ORIGINAL ARTICLE – PERITONEAL SURFACE MALIGNANCY

Preoperative Nutrition Status and Postoperative Outcomes in Patients Undergoing Cytoreductive Surgery and Hyperthermic Intraperitoneal Chemotherapy

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ABSTRACT

Background. Cytoreductive surgery (CRS) and hyperthermic intraperitoneal chemotherapy (HIPEC) is a complex surgery to treat peritoneal surface malignancy (PSM). PSM and gastrointestinal (GI) resection from CRS can lead to significant GI symptoms and malnutrition. There is limited research into the nutrition status of this patient group and the impact of malnutrition on morbidity.

Objective. This study aims to determine if preoperative malnutrition, assessed using the Subjective Global Assessment (SGA), is associated with postoperative morbidity and increased length of stay (LOS) in patients undergoing CRS/HIPEC for PSM.

Methods. This study prospectively assessed the nutritional status of patients undergoing CRS/HIPEC using a validated nutrition assessment tool. Preoperative clinical symptoms, Peritoneal Cancer Index (PCI), intraoperative blood transfusions, operative time, GI resections, postoperative morbidity, and LOS, as well as pre- and postoperative nutritional interventions, were recorded. The impact of preoperative nutritional status was assessed in relation to postoperative complications and hospital LOS.

Results. The study included 102 participants; 34 patients (33%) were classified as malnourished (SGA = B or C). Preoperative weight loss (15% vs. 74%; $p \leq 0.001$) and the presence of clinical symptoms (18% vs. 47%; $p = 0.002$) were significantly higher in malnourished patients. While PCI, intraoperative blood transfusions, and GI resections were independent predictors of morbidity, malnutrition was significantly associated with infectious complications and LOS. For each grade of worsening malnutrition, LOS increased by an average of 7.65 days.

Conclusions. Preoperative malnutrition is prevalent in patients undergoing CRS/HIPEC and postoperative morbidity is common. Malnutrition is linked to LOS and plays a role in postoperative outcomes such as infection. Clear pre- and postoperative nutrition pathways are needed to optimize nutrition support and postoperative recovery.

Cytoreductive surgery (CRS) and hyperthermic intraperitoneal chemotherapy (HIPEC) is complex surgery to treat peritoneal surface malignancy (PSM).[1] PSM arises from gastrointestinal (GI), gynecological, or primary peritoneal cancers.[2] CRS aims to completely remove macroscopic

tumor.[3] In order to achieve complete cytoreduction, multiple abdominal organ resections are often necessary.[3] After cytoreduction, HIPEC is delivered into the abdominal cavity for 30–90 min to treat residual microscopic disease.[4]

CRS/HIPEC has shown increased survival compared with other treatments for pseudomyxoma peritonei (PMP), peritoneal mesothelioma, appendix cancer, colorectal cancer, gastric cancer, and ovarian cancer;[5–9] however, in the initial postoperative period, the risk of complications is high.[10] While the procedure offers significant long-term benefits, the invasive surgery and associated complications have shown an impact on nutrition status and quality of life (QOL).[1,11]

Malnutrition is prevalent in patients undergoing surgery for abdominopelvic malignancy and is associated with increased morbidity, longer hospital length of stay (LOS), and mortality.[12–15] Preoperative malnutrition is a risk factor for organ dysfunction, impaired immune function, wound complications, impaired physical function, and increased LOS.[12,13,16,17] Malnutrition prevalence is documented in up to 67% of patients with ovarian cancer[10] and 30–50% of patients with colorectal cancer.[10,15] Identification and management of malnutrition in patients undergoing CRS/HIPEC has been identified as an important part of perioperative care,[18] but data on the prevalence and impact of malnutrition are scarce. One previous study in a homogenous cohort of CRS/HIPEC patients documented 45% of patients were malnourished according to the Subjective Global Assessment (SGA).[19] Malnutrition was associated with LOS and overall survival.

The aim of the present study was to determine if preoperative malnutrition, assessed using the SGA, is associated with postoperative morbidity and increased LOS in patients undergoing CRS and HIPEC for PSM of a diverse set of primary cancers.

MATERIALS AND METHODS

Setting

This prospective observational study was performed on a cohort of patients undergoing CRS/HIPEC by one surgical team at a tertiary referral hospital between February 2016 and March 2017, and was approved by the South Eastern Sydney Local Health District Human Research Ethics Committee.

Patients

Patients were assessed for suitability of CRS/HIPEC by a multidisciplinary team. All patients over the age of 18 years presenting for CRS/HIPEC with curative intent and able to provide written consent were eligible for inclusion. Patients were excluded if they were unable to provide consent or did not receive concurrent CRS/HIPEC.

Demographic characteristics, including age, sex, surgical history, and preoperative nutritional support (use of oral, enteral, or parenteral nutrition) were gathered from preoperative assessments and supplemented by the medical record. Operation reports were used to collect Peritoneal Cancer Index (PCI), completeness of cytoreduction (CC) and intraoperative outcomes, including operative time, intraoperative blood transfusions, diaphragmatic involvement, small bowel resection, and gastrectomy.

Nutrition Assessment

Preoperative nutrition status was assessed using:

1. *Weight and Height* Preoperative weight and height were taken during preadmission assessments. Preoperative body mass index (BMI) was calculated using the formula weight (kg)/height (m)^2, and BMI was used to classify patients as underweight (< 18.5 kg/m^2), normal weight (18.5–25 kg/m^2), and overweight/obese (> 25 kg/m^2).[20] For patients older than 65 years of age, a healthy weight range of 20–27 kg/m^2 was used.[21]

2. *Subjective Global Assessment* The SGA is a validated nutrition assessment tool that combines anthropometric, clinical, and dietary factors with a physical examination of subcutaneous fat loss, muscle wasting, and presence of oedema and ascites to determine nutritional status.[22] Patients are classified as well-nourished (A), mild–moderately malnourished (B), and severely malnourished (C).[23]

3. *Handgrip Strength* (*HGS*) HGS was measured using a calibrated Jamar handgrip dynamometer (Sammons Preston Rolyan, Bolingbrook, IL, USA). HGS was taken on both hands with the elbow by the side and flexed to 90 degrees. Measures were taken two to three times on each hand and the mean (kilograms) recorded. The resulting mean was converted to a percentage of the predicted grip strength based on age, sex, and BMI.[24]

4. *Clinical Symptoms* Symptoms including the presence of ascites or abdominal distension and partial or complete bowel obstruction were recorded.

Postoperatively, all patients received individualized nutrition support. Patients received early postoperative total parenteral nutrition (TPN) if the surgery included upper GI anastomosis; they were prescribed early postoperative intraperitoneal chemotherapy (EPIC); or they experienced a GI complication such as a fistula or were considered to have a high risk of slow diet progression or

malabsorption. Delayed TPN was considered if full oral fluids were not achieved within 3–5 days.

Intraoperative Outcomes

To measure the extent of surgery, intraoperative outcomes, including operation duration (hours), units of blood transfused, diaphragmatic involvement, small bowel resection and gastric resections were obtained from the registered clinical database.

Postoperative Outcomes

Postoperative outcomes, including complications, hospital LOS, return to theater and 30-day re-admission rates were obtained from medical records and the registered clinical database. Complications were graded according to the Clavien–Dindo classification.[25] Major morbidity was determined when complications were grade 3 or higher.

Cytoreductive Surgery and Hyperthermic Intraperitoneal Chemotherapy

Macroscopic tumor extent and distribution was recorded using the PCI.[26] CRS was performed using Sugarbaker's technique,[27] with all suspected macroscopic lesions removed. Surgery aimed to achieve complete cytoreduction.[26]

HIPEC was administered into the open abdomen for 30–90 min using the colosseum technique. Either mitomycin, oxaliplatin, or cisplatin was used, dependent on the primary cancer type. EPIC (flourouracil) was administered to patients with low-grade appendix tumors.

Statistical Analysis

Statistical analyses were performed using SPSS version 24 (IBM Corporation, Armonk, NY, USA). Statistically significant differences were defined as $p < 0.05$.

Categorical data were compared using the Chi-square or Fisher's exact tests. Continuous data were tested for normality and compared using the independent t-test for normally distributed variables and the Mann–Whitney U test for non-normally distributed variables. A logistic regression model was used to determine risk factors for postoperative major morbidity. All variables with a $p < 0.250$ in the univariate analysis were entered into the multivariate analysis. Linear regression was used to determine risk factors associated with longer LOS. All significant ($p < 0.05$) variables were entered into the multiple linear regression model. A post hoc logistic

regression model was used to determine the relationship between the use of TPN and infectious complications.

RESULTS

Demographics

A total of 131 patients underwent CRS/HIPEC with curative intent during the data collection period. Two patients declined consent, three patients were unable to provide consent due to language or cognition barriers, and 24 patients were unable to be enrolled due to missed consent during inpatient admission or unavailability of the researcher to obtain consent. The remaining 102 (78%) patients were included in the study. Baseline demographics and clinical characteristics are shown in Table 1. Colorectal, appendix, and PMP were the most common tumor types.

Nutrition Assessment

Baseline nutrition parameters and postoperative nutrition support are summarized in Table 2. Thirty-four patients (33%) were classified as malnourished (SGA = B or C). Rates of preoperative weight loss (15% vs. 74%; $p \leq 0.001$) and the presence of GI symptoms (18% vs. 47%; $p = 0.002$) were significantly higher in malnourished patients. Seventeen patients (26%) reported preoperative weight loss of >5% and 10 patients (10%) reported preoperative weight loss of >10%. TPN was started postoperatively in 62 patients (61%). Nine malnourished patients (26%) did not receive TPN at any point in the postoperative period, and 15% were kept fasted for more than 5 days.

Intraoperative and Postoperative Outcomes

Intraoperative, postoperative and morbidity outcomes are shown in Table 3. Malnourished patients required significantly more intraoperative blood transfusions ($p<0.001$) and were more likely to require gastric ($p = 0.006$) or small bowel ($p = 0.010$) resections. Malnourished patients had higher rates of major morbidity compared with well-nourished patients (47% vs. 34%), however this was not statistically significant ($p = 0.195$).

Infectious complications were more common (47% vs. 25%; $p = 0.025$) and LOS was longer (median 24 days vs. 15 days; $p = 0.006$) in malnourished patients. Malnutrition, TPN, age, operation time, units of blood transfused and PCI $\geq$ 10 were included in the post hoc logistic regression model to determine if the use of TPN was an independent predictor of infectious complications. Age ($p = 0.019$) was

TABLE 1 Baseline characteristics of patients undergoing cytoreductive surgery and hyperthermic intraperitoneal chemotherapy

Characteristics	Total [n = 102]	Well-nourished [n = 68]	Malnourished [n = 34]	p value
Demographics				
Sex (male:female)	49:53	33:35	16:18	
Mean age, years (SD)	55 (12.8)	53 (13.1)	59 (11.3)	**0.034**
Peritoneal disease				
PCI score [median (IQR)]	14 (6–29)	13.5 (6–28)	16.5 (9–32)	0.238
Tumor type				
Colorectal	38 (37)	25 (68)	13 (34)	
Appendix	29 (28)	18 (62)	11 (38)	
PMP	19 (19)	13 (68)	6 (32)	
Mesothelioma	9 (9)	7 (78)	2 (22)	
Ovarian	4 (4)	3 (75)	1 (25)	
Other	3 (3)	2 (50)	1 (33)	
Cytoreduction score				
0	87 (85)	61 (90)	26 (76)	
1	14 (14)	7 (10)	7 (21)	
2	1 (1)	0 (0)	1 (3)	
Postoperative EPIC	18 (18)	13 (19)	5 (15)	0.582
Surgical history				
Previous abdominal surgery	74 (73)	46 (68)	29 (85)	**0.041**
Previous CRS and HIPEC	11 (11)	8 (13)	3 (9)	0.652

Bold values indicate statistical significance

Data are expressed as *n* (%) unless otherwise specified

PCI Peritoneal Cancer Index, *PMP* pseudomyxoma peritonei, *EPIC* early postoperative intraperitoneal chemotherapy, *CRS* cytoreductive surgery, *HIPEC* hyperthermic intraperitoneal chemotherapy, *SD* standard deviation, *IQR* interquartile range

the only independent predictor of infectious complications. Mortality was seen in two patients, while these patients were malnourished, this result was not statistically significant ($p = 0.109$).

There were no significant associations between HGS and postoperative outcomes.

Univariate analysis found PCI $\geq$ 10 (odds ratio [OR] 1.64, 95% confidence interval [CI] 0.06–0.47; $p = 0.001$), operative time (OR 1.64, 95% CI 1.26–2.12; $p<0.001$), units of blood transfused (OR 1.29, 95% CI 1.14–1.46; $p<0.001$), small bowel resection (OR 2.78, 95% CI 1.22–6.35; $p = 0.015$), gastrectomy (OR 6.67, 1.31–34.01; $p = 0.022$), and the presence of preoperative clinical symptoms (OR 3.66, 95% CI 1.47–9.05; $p = 0.005$) to be associated with an increased rate of postoperative major morbidity. Furthermore, a multivariate logistic regression analysis found PCI $\geq$ 10 (OR 0.21, 95% CI 0.05–9.2; $p = 0.038$), intraoperative blood transfusions (OR 1.24, 95% CI 1.03–1.49; $p = 0.025$), gastrectomy (OR 0.09, 95% CI 0.01–0.85; $p = 0.010$), and BMI (OR 1.13, 95% CI 1.02–1.25; $p = 0.016$) to be independent predictors of major morbidity (Table 4).

In the univariate analysis for LOS, PCI $\geq$ 10, major morbidity, age, operative time, units of blood transfused, and malnutrition were significantly associated with LOS, with LOS 7.65 days longer in malnourished patients. In the final linear regression model, postoperative major morbidity (Clavien–Dindo grade 3 or higher) was the only independent predictor of hospital LOS (Table 5).

DISCUSSION

The primary aim of this study was to determine if preoperative nutrition status using the SGA is associated with postoperative outcomes in patients undergoing CRS/HIPEC. Findings indicate that, using the SGA, over 30% of patients undergoing CRS/HIPEC are malnourished prior to surgery. This is similar to previous findings in this patient group[19] and other major surgeries such as pelvic exenteration.[28] Rates of malnutrition across cancer types in patients undergoing CRS/HIPEC were similar, however patients who have undergone previous abdominal surgery were more likely to be malnourished. The results of this study show that malnutrition is significantly associated with postoperative outcomes such as postoperative infectious complications and increased hospital LOS, however PCI $\geq$ 10 increased BMI, and factors that reflect the extent of surgery (intraoperative blood transfusions and gastric

TABLE 2 Baseline nutritional parameters in patients undergoing cytoreductive surgery and hyperthermic intraperitoneal chemotherapy

Nutrition parameters	Total [n = 102]	Well-nourished [n = 68]	Malnourished [n = 34]	p value
Anthropometrics				
Weight, kg [mean (SD)]	80.2 (19.0)	83.8 (17.7)	72.8 (19.7)	**0.005**
BMI, kg/m^2 [mean (SD)]	27.9 (6.1)	29.3 (6.0)	25.1 (5.4)	**0.001**
Preoperative LOW	35 (34)	10 (15)	25 (74)	**< 0.001**
HGS <85% predicted	37 (52)[a]	22 (48)[b]	15 (60)[c]	0.327
Clinical				
Ascites/bowel obstruction	28 (27)	12 (18)	16 (47)	**0.002**
Preoperative nutrition				
TPN	2 (2)	0 (0)	2 (3)	0.109*
Postoperative nutrition				
TPN postoperatively	62 (61)	37 (54)	25 (74)	0.062
TPN within 5 days	54 (53)	32 (47)	22 (69)	1.00*
NBM >5 days	14 (14)	9 (13)	5 (15)	1.00*
EN postoperatively	5 (5)	1 (1)	4 (12)	**0.041***
Reasons for postoperative TPN				
UGI anastomosis	9 (15)	3 (8)	6 (24)	
Planned EPIC	23 (37)	15 (41)	8 (32)	
High-volume disease or expected delayed diet progression	17 (27)	11 (30)	6 (24)	
Delayed diet progression	11 (18)	6 (16)	5 (20)	
Gastrointestinal complication	2 (3)	2 (5)	0 (0)	

Bold values indicate statistical significance

Data are expressed as *n* (%) unless otherwise specified

BMI body mass index, *LOW* loss of weight, *HGS* handgrip strength, *TPN* total parenteral nutrition, *NBM* nil by mouth, *EN* enteral nutrition, *UGI* upper gastrointestinal, *EPIC* early postoperative intraperitoneal chemotherapy (note 23 patients were planned for EPIC; 18 patients received one or more doses), *SD* standard deviation

*Fisher's exact test

[a]Data missing for 31 patients

[b]Data missing for 22 patients

[c]Data missing for 9 patients

resections) were the only factors that independently affect these outcomes. To our knowledge, this is the first study that reports on nutrition status and the impact on patients with a diverse primary cancer type requiring CRS/HIPEC.

Our study highlights that postoperative morbidity is common in patients undergoing CRS/HIPEC. While malnourished patients experienced higher rates of overall major morbidity, this did not reach statistical significance. Malnourished patients experienced a significantly higher number of infectious complications, possibly due to the negative effect of malnutrition on the body's immune response.[29] Of interest was the finding that malnourished patients have a significantly longer LOS compared with well-nourished patients, despite the weak link between malnutrition and morbidity. On average, malnourished patients have a LOS 8 days longer than that of well-nourished patients. The role of malnutrition as a predictor of LOS has been established in multiple surgical oncology patient groups,[12] including patients undergoing CRS/

HIPEC.[19] This finding has implications for the patient and the institution, with prolonged LOS linked with QOL[30] and increased health care costs.[29]

PCI ≥ 10, intraoperative blood transfusions, higher BMI, and gastric resection were independent predictors of major morbidity, and these factors are consistent with other studies of patients undergoing CRS/ HIPEC.[31–34] In this study, median PCI was 14 (interquartile range 6–29), with no significant difference between malnourished and well-nourished patients with regard to PCI. The mean BMI for malnourished patients was 25.1 kg/m^2, indicating the majority of patients were within or above the healthy weight range. Although this was significantly lower than that of well-nourished patients, BMI does not account for the presence of tumor or ascites, which may have contributed to increased preoperative weight and therefore BMI. Body composition and sarcopenia should be considered when assessing preoperative nutrition status. Further assessment should be undertaken to determine if

TABLE 3 Comparison of intraoperative and postoperative cytoreductive surgery and hyperthermic intraperitoneal chemotherapy outcomes between malnourished and non-malnourished patients

Intraoperative and postoperative outcomes	Well-nourished [n = 68]	Malnourished [n = 34]	p value
Intraoperative outcomes			
Operative time, hours [mean (SD)]	7.61 (1.769)	8.30 (2.135)	0.085
Blood transfusion, units [median (IQR)]	2 (0–5)	6 (3–9)	**< 0.001**
Diaphragmatic involvement	15 (22)	19 (56)	0.387
Small bowel resection	22 (32)	20 (59)	**0.010**
Gastrectomy	2 (3)	7 (10)	**0.006***
Postoperative outcomes			
Any complication	55 (80)	32 (94)	0.075
Infection/sepsis	17 (25)	16 (47)	**0.025**
Anastomotic leak/fistula/collection	20 (29)	15 (44)	0.140
Ileus/SBO	9 (13)	1 (3)	0.099
Cardiac complication	5 (7)	3 (9)	0.795
Wound infection	4 (6)	4 (18)	0.436*
Respiratory complication	26 (38)	12 (35)	0.467
Bleeding	5 (7)	6 (18)	0.173*
Major morbidity	23 (34)	16 (47)	0.195
Return to theater	11 (16)	11 (32)	0.061
Length of stay, days [median (IQR)]	15 (12–23)	24 (16–30)	**0.006**
In-hospital mortality	0 (0)	2 (6)	0.109*
30-day re-admission	25 (37)	14 (41)	0.666

Bold values indicate statistical significance

Data are expressed as n (%) unless otherwise stated

SBO small bowel obstruction, *SD* standard deviation, *IQR* interquartile range

*Fisher's exact test

TABLE 4 Univariate and multivariate logistic regression analysis of risk factors associated with major morbidity post cytoreductive surgery and hyperthermic intraperitoneal chemotherapy

	Univariate OR (95% CI)	p value	Multivariate OR (95% CI)	p value
Age	1.02 (0.99–1.05)	0.270		
Previous abdominal surgery	0.77 (0.32–1.86)	0.555		
PCI ≥ 10	0.16 (0.06–0.47)	**0.001**	0.21 (0.05–9.2)	**0.038**
Operative time, hours	1.64 (1.26–2.12)	**< 0.001**	1.00 (0.62–1.57)	0.986
Blood transfusion, units	1.29 (1.14–1.46)	**< 0.001**	1.24 (1.03–1.49)	**0.025**
Small bowel resection	2.78 (1.22–6.35)	**0.015**	0.47 (0.16–1.42)	0.179
Gastrectomy	6.67 (1.31–34.01)	**0.022**	0.09 (0.01–0.85)	**0.010**
Malnutrition	1.74 (0.75–4.03)	0.197	3.01 (0.66–13.68)	0.153
BMI	1.04 (0.98–1.12)	0.201	1.13 (1.02–1.25)	**0.016**
Preoperative weight loss, %	1.07 (0.99–1.16)	0.125	1.09 (0.97–1.24)	0.165
Preoperative clinical symptoms	3.66 (1.47–9.05)	**0.005**	0.65 (0.18–2.26)	0.494
HGS—right, % predicted	0.91 (0.97–1.01)	0.322		
HGS—left, % predicted	1.00 (0.98–1.02)	0.888		

Bold values indicate statistical significance

OR odds ratio, *CI* confidence interval, *PCI* Peritoneal Cancer Index, *BMI* body mass index, *HGS* handgrip strength

patients with higher PCI, preoperative abdominal distension, ascites, or more extensive surgery have more significant nutrition decline postoperatively.

The SGA was chosen for this study as it has been extensively used in surgical oncology settings and has been shown to be a good predictor of postoperative morbidity,

TABLE 5 Univariate and multivariate linear regression analysis of risk factors associated with length of stay post cytoreductive surgery and hyperthermic intraperitoneal chemotherapy

	Univariate B (95% CI)	*p* value	Multivariate B (95% CI)	*p* value
Age	0.30 (0.08–0.52)	**0.008**	0.20 (0.04–0.37)	**0.018**
Major morbidity	8.11 (6.43–9.79)	**< 0.001**	14.31 (9.33–19.30)	**< 0.001**
PCI ≥ 10	9.69 (3.87–15.50)	**0.001**	−0.56 (−6.21 to 5.08)	0.842
Operative time, hours	3.66 (2.32–5.00)	**< 0.001**	1.51 (−0.24 to 3.27)	0.091
Blood transfusion, units	1.64 (1.11–2.17)	**< 0.001**	0.41 (−0.27 to 1.09)	0.238
Malnutrition	7.65 (1.67–13.62)	**0.013**	2.10 (−2.80 to 7.00)	0.397
BMI	−0.10 (−0.58 to 0.038)	0.672		
Preoperative weight loss, %	0.42 (−0.16 to 1.01)	0.154		
HGS—left, % predicted	−0.02 (−0.16 to 0.12)	0.790		
HGS—right, % predicted	−0.11 (−0.25 to 0.03)	0.107		

Bold values indicate statistical significance

Data are presented to demonstrate the incremental LOS associated with each variable of interest. Major morbidity was determine using a Clavien–Dindo classification ≥ 3

CI confidence interval, *PCI* Peritoneal Cancer Index, *BMI* body mass index, *HGS* handgrip strength, *LOS* length of stay

survival, and LOS.[19,35,36] The SGA differs from other bedside nutrition indictors, such as BMI or albumin, as it evaluates nutritional adequacy, clinical symptoms, and body composition. The SGA identified a group of patients at risk of longer LOS and postoperative infections, indicating that preoperative malnutrition assessment with SGA is valuable. However, the lack of association between SGA and major morbidity warrants consideration of alternative nutrition assessment methods. Recent studies have evaluated body composition using bioelectrical impedance analysis[37] and computed tomography scans[38] in patients undergoing CRS/HIPEC. These measurements have been shown to be independent predictors of major morbidity, however they require equipment and skilled interpretation. The SGA remains an inexpensive bedside assessment tool and is therefore advantageous over other methods that may not be accessible as routine measurements.

Current guidelines are sparse in directing nutrition practice in this patient group. Generalized guidelines recommend routine preoperative nutrition assessment and 7–14 days of nutrition support prior to surgery for malignancies in malnourished patients to reduce the risk of postoperative morbidity.[39,40] Findings of the present study indicate that preoperative nutrition assessments are completed, however nutrition support focuses primarily on optimizing oral diet. Recent research indicates more aggressive preoperative nutrition support improves outcomes and LOS in patient groups undergoing colorectal[41] and head and neck cancer surgery.[42] The use of parenteral nutrition preoperatively is currently being investigated in patients with upper GI cancers,[43] as well as patients undergoing CRS/HIPEC.[44] Hence, further research into a more aggressive protocol for preoperative nutrition support in patients undergoing CRS/HIPEC is warranted.

Of particular interest were inconsistencies found in postoperative nutrition support. Fifteen percent of malnourished patients fasted for more than 5 days postoperatively, and 26% of malnourished patients did not receive enteral nutrition (EN) or TPN in the postoperative period. Individualized postoperative nutrition support is often adopted in patient groups where there is no clear guidance in the literature; however, this management leaves patients vulnerable to the individual priorities of each surgical team. There is evidence to support the use of clinical pathways in less complex GI surgical patients, particularly in terms of early postoperative feeding.[45] While it is not clear whether early enteral feeding is well-tolerated in patients undergoing CRS/HIPEC, further research is warranted to develop a clinical pathway to support escalation from oral to EN to TPN, and to ensure nutrition support is not overlooked.

Several limitations within this study need to be acknowledged. The small samples size of the study and the high number of outcomes of interest may have exposed the results to type II error, which may have further complicated the interpretation of the significance of nutrition status. The short follow-up limits findings to the immediate postoperative period and does not provide insight into nutrition decline in the postoperative period. As mentioned above, nutrition support was not standardized, therefore potential differences in postoperative outcomes may be unaccounted for, particularly as the use of TPN was used primarily in patients identified to be at higher risk of postoperative complications. The SGA relies on the assessor's ability to collect and interpret data and is therefore open to bias. Finally, no interrater reliability was assessed as part of this study; however, all assessors were trained dietitians. Further research should focus on the development of pre- and

postoperative nutrition pathways, nutritional monitoring, effect of preoperative nutrition interventions, safety of early EN, and further identification of patient groups most at risk of malnutrition.

CONCLUSION

Preoperative malnutrition assessed using the SGA is prevalent in patients undergoing CRS/HIPEC across a diverse group of primary cancer types, and postoperative morbidity is common. Malnutrition is linked to LOS and plays a role in postoperative outcomes such as infection. Routine preoperative nutrition assessment is essential to identify patients at higher nutritional risk, and nutrition support should be provided preoperatively. Clear nutrition pathways are needed to optimize nutrition support and postoperative recovery.

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