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Selected Body Composition Parameters Analysis Based on Bioelectrical Impedance in Patients Operated for Gastrointestinal Cancer

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Abstract. *Background/Aim: Bioelectrical Impedance Analysis is a method that evaluates body composition, useful in assessing the nutritional status of cancer patients. The analysis of its indicators may be helpful in predicting clinical course. The aim of the study was to evaluate the following body composition parameters: fat mass (FM), fat-free mass (FFM), skeletal muscle mass (SMM), muscle mass index (MMI), visceral fat (VF) and body mass index (BMI) measured before and after surgery in patients with gastrointestinal cancer and to determine the relationship between body composition and the course of treatment. Patients and Methods: The study included 125 patients, aged 65-68, operated on due to gastric, pancreatic or colorectal cancer. Body composition was assessed with electrical bioimpedance before and on the fifth postoperative day. The severity of complications was assessed with the Clavien-Dindo classification. Results: In the whole group of patients, the percentage of FM, VF, and BMI levels measured before surgery were significantly higher in curative surgery patients in comparison to palliative surgery patients, p<0.001. The MMI value was also significantly higher, p=0.045. In patients after curative surgery, the values of BMI and FM significantly decreased (BMI – p<0.001; FM – p=0.003) after the surgery. There was no relation between body composition parameters and severity of postoperative complications. Conclusion: In the investigated group, body composition differed between radical and palliative surgery groups. Surgery with curative intent produced more changes in body composition parameters in the early postoperative period than palliative surgery. These observations may be helpful in prehabilitation planning for such patients.*

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Body composition analysis with use of Bioelectrical Impedance Analysis (BIA) is increasingly adapted in clinical practice alongside computed tomography. Global Leadership Initiative on Malnutrition (GLIM) experts recommend bioimpedance measurements in the phenotypic and etiological criteria determining the nutritional status (1). BIA is a non-invasive method; its advantages are its low cost and easy measurements. The accuracy of estimating body mass composition in relation to the reference values has been confirmed by numerous studies (2-5). Using this method, it is possible to determine parameters such as: adipose and lean tissue, muscle and visceral fat tissue, total, intra, and extracellular water contained in the body, and cellular body mass.

This method can be used to compare the patient's body composition at different stages of surgical treatment, which may be a prognostic factor for the occurrence of postoperative complications (6). In patients with cancer, especially gastrointestinal cancer, there are frequent eating disorders that negatively affect the functioning of the body, the activity of the immune system, and postoperative recovery (7). As there is still no consensus regarding the optimal body composition testing method, the use of analysis based on bioimpedance along with the routine methods of nutritional assessment seems reasonable. Measurements of

Table I. *Characteristics of the study group.*

		All patients n=125		Gastric cancer n=56		Pancreatic cancer n=43		Colorectal cancer n=26	
		n	%	n	%	n	%	n	%
Sex	F	52	41.6	14	25	25	58.1	13	50.0
	M	73	58.4	42	75	18	41.9	13	50.0
Surgery	Curative	99	79.2	45	80.3	28	65.1	26	100.0
	Palliative	26	20.8	11	19.7	15	34.9	0	0.0
Complications	CD Score* ≤2	95	76.0	37	66.1	34	79.0	24	92.3
	CD Score* >2	39	24.0	19	33.9	9	21.0	2	7.7
		(3 deaths)	(2.4)	(3 deaths)	(5.4)				

*The severity of postoperative complications according to Clavien-Dindo scale. F: Female; M: male; SD: standard deviation.

skeletal muscle mass and/or adipose tissue have proven effective in predicting various disorders in many fields of medicine, which further supports the argument for introducing such a method into clinical practice (8, 9). Nevertheless, the use of this tool requires an analysis of the obtained results in the context of various diseases, clinical situations, complications, and prognosis.

The aim of the study was to assess the following parameters of body composition: fat mass (FM), fat-free mass (FFM), skeletal muscle mass (SMM), muscle mass index (MMI), visceral fat (VF), and body mass index (BMI), in patients aged over 65, before and after surgery performed due to gastrointestinal cancer, and to determine the relationship between body composition and the course of treatment.

Patients and Methods

This prospective study recruited 125 patients, 52 women (41.6%) and 73 men (58.4%). The age of the patients ranged between 65-68 years. The research was prospective in nature and was carried out at the Department of General, Oncological, Gastroenterological and Transplant Surgery Jagiellonian University Medical College in Krakow in 2019.

The inclusion criteria were: age over 65, elective surgery, diagnosed gastric, pancreatic or colorectal cancer, expressed informed consent to participate in the study. The exclusion criteria were: age below 65, emergency surgery, no confirmation of cancer diagnosis in histopathology results, presence of a pacemaker and significant metal implants (possible incorrect BIA results).

The study included 56 patients with gastric cancer, 43 with pancreatic cancer, and 26 patients with colorectal cancer (Table I).

Body composition was measured using the BIA, a method based on the OMRON BF511 medical device, which enables the measurement of body fat and visceral tissue, as well as the level of skeletal muscles and BMI. The device has been approved for medical applications and complies with the EN60601-1-2: 2001 standard in terms of immunity and emissions. The device is based on eight-sensor technology using both hands and feet. An alternating current [50 kHz, 0.5 mA (milliamperes)] is applied (10).

In our own study, the percentage of FM was analyzed with the calculation of FFM, percentage of SMM, MMI, the level of VF and BMI. MMI was calculated as the ratio of total skeletal muscle mass to the square of body height in m.

Prior to patient admission to the hospital, during the outpatient clinic visit, each patient was informed about the BIA test and recommendations: not to drink alcohol for at least 48 h before the examination; not to perform vigorous exercise for at least 12 h before the examination, and not to eat for 4 h before the examination.

During hospitalization, two measurements were taken in each patient: on the day of admission (before the surgery) and on the 5th postoperative day. The measurements were taken in the morning before breakfast and after emptying the bladder. The examinations were performed in accordance with the manufacturer's instructions.

The study group was divided into two subgroups depending on the type of surgery (curative and palliative surgery). In the case of curative treatments, total or partial gastric resection was performed in patients with gastric cancer, in pancreatic cancer patients – pancreatoduedenectomy or distal pancreatic resection, and in patients with colorectal cancer – hemicolectomy, abdominoperineal rectal resection or anterior rectal resection. Palliative procedures included bypass anastomosis, nutritional microjejunostomy and exploratory laparotomy or laparoscopy.

In the study group the occurrence and severity of the postoperative in-hospital complications were analyzed. Complications were stratified according to the Clavien-Dindo classification (11).

Statistical analysis. The normality of the distribution of variables was tested using the Shapiro-Wilk test and the analysis of histograms. Data are presented as means with standard deviation (SD) or medians with first and third quartiles (Q1-Q3), depending on the distribution of the variables. One-way analysis of variance was used to test mean differences between groups. In case of failure to meet the assumptions of the one-way analysis of variance, the Kruskal-Wallis test (post hoc-Dunn test with Bonferroni correction) was used. To test the differences in the distribution of variables between the groups, the Student's *T*-test for independent samples or the Mann-Whitney *U*-test was used, depending on the fulfillment of assumptions. The level of statistical significance was assumed to be p=0.05. In the case of missing data, the observations were removed in pairs.

The study was conducted and developed in accordance with the principles of Good Scientific Practice, the Act of 10 May 2018 on the protection of personal data, the principles of the Helsinki Declaration, the Regulation (EU) 2016/679 of the European

Table II. *Patients' body composition before surgery.*

		Gastric cancer (a)	Pancreatic cancer (b)	Colorectal cancer (c)	*p*-Value	Multiple comparisons	*p*-Value
BMI (kg/m^2)	Mean (SD)	25.74 (4.69)	24.01 (4.87)	25.46 (3.57)	0.158		
FM (%)	Mean (SD)	25.87 (10.81)	27.48 (9.94)	28.88 (6.64)	0.310		
FFM (%)	Mean (SD)	74.07 (10.90)	72.52 (9.94)	71.12 (6.64)	0.332		
SMM (%)	Median	31.80	29.90	29.00	0.065		
	(Q1-Q3)	(28.48-35.98)	(26.30-36.70)	(26.20-35.60)			
VF (level*)	Median	9.50	7.00	7.50	0.167		
	(Q1-Q3)	(6.75-12.00)	(5.00-9.00)	(6.00-10.25)			
MMI (kg/m^2)	Median	8.40	7.07	7.50	**0.003**	a>b	0.818
	(Q1-Q3)	(7.43-9.21)	(6.17-8.28)	(6.64-8.53)		b<c	**0.002**
						c<a	0.235

*Visceral fat level range on the ordinal scale from 1-59. Statistically significant *p*-values are shown in bold. SD: Standard deviation; BMI: body mass index; FM: fat mass; FFM: fat-free mass; SMM: skeletal muscle mass; VF: visceral fat; MMI: muscle mass index.

Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation) (12, 13).

The study obtained approval of the Bioethics Committee No. 1072.6120.197.2019.

Results

Preoperative body composition. Table II compares the preoperative body composition between the groups of patients with gastric, pancreatic, and colorectal cancer. Only the MMI differed statistically significantly between patients with different cancers (p=0.003). In post-hoc analysis, MMI was significantly lower in the group of patients with pancreatic cancer as compared to the group of patients with colorectal cancer (p=0.002) (Table II).

In the entire study group, the percentage of FM, the level of VF, and BMI were significantly higher among patients who underwent curative surgery in comparison to palliative surgery patients (p<0.001). Also, the MMI value was significantly higher in patients undergoing curative treatment (p=0.045). On the other hand, the percentage of SMM content in curative surgery patients was significantly lower (p=0.006) (Table III).

The groups of patients with gastric cancer and pancreatic cancer were also analyzed separately. In the group of patients with gastric cancer, statistically significant differences were found between all parameters except MMI. The BMI, the percentage of FM, and the level of VF were significantly lower (Table IV).

Palliative pancreatic cancer patients had significantly lower BMI and percentage of adipose tissue than patients operated curatively, while the differences between remaining parameters did not reach statistical significance (Table V).

Table III. *Patients' body composition before surgery, taking into account the type of surgery.*

	All patients		
	Curative surgery	Palliative surgery	*p*-Value
BMI (kg/m^2)			
Mean (SD)	26.04 (4.12)	21.45 (4.50)	**<0.001**
FM (%)			
Mean (SD)	29.07 (8.58)	19.36 (10.40)	**<0.001**
SMM (%)			
Median	30.05	35.40	**0.006**
(Q1-Q3)	(23.5-34.3)	(29.55-39.8)	
VF (level*)			
Median	9.00	6.00	**<0.001**
(Q1-Q3)	(6.00-11.25)	(3.00-7.50)	
MMI (kg/m^2)			
Median	7.99	6.91	**0.045**
(Q1-Q3)	(6.77-8.90)	(6.07-8.07)	

*Visceral fat level range on the ordinal scale from 1-59. Statistically significant *p*-values are shown in bold. SD: Standard deviation; BMI: body mass index; FM: fat mass; SMM: skeletal muscle mass; VF: visceral fat; MMI: muscle mass index.

Postoperative complications. Complications were analyzed on the basis of the Clavien-Dindo classification. In the entire study group, postoperative complications occurred in 56 patients (44.8%). The occurrence and grade of complications did not differ significantly between patients undergoing curative and palliative surgeries.

To see if there was any association between the preoperative body composition and the occurrence of complications, the following analysis was performed. The body composition was compared between the patients who

Table IV. *Body composition of patients with gastric cancer before surgery, taking into account the type of surgery.*

	Gastric cancer patients		
	Curative surgery	Palliative surgery	*p*-Value
BMI (kg/m^2)			
Mean (SD)	26.97 (4.04)	21. 27 (3.60)	**<0.001**
FM (%)			
Mean (SD)	28.61 (9.56)	15.46 (8.33)	**<0.001**
FFM (%)			
Mean (SD)	71.25 (9.62)	84.54 (8.33)	**<0.001**
SMM (%)			
Median	31.20	35.40	**0.017**
(Q1-Q3)	(27.80-34.80)	(29.90-41.18)	
VF (level*)			
Median	10.37	4.50	**<0.001**
(Q1-Q3)	(8.00-12.00)	(1.75-7.75)	
MMI (kg/m^2)			
Median	8.50	7.62	0.098
(Q1-Q3)	(7.59-9.32)	(6.51-9.19)	

*Visceral fat level range on the ordinal scale from 1-59. Statistically significant *p*-values are shown in bold. SD: Standard deviation; BMI: body mass index; FM: fat mass; FFM: fat-free mass; SMM – skeletal muscle mass; VF: visceral fat; MMI: muscle mass index.

Table V. *Body composition of patients with pancreatic cancer before surgery; taking into account the type of surgery.*

	Pancreatic cancer patients		
	Curative surgery	Palliative surgery	*p*-Value
BMI (kg/m^2)			
Mean (SD)	25.10 (4.53)	21. 98 (4.98)	**<0.044**
FM (%)			
Mean (SD)	29.99 (8.72)	22.79 (10.67)	**<0.022**
MM (%)			
Mean (SD)	29.67 (5.93)	32.55 (7.33)	0.170
VF (level*)			
Median	9.00	6.00	
(Q1-Q3)	(6.00-11.5)	(3.00-7.50)	0.163
MMI (kg/m^2)			
Mean (SD)	7.13 (1.58)	6.45 (1.72)	0.249

*Visceral fat level range on the ordinal scale from 1-59. Statistically significant *p*-values are shown in bold. SD: Standard deviation; BMI: body mass index; SMM: skeletal muscle mass; VF: visceral fat; MMI: muscle mass index.

Table VI. *Body composition of patients before surgery; taking into account the type of surgery.*

	All patients		
	CD Score*≤2	CD Score*>2	*p*-Value
BMI (kg/m^2)			
Mean (SD)	24.87 (4.54)	25.77 (4.73)	0.354
FM (%)			
Mean (SD)	27.07 (9.70)	26.99 (10.19)	0.969
SMM (%)			
Median	30.80	31.75	0.692
(Q1-Q3)	(26.90-35.60)	(27.73-36.25)	
VF (level**)			
Median	8.00	10.00	0.951
(Q1-Q3)	(5.75-10.00)	(3.00-12.00)	
MMI (kg/m^2)			
Median	7.71	8.18	0.763
(Q1-Q3)	(6.47-8.74)	(6.97-8.96)	

*The severity of postoperative complications according to Clavien-Dindo scale. **Visceral fat level range on the ordinal scale from 1-59. SD: Standard deviation; BMI: body mass index; FM: fat mass; SMM: skeletal muscle mass; VF: visceral fat; MMI: muscle mass index.

did and did not experience severe postoperative complications defined as grade 3 or more in Clavien-Dindo Scale. The analysis did not show any significant differences in individual parameters between the two groups. There was a tendency for a higher VF and BMI level in patients with severe complications as compared to patients with less severe complications (Table VI).

A comparative analysis of three selected body composition parameters (VF, MMI, BMI) was performed in the group of patients with gastric and pancreatic cancer and taking into account the type of surgery (Table VII). The analysis showed no significant differences in the selected parameters, both in gastric and pancreatic cancer, as well as after curative and palliative surgery. In patients with gastric cancer, the median VF was higher in patients who suffered from severe complications than in patients with minor complications (the result was not statistically significant). This observation also concerned patients who underwent curative surgery. Such a phenomenon has not been observed in patients with pancreatic cancer (Table VII).

In the study population, after curative surgery, the values of BMI and FM significantly decreased (BMI – $p<0.001$; FM – $p=0.003$) when compared to the values before surgery. In patients after palliative surgery, BMI also decreased, but the result did not reach the level of statistical significance (Table VIII).

Discussion

In this study, the elements of body composition were analyzed using bioelectric impedance. BIA is a useful diagnostic method commonly used due to the low cost of measurement and the accuracy of the obtained results. Body composition analysis is an important element of both diagnostic and therapeutic measure, as it gives an opportunity to assess changes in the body

Table VII. *Patients' body composition before surgery; taking into account the type of disease; surgery and postoperative complications.*

	Gastric cancer			Pancreatic cancer			Curative surgery			Palliative surgery		
	CD Score*≤2	CD Score*>2	*p*-Value	CD Score*≤2	CD Score*>2	*p*-Value	CD Score*≤2	CD Score*>2	*p*-Value	CD Score*≤2	CD Score*>2	*p*-Value
BMI (kg/m^2)												
Mean (SD)							25.69 (4.12)	27.14 (4.00)	0.121	21.81 (4.80)	20.28 (3.36)	0.811
Median	25.00	26.40	0.511	22.70	22.80	0.964						
(Q1-Q3)	(23.20-29.50)	(23.50-29.50)		(20.10-28.15)	(21.20-27.15)							
VF (level**)												
Mean (SD)										5.45 (3.35)	6.40 (4.62)	0.603
Median	6.00	11	0.131	7.00	6.00	0.869	8.00	11	0.096			
(Q1-Q3)	(2.00-8.50)	(7.75-12.25)		(4.75-9.00)	(4.75-9.00)		(6.00-11.00)	(7.00-12.00)				
MMI (kg/m^2)												
Mean (SD)							7.75 (1.43)	8.24 (1.38)	0.152	7.40 (1.95)	5.81 (0.73)	0.468
Median												
(Q1-Q3)	8.32	8.73	0.583	6.77	7.12	0.881						
	(7.23-9.21)	(7.23-9.21)		(6.15-8.32)	(6.08-7.84)							

*The severity of postoperative complications according to Clavien-Dindo scale. **Visceral fat level range on the ordinal scale from 1-59. BMI: Body mass index; VF: visceral fat; MMI: muscle mass index.

composition of patients and to monitor the effects of therapy. The assessment of individual changes in body composition is also applicable among surgical patients to monitor the course of treatment and prevent adverse effects (14, 15). This may particularly apply to the elderly. In this particular group of patients, the changes in body composition, including sarcopenia and increase in FM, may adversely affect the functional status and contribute to frailty syndrome development (16).

Authors of various publications have suggested that changes in body composition may influence treatment outcomes for various cancers. The decreased FFM is known to be a risk factor of poor prognosis in oncological patients (17, 18). Also, the presence of a high level of visceral adipose tissue may cause technical difficulties during surgeries, increase the rate of postoperative infections, and reduce the overall survival rate in gastric cancer (19).

In our study, selected parameters of the body composition: adipose (FM), lean (FFM) and skeletal muscle (SMM), body weight, and VF as well as MMI and BMI were estimated in patients undergoing surgery for gastric, pancreatic or colorectal cancer.

In our study, preoperatively, the comparison of groups of patients with gastric, pancreatic, and colorectal cancer in terms of FM, FFM, SMM, and VFA showed no significant differences. Only a significant difference in MMI was found between colorectal cancer and pancreatic cancer patients, $p=0.002$ (median 7.5 *vs.* 7.07).

In patients with pancreatic cancer, a tendency to lose muscle mass is considered a prognostic factor for postoperative complications. That is why the Skeletal Muscle Mass Index was developed (20). The alternative index-MMI, which was used in our study, is easier to obtain, as it does not require abdominal computed tomography (CT) examinations. We suggest that it can be an alternative when the CT scan is not available or multiple measurements in different points in time are needed.

In the FM analysis in the entire study group, the level of the parameter before surgery was significantly higher in patients who underwent curative surgery compared to palliative surgery ($p<0.001$). A similar observation was shown in patients with pancreatic cancer ($p=0.022$). This confirms the greater loss of FM in patients with advanced cancer (21).

In the comparative analysis of the pre- and postoperative measurements, in the group of patients who underwent curative treatments, the decrease in FM was significant, $p=0.003$ (mean FM 28.93% *vs.* 27.81%). In the group of patients undergoing palliative surgery, a decrease in FM was also observed, but not statistically significant. These results may indicate the body's reaction to a more extensive surgical trauma in the case of curative treatments. One cannot forget about the loss of operative specimen, which can be up to several kilograms. It is likely that fluid therapy in the early postoperative period also affects body composition.

Table VIII. *Comparison of body mass index (BMI), fat mass (FM), visceral fat (VF) and muscle mass index (MMI) values before and after surgery; taking into account the type of surgery*

		Curative surgery			Palliative surgery		
		Before surgery	After surgery	*p*-Value	Before surgery	After surgery	*p*-Value
BMI (kg/m^2)	Mean (SD)	25.76 (4.05)	25.18 (4.27)	**<0.001**	21.60 (4.48)	21.37 (3.76)	0.352
FM (%)	Mean (SD)	28.93 (8.65)	27.81 (8.09)	**0.003**	19.60 (10.42)	19.69 (9.01)	0.887
VF (level*)	Mean (SD)				5.46 (3.50)	5.38 (3.49)	0.776
	Median (Q1-Q3)	8.00 (6.00-11.00)	8.00 (6.00-11.00)	0.567			
MMI (kg/m^2)	Mean (SD)				7.27 (1.81)	7.22 (1.39)	0.864
	Median (Q1-Q3)	7.95 (6.69-8.82)	7.78 (6.53-8.78)	0.877			

*Visceral fat level range on the ordinal scale from 1-59. Statistically significant *p*-values are shown in bold.

Similarly, other authors' studies have shown that the surgical procedure contributed to the reduction in the adipose tissue content. In patients with gastric, pancreatic or colorectal cancer, after surgery, there was a loss of adipose tissue in each of the studied groups compared to that in the preoperative period by an average of 3 percentage points (22). The observations from our own research related to the decrease in FM after surgery were confirmed by a decrease in BMI after surgery compared to the preoperative period. A decrease in BMI was demonstrated in the entire group of patients studied. In the group of patients after curative surgery, the decrease was significant, $p<0.001$ (mean 25.76 *vs*. 25.18). The reduction in FM and BMI may be a consequence of an injury such as surgery (23), as well as the loss of surgically removed tissues.

Changes in the percentage of lean body mass were not always shown in the present study because with FM they add up to the sum of 100% and changes in one of the parameters reflect opposite changes in the other one. The muscle mass index (MMI) was used as a parameter independent of the percentage values.

Available research papers emphasize also the importance of maintaining muscle mass after surgery for cancer (24, 25). It has been shown that significant loss of muscle mass after surgery may lead to late postoperative complications and poor prognosis (26-29). Scientific reports also indicate that a decrease in muscle mass is associated with decreased FFM. It has been shown that in older patients with reduced FFM, sarcopenia is often diagnosed, as a result of which an increased rate of postoperative complications is observed (30). A meta-analysis of studies describing body composition assessment in 8,402 patients with gastric cancer showed that in the case of reduced FFM after gastrectomy, there is a higher rate of serious postoperative complications (31). A meta-analysis of studies describing overall survival after gastrectomy showed a worse prognosis in patients with reduced FFM (32). Similarly, in CT studies, it was found that a decrease in mass and deterioration in skeletal muscle function were associated with postoperative complications, prolonged hospital stay and a worse prognosis (33-42).

In our study, in the pre-and post-operative analysis, MMI decreased in the group of curative procedures (median 7.95 *vs*. 7.78) and in the group of palliative surgeries (mean 7.27 *vs*. 7.22), but not significantly. No association between post-operative complications and preoperative MMI was found.

Another parameter of body composition included in our study was visceral adipose tissue.

In recent years, the role of visceral obesity in the progression of cancer and its comorbidities has been studied (43, 44). Some cancer patients, especially in the early stages, tend to consume excess energy daily with limited daily physical activity. As a consequence, they can develop sarcopenic obesity. A tumor of gastrointestinal origin may also affect digestion and nutrient absorption. Therefore, the metabolic transformation and nutritional management differ in patients with different body composition (45). Patients with different VF status require different energy composition and macronutrients (46). In view of the above facts, visceral obesity should be diagnosed before surgery in order to select an appropriate surgical method and undertake interventions to prevent complications. In addition, low-grade chronic inflammation produced by excessive visceral adipose tissue is considered a suitable microenvironment for tumor progression. Growth factors released by visceral adipose tissue also mediate cancer progression (43, 44). In our study, the VF values were within the normal range in the entire group before the surgery. It was observed that patients who underwent palliative surgery had a significantly lower level of VF compared to patients who underwent curative surgery, $p<0.001$ (median 6.00 *vs*. 9.00). Thus, in these patients, in addition to FM, visceral fat also decreased. In the analysis of the entire study group, the level of VF was slightly higher

in patients with severe postoperative complications compared to patients with less severe complications (median 10.00 *vs*. 8.00). In the subgroup analysis, similar observations were made in patients with gastric cancer (median 11.00 *vs*. 6.00). Because we did not have patients with visceral obesity, VF should not influence complications.

The results suggest that reducing visceral tissue before surgery could reduce the risk of severe complications. Therefore, it is important to recognize the level of visceral tissue both before and after surgery to ensure individualized and balanced nutritional support for patients (47).

In our study, in the entire group, 56 patients (44.8%) experienced postoperative complications, including 30 (24%) severe complications (grade 3-5). In the analysis carried out among patients with gastric and pancreatic cancers, no association was found between the parameters of body composition and the severity of complications in particular types of surgical procedures.

In the studies of other authors, among patients with pancreatic diseases, a similar number of serious complications was found, which amounted to 27.8% (48). In subsequent studies in patients with colorectal cancer, it was found that preoperative body composition and short-term weight loss were not associated with postoperative complications over a 30-day follow-up (49). In a recently published systematic review and meta-analysis, no significant differences were found between patients with visceral obesity and normal VF in terms of general postoperative complications. An association has been demonstrated between the incidence of visceral obesity and increased surgical site infection, pneumonia, and postoperative pancreatic fistula (50). A study conducted in Japan among 200 patients diagnosed with esophageal cancer based on the lean body mass index (FFMI) showed that FFMI was not a prognostic factor for postoperative complications, but was a significant independent factor of poor prognosis after surgery in the analysis of survival up to 3 years (51).

Study limitations. The presented study had several limitations. It was carried out in one center, among patients with various types of gastrointestinal cancers. The results of the tests were not compared with the assessment of muscle or adipose tissue based on CT. Extending the research to many centers, standardizing the study group in terms of single organ cancer, and extending the follow-up period after hospitalization, could provide wider results.

In the cohort of patients with gastrointestinal cancer, the body composition test showed that pancreatic cancer patients had the lowest muscle mass index. In patients with the most advanced cancers who were treated palliatively, the parameters of body composition, such as the percentage of FM, VF, as well as MMI and BMI, were significantly lower. Trauma caused by the curative treatment causes a significant reduction in the percentage of FM and BMI in the first 5 days after the procedure. However, no relationship between the examined parameters and the occurrence of serious complications was found. The BIA testing can be useful for planning pre-rehabilitation, assessing the clinical condition of patients before treatment and after surgery in order to minimize the potential consequences of a surgical trauma.

Conflicts of Interest

The Authors report no conflicts of interest in relation to this study.

Authors' Contributions

LS: study concept and design, analyses, manuscript preparation; EW: interpretation of the results, manuscript preparation, literature search; IB-C: literature search, analyses; US-Z: interpretation of the results, statistical analysis, final approval, PR: study concept and organization, recruitment of patients, critical analysis of the manuscript, AMS: manuscript preparation, interpretation of the results, statistical analysis, final approval, supervision.

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