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Prognostic factors associated with severe complications after cytoreductive surgery and HIPEC

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Abstract

Cytoreductive surgery (CRS) and hyperthermic intraperitoneal chemotherapy (HIPEC) can significantly improve outcomes in certain peritoneal carcinomatosis patient groups, but it is a complicated surgical procedure with high morbidity and mortality rates. Our study evaluated the preoperative and perioperative variables to understand whether any variable was associated with an increased risk of complications. We retrospectively evaluated thirty-three successive patients who underwent CRS and HIPEC between 2017 and 2020. Patients were assigned to Group 1 (15 patients) and Group 2 (18 patients) according to the severity of the complications. When the groups were compared in terms of age, gender, BMI, presence of the previous operation, presence of sarcopenia, primary malignancy, peritoneal cancer index, and cytoreduction completeness scores, no statistical differences were found. When the serum albumin levels in the preoperative and postoperative seventy-second hour were compared, both groups had a significant decrease (p=0.011 and p=0.001, respectively). When the decrease rate of serum albumin levels was compared, there was no significant difference (p=0.539). There was a statistically significant difference between the preoperative and postoperative seventy-second-hour haemoglobin levels in both groups (p=0.01 and p=0.00, respectively). When the groups were compared according to the decrease rate in haemoglobin levels, fall was more pronounced in patients with more severe complications (p=0.036). We concluded that the decrease in albumin levels and haemoglobin levels in the perioperative period is significant and that a significant decrease in haemoglobin levels in the first seventy-two hours may be pioneering data in terms of the development of serious complications. Therefore, closer monitoring of those patients and being more proactive in their treatment can contribute to the prevention of serious complications that may develop.

Keywords: Cytoreduction surgical procedures, hyperthermic intraperitoneal chemotherapy, prognosis, albümin, haemoglobin, postoperative complications

1. Introduction

Cytoreductive surgery (CRS) and hyperthermic intraperitoneal chemotherapy (HIPEC) can significantly improve outcomes in certain peritoneal carcinomatosis patient groups, proven in ovarian cancer, and future promising trials are in the pipeline for other malignancies (1).

It is a complicated surgical procedure with high morbidity (12-60%) and mortality rates (0.9-5.8%) (2,3). In addition to the patient's age (4) and comorbidities, peritoneal cancer index (PCI) and cytoreduction completeness (CC) scores also increase morbidity and mortality (5,6). It is known that the nutritional status of the patients in the preoperative period and the serum albumin level, which is an indicator of this, also affect morbidity and mortality. It has been shown that patients who have preoperative hypoalbuminemia and have undergone SRC and HIPEC have higher mortality (7-9). During those procedures, a significant protein loss is secondary to the exudating ascitic fluid and extensive surgical dissection. The postoperative decline in albumin levels is expected, which starts intraoperatively and continues postoperatively, with the need for exogenous replacement. Low preoperative haematocrit is also a prognostic marker and affects long-term survival in ovarian cancer patients undergoing CRS (10).

Over the years since its introduction in the 1980s, better patient selection, improvements in surgical techniques, and refined perioperative management strategies have further reduced the morbidity and mortality of CRS and HIPEC and improved survival.

Our study evaluated the preoperative and perioperative variables of our consecutive thirty-three CRS and HIPEC patients. We tried to understand whether any variable was associated with an increased risk of complications and aimed to find out whether the rate of decrease in serum albumin and haemoglobin levels in the first seventy-two hours is a harbinger of more severe complications.

2. Materials and Methods

All patients diagnosed with peritoneal carcinomatosis in our hospital are referred to the 'Peritoneal Cancers Centre'. A dedicated surgery team makes initial clinical evaluations and schedules work-up studies. Patients are also evaluated by Medical Oncology and Radiation Oncology teams. All results of the patients are discussed in the 'Peritoneal Cancers Tumour Board', and the treatments are tailored according to the recommendations.

In this study, we retrospectively evaluated the electronic

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records of thirty-three successive patients who underwent CRS and HIPEC between 2017 and 2020. Patients were assigned into two groups according to the severity of the complications. Fifteen patients with less severe complications according to the modified Dindo-Clavien system (11) (Modified Dindo-Clavien 1 and 2) were assigned to Group 1, and 19 patients with more severe complications (Modified Dindo-Clavien 3 to 5) were assigned to Group 2.

Groups were compared according to age, gender, body mass index (BMI), presence of previous surgery, sarcopenia status, peritoneal cancer index (PCI), primary site, surgically intervened organs, cytoreduction completeness (CC) score and length of hospital stay. Preoperative and postoperative seventy-second-hour serum albumin and haemoglobin levels were compared. For both variables, serum albumin and haemoglobin levels, the rates of change in both groups within 72 hours were calculated, and the two groups were also compared in terms of these rates.

The psoas muscle index is used to evaluate sarcopenia. In the calculation, we use psoas muscles located at the third lumbar vertebra (L3), the level of the umbilical fossa. In preoperative CTs, the index is determined by dividing the mean area of these muscles, calculated as cm^2, by the body surface area, calculated as m^2 (cm^2/m^2). Considering Hamaguchi's study, since this index differs between men and women, sarcopenia was considered below the level of 6.36 cm^2/m^2 in men and 3.92 cm^2/m^2 in women (12).

Preoperative CT first anticipated the PCI of the patients. This foresight was a crucial decisive factor in our tumour board discussions, and we are usually reluctant to CRS in patients with high PCI (ex. >20). The definitive calculation was performed during the surgical exploration. The largest tumour sizes are measured in pre-defined 13 regions, and the region without a tumour is scored as '0'. If the tumour size is smaller than 0.5 cm, 1 point; if it is between 0.5 to 5 cm, 2 points and if it is more significant than 5 cm, 3 points. According to the tumour size in these 13 regions, the PCI was calculated to be a maximum of 39 (13).

The CC score was evaluated according to the tumour burden remaining at the end of the surgery. Since intraperitoneal chemotherapy would be effective if the remaining tumour size is less than 2.5 mm, patients with a CC score of 0 and 1 are defined as "complete cytoreduction" and other patients (CC score > 1) as "incomplete cytoreduction".

Patients were followed up in the ICU in the postoperative period according to our pre-determined multidisciplinary follow-up plan. Besides daily electrolytes, complete blood count, blood proteins, and lactate levels, more extensive laboratory examination panels were ordered on the third postoperative day. Alongside necessary interventions for hemodynamic stability and electrolyte imbalances, transfusion requirements (erythrocyte, fresh frozen plasma, albumin) are fulfilled according to our standard protocol.

The descriptive statistics were given as mean, standard deviation, median, minimum, maximum, frequency, and ratio values. The distribution of the variables was tested with the Kolmogorov-Smirnov test. The Mann-Whitney U test was used to analyze the quantitative independent variables, the chi-square test was used to analyze the qualitative independent variables, and the Wilcoxon test was used to compare the two paired groups. The analyses are performed using the SPSS 27.0 program (IBM Corp., Armonk, NY, United States).

3. Results

Among 33 patients 25 were female (75.8%), and eight were male (24.2%). The median age of the cohort was 52 years. Twenty-six patients (78.8%) had previous operations, and nine (27.3%) had sarcopenia. When we evaluated the patients in terms of their primary cancer, the most common site was the ovary (14 patients; 42.4%), followed by the gastric (8 patients; 24.2%) and colon cancer (7 patients; 21.2%) (Table 1a).

Table 1a. Gender distribution, presence or absence of previous operation and sarcopenia of the patients, and type of primary malignancies

	n	
Gender		
Female	25	75.8
Male	8	24.2
Previous operation		
Present	26	78.8
Absent	7	21.2
Sarcopenia		
Present	9	27.3
Absent	24	72.7
Primary malignancy		
Colon	7	21.2
Gastric	8	24.2
Ovary	14	42.4
Pancreas	1	3.0
Primary peritoneal	3	9.1
Cytoreduction Completeness		
Complete	28	84.8
Incomplete	5	15.2

Median BMI was calculated as 27 kg/m^2. The median preoperative albumin values of the patients were 3.3 g/dL, and the mean was 3.46 ± 0.79 g/dL. The median haemoglobin level was 11.7 g/dL, and the mean was 11.49 ± 1.27 g/dL (Table 1b).

Except for the peritoneum, which is a component of the surgery, the most frequently intervened organs at the surgeries were the omentum (60.6%), colon (54.5), gall bladder (48.5%) and lymph nodes (45.5%) (Table 2).

The median PCI value of our cohort was 10 (Table 1b). Twenty-eight patients (84.8%) had complete cytoreduction with 0 CC score, and five patients (15.2%) had incomplete cytoreduction (Table 1a). The median length of stay was nine days, and the mean was 14.79 ± 13.48 days (Table 1b).

Group 1 consisted of 15 patients with low modified Dindo-Clavien system complication scores (0 – 2), and Group 2 consisted of 19 patients with more serious Dindo-Clavien complication scores (3 to 5).

Table 1b. Age, body mass index (BMI), peritoneal cancer index (PCI), preoperative serum albumin and hemoglobin levels

	Min - Max	Median	Mean ± sd
Age	23 - 68	52.00	49.88 ± 11.19
BMI (kg/m^2)	18.50 - 43.10	27.00	27.24 ± 5.35
PCI	3 - 26	10.00	10.73 ± 5.60
Preoperative serum albumin level (g/dL)	2.10 - 4.90	3.30	3.46 ± 0.79
Preoperative hemoglobin level (g/dL)	9.10 - 14.10	11.70	11.49 ± 1.27
Length of stay (day)	5-63	9.00	14.79 ± 13.48

Table 2. Surgically intervened organs during cytoreductive surgeries

	n	%
Stomach	9	27.3
Liver	2	6.1
Gall bladder	16	48.5
Spleen	14	42.4
Head of pancreas	1	3.0
Tail of pancreas	2	6.1
Colon	18	54.5
Appendix	9	27.3
Rectum	10	30.3
Small intestine	11	33.3
Uterus and ovaries	12	36.4
Lymph nodes	15	45.5
Omentum	20	60.6
Rib	1	3.0
Ureter	1	3.0
Bladder	1	3.0
Abdominal wall	2	6.1

Fifteen patients in Group 1 had a median age of 52, and 18 patients assigned to Group 2 had a median age of 51.5 (Table 3a). Thirteen of the patients in Group 1 and 11 in Group 2 were female (86.7% and 66.7%, respectively) (Table 3b). The patients' mean BMI was 27.7 kg/m^2 in Group 1 and 26.8 kg/m^2 in Group 2 (Table 3a). Twelve patients (85.7%) had a history of previous surgery in Group 1 and 14 (73.6%) in Group 2. Three patients (21.4%) in Group 1 and 6 (31.5%) in Group 2 had sarcopenia (Table 3b). The median PCI score was 12 and 9, respectively (Table 3a). The most frequently intervened organs during the surgeries were the omentum (60%) and gall bladder (53.3 %) in Group 1, colon (66.7%) and omentum (61.1%) in Group 2. Thirteen patients (86.7%) had complete cytoreduction in Group 1 and 15 (83.3%) in Group 2 (Table 3b). The mean length of stay was 8.9 days in Group 1 and 19.7 days in Group 2 (Table 3a).

Only six minor complications, like postoperative fever, superficial surgical site infection, urinary retention, and atelectasis, were developed in Group 1 patients. In Group 2 patients, 18 complications developed. Seven patients (38.9%) had intra-abdominal abscesses requiring percutaneous drainage. Five patients (27.8%) had anastomotic leakage requiring relaparotomy and an open abdomen with negative pressure wound therapy (NRWT). Three patients (16.7%) had deep surgical site infections requiring debridement and vacuum-assisted closure (VAC). Two patients (11.1%) had pneumothorax requiring tube thoracostomy, and one (5.6%) had small bowel perforation. Six patients (40%) were readmitted in Group 1, and 2 (11.1%) were readmitted in Group 2.

Table 3a. Comparison of age, body mass index (BMI), peritoneal cancer index (PCI), and length of stay (^{m} Mann-Whitney U test: Analyse the quantitative independent variables)

	Group 1 (n=15)		Group 2 (n=18)		*p*
	Median	Mean ± sd	Median	Mean ± sd	
Age	52.00	50.4 ± 12.0	51.50	49.4 ± 10.8	0.957^{m}
BMI (kg/m^2)	28.50	27.7 ± 4.4	26.50	26.8 ± 6.1	0.199^{m}
PCI	9.00	10.0 ± 6.0	12.00	11.3 ± 5.4	0.425^{m}
Length of (day)	8.00	8.9 ± 2.5	11.50	19.7 ± 16.7	**0.003^{m}**

Table 3b. Comparison of gender distribution, presence or absence of previous operation and sarcopenia of the patients, primary malignancies, surgically intervened organs, and cytoreduction completeness (^{m} Mann-Whitney U test: Analyse the quantitative independent variables; ^{x2} Chi-square test: Analyse the qualitative independent variables)

	Group 1 (n=15)		Group 2 (n=18)		*p*
	n	%	n	%	
Gender					
Female	13	86.7	12	66.7	0.182^{x2}
Male	2	13.3	6	33.3	
Previous operation					
Present	13	86.7	13	72.2	0.312^{x2}
Absent	2	13.3	5	27.8	
Sarcopenia					
Present	5	33.3	4	22.2	0.475^{x2}
Absent	10	66.7	14	77.8	
Primary malignancy					
Colon	3	20	4	22	0.785^{m}
Gastric	3	20	5	28	0.911^{m}
Ovary	7	47	7	39	0.923^{m}
Pancreas	0	0	1	6	1.000^{m}
Primary peritoneal	2	13	1	6	0.579^{m}
Intervened organs					
Stomach	3	20.0	6	33.3	0.392^{m}
Liver	1	6.7	1	5.6	1.000^{m}
Gall bladder	8	53.3	8	44.4	0.611^{m}
Spleen	7	46.7	7	38.9	0.653^{m}
Head of pancreas	0	0.0	1	5.6	1.000^{m}
Tail of pancreas	0	0.0	2	11.1	0.489^{m}
Colon	6	40.0	12	66.7	0.126^{m}
Appendix	5	33.3	4	22.2	0.475^{m}
Rectum	4	26.7	6	33.3	0.678^{m}
Small intestine	3	20.0	8	44.4	0.138^{m}
Uterus and ovaries	5	33.3	7	38.9	0.741^{m}
Lymph nodes	6	40.0	9	50.0	0.566^{m}
Omentum	9	60.0	11	61.1	0.948^{m}
Rib	1	6.7	0	0.0	0.455^{m}
Ureter	0	0.0	1	5.6	1.000^{m}
Bladder	0	0.0	1	5.6	1.000^{m}
Abdominal wall	1	6.7	1	5.6	1.000^{m}
Cytoreduction Completeness					
Complete	13	86.7	15	83.3	0.790^{x2}
Incomplete	2	13.3	3	16.7	

When we compared the groups in terms of age, gender, BMI, presence of the previous operation, presence of sarcopenia, primary malignancy, PCI, and CC scores, no statistical differences were found (Table 3 a & b). Lymph node dissection was higher in Group 1, and gastric resection was higher in Group 2, but these differences did not reach statistical significance ($p > 0.05$) (Table 3b). It was observed that the patients in the second group stayed longer in the hospital (19.7 ± 16.7 days) when compared with the first group (8.9 ± 2.5 days) ($p<0.05$) (Table 3a).

When the serum albumin levels in the preoperative and postoperative seventy-second hour were compared, both groups had a statistically significant decrease. In Group 1, the mean preoperative serum albumin level was 3.6±0.8 g/L, and the postoperative seventy-second hours mean level was 2.7±0.6 g/L. The decrease was calculated as 20.6% (p=0.011). In Group 2, the mean preoperative serum albumin level was 3.4±0.8 g/L, and the postoperative seventy-second-hour mean level was 2.4±0.8 g/L. The decrease was 26% (p=0.001) (Table 4).

Table 4. Comparison of preoperative and postoperative 72. hours serum albumin and hemoglobin levels. Rate of changes of these variables between Group 1 and Group 2 were also compared ([m] Mann-Whitney u test: Analyse the quantitative independent variables.) Ingroup changes of preoperative and postoperative 72. hours serum albumin and hemoglobin levels were also compared ([w] Wilcoxon test: Compare two paired groups)

	Group 1 (n=15)	Group 2 (n=18)	p
	Mean ± sd	Mean ± sd	
Serum albumin level (g/dL)			
Preoperative	3.6 ± 0.8	3.4 ± 0.8	0.480[m]
Postoperative 72. hrs	2.7 ± 0.6	2.4 ± 0.8	0.070[m]
Rate of change (%)	-20.6 ± 26.1	-26.0 ± 24.0	0.539[m]
Ingroup change	***p*=0.011**[w]	***p*=0.001**[w]	
Hemoglobin level (g/dL)			
Preoperative	11.5 ± 1.2	11.5 ± 1.4	0.800[m]
Postoperative 72. hrs	9.4 ± 1.4	8.7 ± 1.3	0.186[m]
Rate of change (%)	-17.5 ± 10.5	-24.6 ± 7.8	**0.036**[m]
Ingroup change	***p*=0.001**[w]	***p*=0.000**[w]	

When the groups were compared, there was no statistically significant difference between the groups' preoperative and postoperative seventy-second-hour serum albumin levels (p=0.48 and p=0.07, respectively). When the decreased rate of serum albumin levels (Group 1: 20.6% and Group 2: 26%) were compared, there was also no statistically significant difference (p=0.539) (Table 4).

There was a statistically significant difference between the preoperative and postoperative seventy-second-hour haemoglobin levels in both groups. In Group 1, the mean preoperative haemoglobin level was 11.5±1.2 g/dl, the postoperative seventy-second-hour level was 9.4±1.4 g/dl, and the decrease rate was 17.5±10.5% (p=0.01), (Table 4). In Group 2, the mean preoperative haemoglobin level was 11.5±1.4 g/dl, the postoperative seventy-second-hour level was 8.7±1.3 g/dl, and the decrease rate was 24.6±7.8% (p=0.00).

When the groups were compared, there was no statistically significant difference between the groups' preoperative and postoperative seventy-second-hour haemoglobin levels (p=0.80 and p=0.186, respectively). However, when the groups were compared according to the decrease rate in haemoglobin levels (Group 1: 17.5±10.5% and Group 2: 24.6±7.8%), fall was more pronounced in patients with more severe complications, Group 2 and this difference was statistically significant (p=0.036), (Table 4).

4. Discussion

Extensive surgery, prolonged hospital stays, high morbidity, increased risk of rehospitalization, and high mortality rates negatively affect the enthusiasm of surgeons and patients who can benefit from CRS and HIPEC (1).

Available CRS and HIPEC-specific data evaluating postoperative risk and complications are minimal and primarily by small sample size, and thus, reproducibility of the data is a significant limitation (3). The impact of preoperative, perioperative, and postoperative variables on surgical outcomes was explored in different studies, but the prognostic importance of those variables is still unclear (2). We also have limited data about the consequences of variation of those values on patient outcomes, especially on complication rates. However, identifying variables, particularly modifiable ones that impact the outcome, will be helpful. Thus, we can have an individualized risk assessment, tailor our treatment plans according to those data and improve the clinical results. Determining patients expected to have a higher rate of complication risk may also evoke early and proactive interdisciplinary planning and enable more effective resource management, treatment modification, and shared decision-making with patients.

Our study evaluated the preoperative and perioperative variables of our thirty-three consecutive CRS and HIPEC patients. We tried to understand whether any variable was associated with an increased risk of complications. For this purpose, we grouped our patients into clinically insignificant complications (Group 1) and those with more severe complications (Group 2). By comparing the variables of the patients in these two groups, we evaluated whether any variable was associated with the development of more severe complications. We also evaluated the preoperative and seventy-second-hour serum albumin and haemoglobin levels of the patients in these two groups and the rate of change during this period; at this moment, we intended to understand whether the decrease in serum albumin and haemoglobin levels differed between the two groups. That is, we aimed to find out whether the rate of decrease in serum albumin and haemoglobin values in our cohort was a harbinger of more severe complications in the CRS and HIPEC patients.

Cardi et al. reported that ASA score, blood loss, performance status, PCI, large bowel resection, postoperative serum albumin levels, and nutritional status correlated with a higher risk for postoperative infectious complications in CRS and HIPEC patients (7). Collins et al. investigated perioperative variables associated with prolonged Intensive Care Unit (ICU) admission following CRS for ovarian cancer (14). Significant intraoperative variables associated with prolonged ICU stay included greater duration of operation, more significant estimated blood loss, the requirement for intraoperative blood transfusion, bowel resection, and greater total volume of intraoperative fluids transfused. Postoperative variables associated with prolonged ICU stay included higher immediate postoperative lactate, lower postoperative albumin (30 versus 24 g/dl, p=0.018), and requirement for postoperative blood transfusion (p=0.001).

In our study, the groups assigned according to the severity of the complications were compared. There was no statistically significant difference in age, gender, BMI, presence of the previous operation, sarcopenia, primary malignancy, PCI, and CC scores (Table 3). The only difference was in hospital stay, and in Group 2, patients with severe complications stayed longer in the hospital when compared with the first group ($p<0.05$) (Table 3). In addition to this predicted finding, it was observed that the first group of patients with shorter hospitalization periods had a higher rate of readmission. While six patients in this group needed rehospitalization (40%), the number of patients who needed rehospitalization was limited to two (11.1%) in the second group. This data was noted for reconsideration of the accelerated discharge policy in patients who did not develop significant complications and whose recovery process was quick and uneventful.

Wiseman et al. published a textbook outcome (TO) for patients who underwent CRS ± HIPEC between 1999 and 2017 from 12 institutions (8). A TO was defined as the absence of the following criteria: completeness of cytoreduction >1, reoperation within 90 days, readmission within 90 days, mortality within 90 days, any 'grade ≥ 2' complications, hospital stay above 75th percentile, and non-home discharge. Among 1904 patients who underwent CRS, only 30.9% achieved a TO, most commonly because of postoperative complications. On multivariable analysis, besides a couple more, albumin ≥3.5 g/dl and blood loss ≤1000 ml were found to be associated with achieving a TO ($p < 0.05$). They also concluded that failure to achieve a TO is common and independently associated with worse overall survival.

Our study evaluated the patient's preoperative and postoperative seventy-second-hour serum albumin levels. In Group 1, we found a vital decrease (20.6%) in seventy-second-hour serum albumin levels, which were also statistically significant (p=0.011). Likewise, the decrease in serum albumin levels in a seventy-second hour was explicit (26%) and statistically significant (p=0.001) in Group 2 (Table 4).

When we compared the groups regarding the preoperative and postoperative seventy-second-hour serum albumin levels, we found no difference in Group 1 and Group 2 patients' serum albumin levels at these two-time points (p=0.48 and p=0.07, respectively). Furthermore, the decreased rate of serum albumin levels (Group 1: 20.6% and Group 2: 26%) were compared and again, no statistically significant difference was found between the groups (p=0.539) (Table 4).

We noticed a significant albumin loss both in the intraoperative and early postoperative period and significant decreases in serum albumin levels right at the beginning of our SRC and HIPEC experience. Thus, we determined frequent intraoperative and postoperative measurement times and standardized our transfusion criteria. Despite this practice, our study noticed a significant decrease in patient's seventy-two-hour serum albumin levels compared to preoperative values. This finding was valid for both Group 1 and Group 2. This data showed us that we may consider reviewing our transfusion policy and can decrease our threshold for transfusion. When the decrease rates of both groups were compared, there was no difference between them, revealing that the decrease in serum albumin level was not one of the determining factors in the development of complications. Of course, we need prospective studies evaluating more patients to confirm this data and conclusion.

Our study also evaluated the patient's preoperative and postoperative seventy-second-hour haemoglobin levels. In Group 1, we found a vital decrease (17.5%) in seventy-second-hour haemoglobin levels, which was statistically significant (p=0.001). Additionally, the decrease in haemoglobin levels in a seventy-second hour was prominent (24.6%) and statistically significant (p=0.00) also in Group 2 (Table 4).

In our study, when the groups were compared, there was no statistically significant difference between the groups' preoperative and postoperative seventy-second-hour haemoglobin levels (p=0.80 and p=0.186, respectively). However, when the first group was compared with the second group according to the decreased rate in haemoglobin levels (Group 1: 17.5% and Group 2: 24.6%), the fall was found to be more pronounced in Group 2 patients, and this difference was statistically significant (p=0.036), (Table 4).

In our SRC and HIPEC surgeries, we prioritise the patient's haemoglobin level, like serum albumin level. In this study, the seventy-second-hour haemoglobin values were significantly decreased compared to the preoperative levels in both groups. This data can be implemented in our clinical practice, and we may consider early interventions for those patients. One of the most striking results of our study was that the rate of decrease in haemoglobin level was significantly pronounced in Group 2 patients compared with Group 1 (p=0.036). With this limited data, the risk of developing severe complications may be higher in patients with a more significant decrease in haemoglobin levels in the first seventy-two hours. Therefore, closer monitoring of those patients and being more proactive in their treatment can contribute to the prevention of serious complications that may develop and may improve patient outcomes. Of course, this inference must be evaluated in prospective, randomized, multicentre studies involving many patients. Being a retrospective, single-centre study with a limited number of patients is the main limitation of our study. Another significant limitation of our study is that it was carried out on thirty-three patients with different primary diseases and disease burdens that need to be intervened. Since it was a non-randomized study, the effects of patient's comorbidities on the development of complications could not be evaluated. In addition, although standard cut-off values and protocols were used for transfusions, we must accept the bias potential in serum levels due to the individual characteristics of patients.

We also know that the prevention of complications not only affects the perioperative period but has a positive impact on long-term cancer outcomes and survival rates (15,16). This information further increases the importance of targeted treatments for variables that we have shown to coexist in seriously complicated patients undergoing CRS and HIPEC.

In conclusion, we evaluated the variables in the patient groups with mild and severe complications and tried to reveal the variables that will increase the risk for severe complications. We obtained clues that the decreases in serum albumin and haemoglobin levels at the end of seventy-two hours are significant. Patients with severe complications have a more prominent haemoglobin drop at this time. Our results need to be validated with prospective and randomized studies. However, the risk of complications in CRS and HIPEC patients can be further reduced with early warning systems being created under the guidance of those variables.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Authors' contributions

Concept: H.K.R., H.K.T.,Design: H.K.R., H.K.T., Data Collection or Processing: A.E., Analysis or Interpretation: H.K.T., Literature Search: H.K.R., Writing: H.K.R., H.K.T.

Ethical Statement

The study was conducted following the Declaration of Helsinki (revised in 2013) and was approved by the Anadolu Medical Center Hospital review board and ethics committee (ASM-EK-22/192).

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