 kcal and 74 g of protein.

≥70% of their estimated requirements for both calories and protein for at least 1 day. Among those patients, four met 100% of their estimated requirements for 1 day. By contrast, the oral intakes of 11 patients (of 41 [26%]) never reached 50% of their estimated requirements. There was a trend for a higher proportion of patients with valvular heart disease in the group with very insufficient intake (8 of 11 patients [72.7%]) compared with patients in the sufficient-intake group (6 of 17 patients [35.3%]) ($P = 0.053$). There was also a trend for longer use of mechanical ventilation after CS in the group of patients with very insufficient intakes compared with those who reached sufficient intakes (439 ± 384 vs 196 ± 215 min, respectively; $P = 0.076$). There was no difference in the proportion of men and women between patients with sufficient intakes and those who had very insufficient intakes ($P = 0.65$).

Daily intakes for men and women, adjusted for weight, are presented in Table 5. Women's intakes of calories and protein on POD1, at 7.0 ± 4.9 kcal/kg and 0.32 ± 0.23 g/kg, respectively, were significantly lower than men's intakes, which were 10.7 ± 4.0 kcal/kg and 0.49 ± 0.19 g/kg ($P = 0.02$), respectively. However, intakes from POD2 through POD4 were not significantly different when stratified by sex. Men's calorie intakes on POD4 were lower than their intakes on POD2 ($P = 0.049$), and a trend for higher intakes was observed in men who had an early discharge compared with those who had prolonged hospitalization. Specifically, calorie intakes on POD3 were 18.2 ± 7.5 kcal/kg for men discharged on POD4, compared with 15.6 ± 6.2 kcal/kg for those discharged after POD4 ($P = 0.28$). Finally, women's calorie and protein intakes did not significantly differ between POD2, POD3, and POD4.

ONSs are offered starting on POD2 in our hospital. Of the 38 patients whose oral intakes were analyzed starting that day, 26 patients (of 38 [68.4%]) received ONSs after surgery, and 12 patients (of 38 [31.6%]) asked to switch to enriched foods. On POD2, 10 patients (of 26 [38.5%]) consumed 100% of the ONSs offered. There was a significant decrease in daily contribution of ONSs to oral intakes, which is presented in Figure 2. ONSs contribution to calorie intake was 34.9% ± 18.9% on POD2 compared with 19.2% ± 18.1% on POD3. Similarly, ONSs contribution to protein intake was 37.8% ± 19.6% on POD2 compared with 20.2% ± 17.7% on POD3. The decrease in ONSs contribution to intakes was significant between POD2 and POD3 ($P \leq 0.0005$). ONSs contributions to intakes were also lower on POD4 compared with those on POD2 and POD3

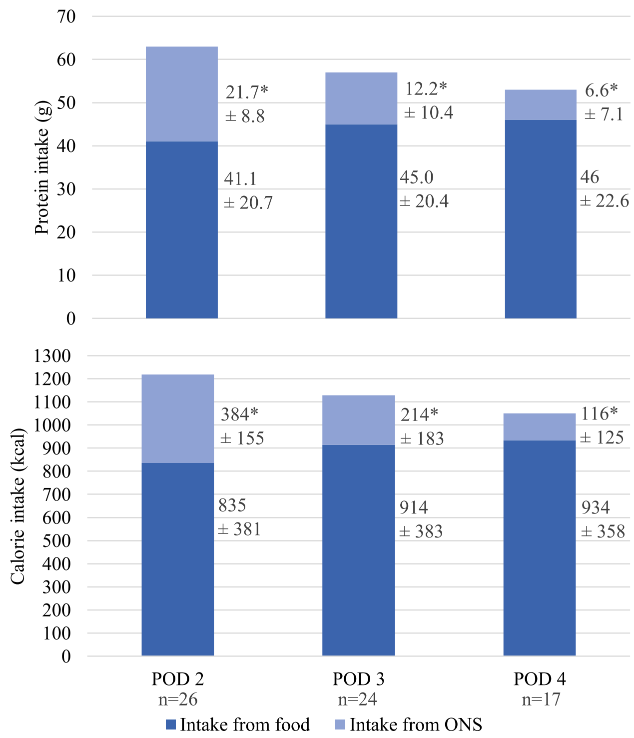

FIGURE 2 Daily contribution of oral nutrition supplements (ONSs) to mean oral intakes. Mean calorie and protein intakes from ONSs were significantly lower on postoperative day (POD) 3 and POD4 compared with those on POD2 ($P < 0.0001$), as well as those on POD4 compared with those on POD3 ($P = 0.0002$).

TABLE 5 Daily calorie and protein intakes for men and women, adjusted for body weight.

	Daily calorie intake, mean ± SD, kcal/kg			Daily protein intake, mean ± SD, g/kg		
Postoperative day	**Men**	**Women**	***P* value**	**Men**	**Women**	***P* value**
POD1 ($n = 41$) (31 men; 10 women)	10.7 ± 4.0[a]	7.0 ± 4.9[a]	0.021*	0.49 ± 0.19[b]	0.32 ± 0.23[b]	0.024*
POD2 ($n = 38$) (28 men; 10 women)	17.0 ± 5.8[c]	13.4 ± 6.1[c]	0.085	0.90 ± 0.36[d]	0.76 ± 0.26[d]	0.237
POD3 ($n = 33$) (24 men; 9 women)	16.6 ± 6.7[c]	14.0 ± 5.1[c]	0.135	0.85 ± 0.35[d]	0.73 ± 0.27[d]	0.182
POD4 ($n = 22$) (15 men; 7 women)	14.4 ± 5.9[e]	13.9 ± 4.4[c]	0.918	0.70 ± 0.35[d]	0.81 ± 0.26[d]	0.616

Note: *P* value represents difference between men and women for each day.

Abbreviation: POD, postoperative day.

[a,b]Difference between intakes on POD1 and on other days is statistically significant, for both men and women ($P \leq 0.001$) and [c,d]not statistically different.

[e]Difference between calorie intake for men on POD4 compared with that on POD2 is statistically significant ($P = 0.049$).

*Statistically significant ($P < 0.05$).

($P < 0.0001$ between POD2 and POD4; $P \leq 0.003$ between POD3 and POD4). Total mean nutrition intake (calorie and protein), as well as mean protein intake from food, did not differ between days. There was a trend for higher mean calorie intake from foods on POD4 compared with that on POD2 ($P = 0.052$). On all days, daily consumption of ONSs did not differ between men and women (all $P \geq 0.5$). Eighty-two percent of patients (14 of 17 patients) who reached ≥70% of their estimated calorie and protein requirements received postoperative ONSs after their CS. Furthermore, nine (of 17 patients [53%]) of those patients achieved ≥70% of their estimated requirements on the day that they consumed 100% of the ONSs offered.

DISCUSSION

One of the main purposes of the ERAS approach is to implement protocols that promote prompt return to a normal functional status, including resumption of basic activities such as eating.[1] This observational study showed that in an ERACS pathway, almost all patients resumed to oral intakes starting on POD1. Although mean intakes were insufficient from POD2 to POD4, 17 patients (of 41 [41%]) had adequate calorie and protein intakes for at least 1 day. Prompt resumption of oral intakes after CS is highly recommended, although means to ensure their adequacy have rarely been discussed.[16,17] Few studies have described postoperative oral intakes after CS, and to our knowledge, none have done so in an ERACS pathway. In a study involving 22 patients undergoing CS, mean oral intakes of 3 days, starting on POD2 or POD3, were 1211 ± 447 kcal and 0.7 ± 0.3 g/kg protein.[10] Goldfarb et al. reported that only one patient (4.5%) met protein requirements. In a study from Ogawa et al. involving 250 patients undergoing CS, mean intakes from POD3 to POD7 were 1275 ± 405 kcal and 0.9 ± 0.4 g/kg protein.[18] Sixty-three percent of patients reached 100% of their calorie requirement, but the mean protein intake of this subgroup was still insufficient. In the present study, mean oral intakes from POD2 to POD4 were 1088 ± 437 kcal and 0.8 ± 0.3 g/kg protein, and four patients (9.8%) met 100% of their requirement for both calories and protein. Lower intakes on POD1 were expected because the food offer on that day consisted of light meals that provided less calories and protein than on other days. Studies by Goldfarb et al.[10] and Ogawa et al.[18] did not include oral intakes on POD1, and mean calorie intakes in both studies were higher than the present report. One possible explanation lies in the fact that in the present study, there was a trend for lower intakes on POD4, as a significant number of patients with greater oral intakes were discharged on POD3 and POD4. By contrast, no patients were discharged in the first week after CS in the studies by Goldfarb et al. and Ogawa et al.[10,18] Because the ERAS approach enables earlier patient discharge,[1] intakes of patients with prolonged hospitalization should be closely monitored.

A key component of ESPEN recommendations is identifying patients who are at risk for insufficient nutrition intakes.[3] In the present study, factors that could be associated with lower postoperative intakes were sex, the presence of valvular heart disease, and time undergoing mechanical ventilation after CS. Calorie and protein intakes on POD1 were significantly lower in women, although mean oral intakes from POD2 to POD4 did not differ according to sex. A similar result was reported in an ERAS study in colorectal surgery, in which male sex was one of the factors associated with prompt resumption of oral intakes. Indeed, the ratio of women to men was higher in the group of patients with delayed resumption of oral intakes, suggesting that proportionately fewer women were able to tolerate early resumption of solid food.[19] In the present study, there was also a trend for a larger proportion of patients with valvular heart disease in the group of patients who never reached 50% of their estimated requirements, compared with the group of patients who had sufficient intakes. One possible explanation is reduced appetite, which was found to be more common in patients with severe aortic stenosis compared with healthy individuals.[20] Interestingly, both sex and the presence of valvular heart disease are factors incorporated in the evaluation of surgical risk before CS, as assessed by the STS score.[21] Finally, 78.6% of patients in our study were extubated in the 6 h after surgery, as recommended in the ERACS guidelines.[4] However, there was a trend for insufficient intakes in patients requiring longer use of mechanical ventilation. In one study, the number of days of mechanical ventilation was a predictor of oral intakes, but that study did not include patients undergoing CS.[22] Therefore, patients with an inherent risk factor before surgery or those who follow a pathway that diverges from ERAS recommendations can present an increased nutrition risk.

ONSs are recommended as a perioperative nutrition therapy.[3,23] Numerous studies in the field of gastrointestinal surgery have assessed the contribution of postoperative ONSs to oral intakes in the ERAS pathway. In one study in colorectal surgery, consumption of ONSs allowed the mean calorie intakes from POD1 to POD3 to reach 60% of mean estimated requirements.[24] In the present study, ONSs intake contributed to adequate oral intakes, as 9 of 17 patients who achieved ≥70% of their estimated requirements did so on the day that they consumed 100% of the ONSs offered. By contrast, only three patients reached 70% of their estimated requirements without ONSs. However, there was a significant decrease in ONSs consumption starting on POD3, although a decline in ONSs contribution to intakes was expected on POD4 because smaller quantities of ONSs are systematically provided by our hospital starting on that day. Furthermore, only 38% of patients had optimal ONSs intake on POD2. Low adherence to postoperative ONSs has been reported in an ERAS study in patients undergoing colorectal surgery. Indeed, only 23% of the 69 patients had optimal adherence to ONSs on POD1 and POD2, and there was also a decrease in ONSs consumption on POD3, which was partially explained by early discharge.[25] In the present study, 31.6% of patients declined receiving postoperative ONSs and preferred eating enriched foods. Reasons for patients' disinterest in ONSs and barriers preventing optimal adherence were not evaluated in the present study, as greater adherence to ONSs was initially expected based on a systematic review.[26] In one study conducted after hospital discharge following gastrointestinal surgery, limiting factors to sufficient ONSs consumption reported by patients were gastrointestinal symptoms, including early satiety, and aversion.[27] Another barrier to ONSs adherence could be the lack of nutrition education. In a qualitative study evaluating ERAS nutrition care, insufficient information and misconception were common patient-reported barriers to the resumption of postoperative oral intakes, including consumption of ONSs.[28] In our study, less than half of the patients who had an elective surgery remembered watching the nutrition information video, and nutrition education before CS was not offered to hospitalized patients. Because our results suggest that optimal adherence to ONSs contributes to sufficient nutrition intakes, additional research will be needed to identify barriers preventing ONSs intake. Furthermore, this study highlighted the necessity to implement a protocol documenting postoperative ONSs consumption, as ONSs administration is not currently systematically monitored in our institution.

Malnutrition before CS is a well-known risk factor associated with poor clinical outcomes.[29,30] Preoperative nutrition optimization is the main nutrition recommendation of the ERACS guidelines, although no specific criteria are suggested to screen patients, other than serum albumin level <30 g/L.[4] Serum albumin level can be used to identify patients who could be at nutrition risk, because a low level indicates an inflammatory state.[3] However, serum albumin level does not directly correlate to nutrition status[31]; therefore, our institution additionally uses the CNST for nutrition risk screening. The use of the CNST is recommended by the Canadian Malnutrition Task Force[32] and has been described in another Canadian ERAS study, set in colorectal surgery.[33] Adherence to nutrition screening was satisfactory in the present study, as 90.7% of patients were screened. After nutrition screening with the CNST, preoperative nutrition optimization was offered to two malnourished patients (SGA B). However, it was not offered to the other three patients who were malnourished according to the SGA because they were not identified by the CNST as being "at nutritional risk." One explanation for this is that in our institution, the CNST is self-filled for some patients, although it has been validated to be performed by nursing staff.[14] Furthermore, no patients with a serum albumin level <30 g/L were referred to an RD for optimization based on this criterion. Therefore, adherence to nutrition optimization was insufficient. Incidentally, this care element has been identified as one that needs to be further investigated within the ERAS pathway.[34]

LIMITATIONS

The present study has some limitations. First, the sample size was small, as only 43 patients were included. Some analysis—namely, the difference in adequacy of intakes depending on preoperative nutrition status—was not possible because of the small proportion of malnourished patients. Second, adherence to all the ERACS protocols in place in our institution was not assessed, as the aim of this study was to specifically investigate nutrition care within an ERACS approach. Third, postoperative oral intakes could be underestimated because intake from snacks was not evaluated. Furthermore, food intake assessment through meal observation tends to underestimate intakes, compared with the reference method of weighed food items.[9] Finally, 14% of the data on ONSs consumption were missed because some patients kept their containers in their room, precluding inclusion in intake assessments. However, for most patients, the missing data represented no more than one portion of 120 ml of ONSs.

CONCLUSION

This study provided data that in an ERACS pathway, 41 patients (95%) were able to promptly resume oral intakes. Although mean oral intakes in the first 4 days after CS were insufficient, 17 patients (of 41 [41%]) met ≥70% of their estimated requirement for both calories and protein. Postoperative ONSs adherence declined significantly over time; however, when consumed, ONSs helped 14 patients (of the 17 who met their estimated requirements [82%]) reach sufficient intakes. Therefore, our results suggest that within an ERACS pathway, implementing nutrition protocols, such as offering postoperative ONSs, can facilitate early resumption of sufficient oral intakes. Finally, as adherence to preoperative nutrition education and optimization of nutrition status was insufficient, future studies will need to prioritize investigation of preoperative nutrition care on postoperative clinical outcomes, including oral intakes and ONSs adherence.

AUTHOR CONTRIBUTIONS

Bianca Beaulieu and Guylaine Ferland equally contributed to the conception and the development of the study. Nicolas Rousseau-Saine and Yoan Lamarche equally contributed to the development of the study. Bianca Beaulieu acquired and interpreted the data and wrote the manuscript. Guylaine Ferland, Nicolas Rousseau-Saine, and Yoan Lamarche equally contributed to interpretation of the data and critical revision of the manuscript. All authors read and approved the final manuscript.

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CONFLICT OF INTEREST STATEMENT

None declared.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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