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Sarcopenia in chronic liver disease, can we predict complications?

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Abstract

Introduction. *Sarcopenia is a common complication of chronic liver disease. Today many studies are devoted to sarcopenia impact on the course of liver diseases. At the same time, many studies are being performed on the correlation of sarcopenia in patients with cirrhosis of the liver and the incidence of early complications after liver transplantation. In this regard, we conducted our own retrospective study of the correlation relationship of sarcopenia in patients with chronic liver diseases.*

Aim. *To determine the correlation between the severity of sarcopenia and the incidence of complications of liver cirrhosis in patients on the waiting list for liver transplantation.*

Material and methods. *In our own retrospective observational study, 87 patients suffering from chronic liver diseases and treated at the Minsk*

*Scientific and Practical Center of Surgery, Transplantation and Hematology were included. The assessment of sarcopenia was carried out using the CT technique for assessing indexed parameters of the patient's muscle mass. Mathematical processing was performed using the FDA-approved Osirix^{TM} software. The study was conducted within the framework of the project "**ClinicalTrials: NCT04281797**"*

Results. *Body mass index was significantly correlated with the presence of sarcopenia (r_{pb}=-0.48, 95% CI [-0.65;-0.27]). At the same time, the groups of patients with and without sarcopenia differed significantly (p<0.0001), (Hedges g=-0.93, 95% CI [-1.37;-0.48]). In groups of patients with various etiological factors of chronic liver diseases, sarcopenia occurred most often among patients with autoimmune hepatitis, while the uneven distribution of the incidence of sarcopenia in different nosological groups was significant (p=0.028; χ^2=14.1).*

Conclusion. *Body mass index plays an important prognostic role in muscle mass loss among patients with clinically advanced liver disease. However, skeletal muscle index and Body Mass Index differ significantly between patients with and without sarcopenia. In addition, our study showed a significant difference in the occurrence of sarcopenia in patients on the waiting list of different etiological groups. Thus, further extensive randomized studies in this direction are needed today.*

Keywords: sarcopenia, hepatic encephalopathy, hepatic encephalopathy, liver cirrhosis, decompensated cirrhosis, chronic liver disease, computed tomography, liver muscle axis, gut liver axis

Conflict of interests Authors declare no conflict of interest

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AIH, autoimmune hepatitis

ALD, alcoholic liver disease

BMI, body mass index

CLC, cryptogenic liver cirrhosis

CLD, chronic liver disease

CT, computed tomography

CTP, Child-Turcotte-Pugh

HE, hepatic encephalopathy

ICD, international classification of diseases

ONCO, a group of patients with liver cancer

PLI, parasitic liver invasion

SMI, skeletal muscle (mass) index

VH, viral hepatitis

WK, Wilson-Konovalov disease

Introduction

The term "sarcopenia" was first coined by Irvine Rosenberg in 1989 in "Brief Comments: Epidemiological and Methodological Issues in Determining the Nutritional Status of the Elderly" published in *American Journal of Clinical Nutrition*. In it, the author points out the need for further study of changes in the metabolic status of age-related patients, focusing on comorbidities and a decrease in muscle mass [1]. Since that time, a large number of works have been devoted to the problem of sarcopenia and its influence both on the course of various pathological processes and on the treatment results in certain types of pathologies. A large number of retrospective and prospective studies and extensive meta-analyses have been published. In this regard, today a lot of experience has been gained in the field of clinical nutrition. However, many processes, in particular those related to the mechanisms of development of sarcopenia in various chronic diseases, are still not understood completely [2, 3].

Moreover, Irwin Rosenberg himself described his reasoning about the term "sarcopenia" as follows – "Is it a loss of muscle mass and function associated with age, or a disease of normal aging?" [4]. In addition, despite the fact that sarcopenia was initially considered as a pathology associated with the loss of muscle mass associated with aging, many works have been devoted specifically to the loss of muscle mass during nutritional intake disbalance associated with another organic pathology not directly related to the natural aging process [5]. Despite the discovery of sarcopenia in 1989 and the already almost universal use of the term both in clinical practice and in academic research, the very concept of "sarcopenia" had not been registered in the International Classification of Diseases (ICD) for almost 30 years. The situation changed in September 2016 when, sarcopenia was nevertheless included in the ICD-10 as an independent nosological unit, however, with the note “associated with age”.

At the same time, incomplete clarity both in the definition of the concept and in the very structure of understanding this pathological condition is also evidenced by the fact that the term "sarcopenia" itself was again removed from the ICD-11 revision, that is, 2 years after its registration [6].

Today, the relationship of sarcopenia with various pathological conditions is of great interest. Thus, a number of authors have determined the relationship of sarcopenia with chronic diffuse liver diseases and, in particular, with their complications, such as hepatic encephalopathy (HE), severe liver failure, as well as the association of the severity of sarcopenia with the incidence of postoperative complications. A significant event was the “MELD – Sarcopenia” score presented in 2015 in the journal “American College of Gastroenterology”. The authors of that publication pointed out the great prognostic significance of sarcopenia in relation to

early mortality in patients on the waiting list for liver transplantation [7]. Despite the high quality of the study, the score has not received its widespread use, however, scientific interest in it still remains relevant.

At the same time, in a large number of works devoted to the studying sarcopenia in patients with chronic progressive liver diseases (CPLDs), the data obtained are extremely contradictory; a number of studies indicate highly significant correlations, others, on the contrary, the absence of any statistically significant results between the severity of sarcopenia and severity of CPLD. Of even greater interest is the hypothesis of a possible relationship of sarcopenia with the bowel microbiome and short-chain fatty acids, which play a significant role in the processes of the microbiota formation. Research in this direction will open up new facts in understanding the pathophysiological features of the course of chronic liver diseases and their complications [8].

Today, there is no doubt that studies in this direction, in particular prospective, controlled ones, are critically necessary both from an academic, and also practical point of view [9]. In this regard, we decided to conduct our own observational study.

The objective was to determine the correlation between the severity of sarcopenia and the incidence of liver cirrhosis complications in patients on the waiting list for liver transplantation.

Material and methods

The study was designed as a retrospective observational study based on the results of investigating 87 patients who received inpatient treatment at the State Institution "Minsk Scientific and Practical Center of Surgery, Transplantology and Hematology". All patients were admitted with a diagnosis of CPLD of various etiologies as the underlying disease.

There were 52 women and 35 men. The age of the patients ranged from 19 to 72 years (mean=49.6; SD=12.2). The mean MELD was 19.1 (SD=8.5). Child–Turcotte–Pugh (CTP) functional classes A, B, C were assigned to 18; 30; 31 patients. To analyze the correlation between sarcopenia and the nosological form of CPLD, seven study groups were formed (Fig. 1).

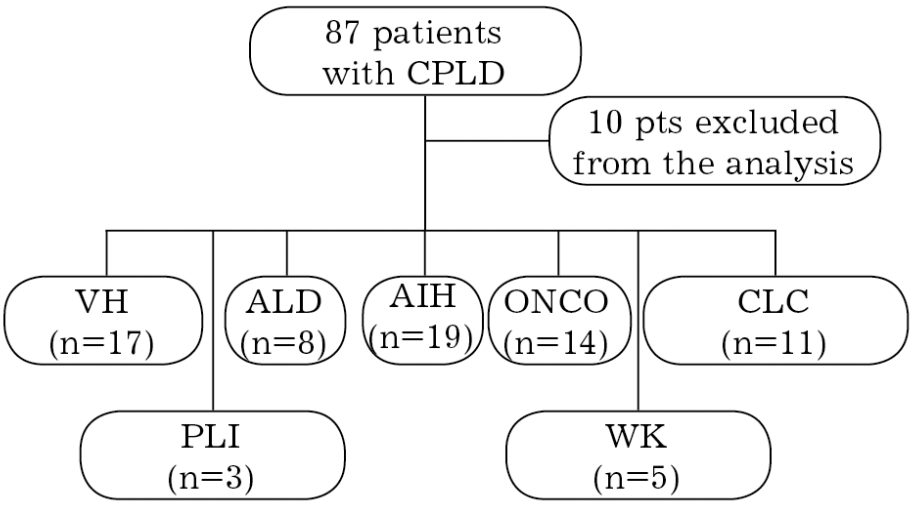

Fig. 1. Distribution of patients by nosological study groups

CPLD, chronic progressive liver disease; VH, group of patients with viral hepatitis; ALD, group of patients with alcoholic liver disease; AIH, group of patients with autoimmune hepatitis; ONCO, a group of patients with liver cancer; CLC, group of patients with cryptogenic liver cirrhosis; PLI, a group of patients with parasitic liver invasion; WK, group of patients suffering from Wilson-Konovalov disease

Inclusion criteria. All CPLD patients aged 18 to 75 were included in the waiting list for liver transplantation. Considering the anthropometric difference in indexed parameters of body muscle mass for different populations, only patients from the Eastern European population were included in the study. Diagnostic investigations were made at the time of the patient inclusion in the waiting list.

Exclusion criteria. Patients included in the waiting list for liver retransplantation, patients who had previously undergone transplantation of other solid organs. When analyzing the correlation of sarcopenia and the nosological form of CPLD, 10 patients with a mixed diagnosis were

excluded from the analysis, which made it difficult to distribute patients according to groups.

Registration of the study. This study was performed within the framework of the registered study "*ClinicalTrials.gov Identifier: NCT04281797"*.

Integral assessment of sarcopenia was performed using a computed tomography (CT) technique for assessing the indexed parameters of patient's muscle mass according to the "Segmentation And Linear measurement For Body composition Analysis". CT mapping was performed on the "Aquilion One" 640-slice CT scanner (Toshiba, Japan). Image processing was performed using *the FDA-approved Osirix^{TM} software (Pixmeo SARL, Switzerland).* The threshold value of the skeletal muscle mass index (SMI), below which the state of muscle tissue is regarded as sarcopenia, was calculated by the standard formula for dividing the calculated muscle mass^2/height^2 (52.4 cm^2/m^2 for men; 38.5 cm^2/m^2 for women). Hounsfield units ranging from -29 to +150 HU were used as parametric program data for muscle mass mapping. Native images were evaluated at the level of the middle of the L3 transverse section of the spinal column.

Body mass index (BMI). Patients were classified as being underweight (BMI<18.5), having normal weight (BMI 18.5–24.9), and being overweight (BMI 25–29.9), or obese (BMI>30) according to the World Health Organization accepted classification.

The degree of decompensation was assessed based on the CTP classification, MELD score, and the West-Haven encephalopathy classification.

Statistical analysis of the obtained results was made using generally accepted parametric and nonparametric methods. To describe the data obtained, the standard methods of descriptive statistics were

used. The central tendency and variation of a feature, were estimated by the mean values and the standard deviation ($M \pm \sigma$) when its distribution corresponded to the normal distribution model, and by the median values and quartiles with a distribution other than normal. The distribution of quantitative data was checked for the compliance with the normal distribution model using the Shapiro-Wilk test. The significance of intergroup differences of normally distributed quantitative variables was determined using Student's t-test or, in the case of more than two compared groups, using analysis of variance (ANOVA) followed by a posteriori comparison. The significance of intergroup differences of quantitative variables with a non-normal distribution was determined using the Mann–Whitney test. The effect size (Hedges' g) was also estimated. To assess the significance of the relationship of nominal variables, Pearson's χ^2 test and Fisher's exact test were used; Pearson's χ^2 test was used to check the correspondence of the empirical frequency distribution to the theoretical one. Pearson's correlation coefficient (r) was used to assess the strength of the relationship between quantitative variables. To assess the strength of the relationship between binary variables and quantitative data, a point biserial correlation coefficient r_{pb} was used. The indicators of significance (sensitivity and specificity) for diagnostic tests were calculated. The significance level α was taken equal to 0.05. The language for statistical data processing R, packages dplyr, ggplot2, ggstatsplot [10–12] were used for calculations and data preparation for analysis.

Results

The mean overall BMI was 25.49±4.6. The distribution of BMI by gender was as follows: 26.66±4.273 for males; 24.7±4.768 for females. Insufficient body mass index was diagnosed in 3 patients (3.4%).

Overweight was diagnosed in 37 patients (42.5%). Sarcopenia was identified in 37 patients (42.5%): 17 men (19.5%) and 20 women (23%). Meanwhile, SMI in our study in the total cohort of patients was 46.08±10.28: 52.06±8.186 for males, 42.05±9.618 for females. HE was diagnosed in 54 patients (61.3%). The distribution according to HE severity of West-Haven classification was as follows: grade I in 40 patients (47,1%); grade II in 13 patients (15,3%); grade III in 1 patient (1.2%); grade IV was not seen. The median MELD was 15 points (1^{st} and 3^{rd} quartiles: 12;25). Child–Turcotte–Pugh (CTP) functional classes A, B, C were assigned to 18; 30; 31 patients.

Body mass index vs sarcopenia

We found that BMI has a significant correlation with the presence of sarcopenia (r_{pb} =-0.48, 95% CI [-0.65;-0.27]). Thus, in the general cohort of patients suffering from CPLD and the presence of sarcopenia, a significant decrease in BMI was noted in comparison with patients in whom sarcopenia did not complicate the course of the underlying disease. Thus, the median values of BMI in patients with developed sarcopenia and without it were 23.34 and 26.58, respectively (mean = 23.21; 95% CI [22.06;24.35] and 27.17 (95% CI [25.83;28.52]), respectively). The groups differed significantly ($p<0.0001$), and there was also a fairly large effect size (Hedges g=-0.93, 95%CI [-1.37;-0.48]), indicating a significant difference between the groups. It should be noted that this result is consistent with the results of studies by other authors (Fig. 2).

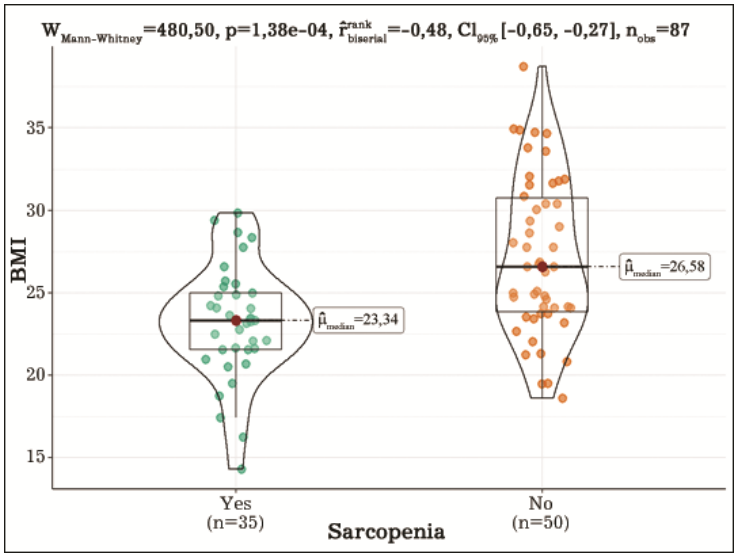

Fig. 2. Comparison of groups by body mass index in patients with chronic progressive liver diseases. ("Yes" indicates patients with sarcopenia. "No" indicates patients without sarcopenia)

Body mass index vs skeletal muscle mass index

In our opinion, the results obtained in the course of the correlation analysis of the relationship between BMI and SMI can be considered quite interesting. This analysis showed that in patients with developed sarcopenia, there is a significant moderate association between BMI and SMI (r=0.42*;* CI95% [0.10;-0.66]*;* p<0.01), which was not found in patients without sarcopenia (r=0.21*;* CI95% [0.07;-0.46]*;* p=0.14). This result may be indirect evidence of the prognostic significance of BMI in the development of sarcopenia syndrome (Fig. 3).

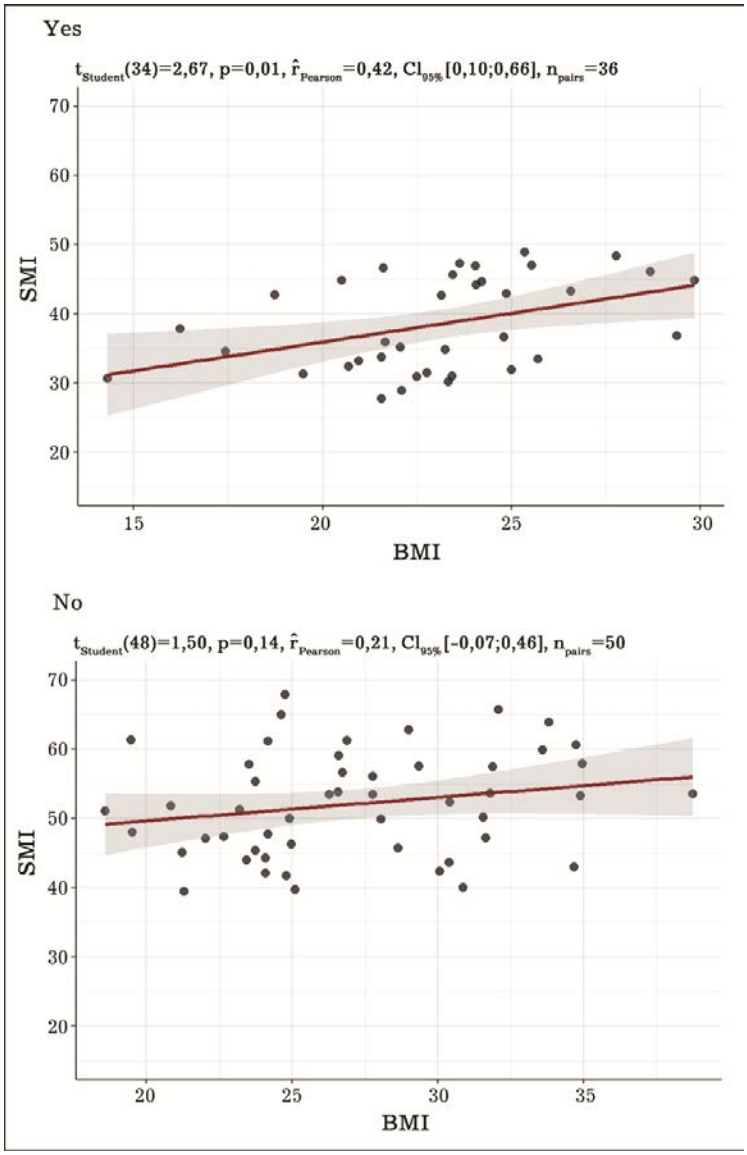

Fig. 3. Correlation relationship between skeletal muscle mass index and body mass index in patients with chronic progressive liver diseases without developed sarcopenia and with sarcopenia. ("Yes" indicates patients with sarcopenia. "No" indicates patients without sarcopenia).

*1 patient was excluded from the correlation analysis due to the high probability of a statistical outlier in the distribution

At the same time, it is known that the development of sarcopenia can be influenced to some extent by ethnic and gender differences [9]. In

this regard, we conducted a comparative analysis of the differences in the relationship between BMI and sarcopenia depending on the gender.

In our obtained results, we identified a significant correlation relationship between BMI and sarcopenia in groups by gender. Thus, the median BMIs in the group of female patients with developed sarcopenia and without sarcopenia were 22.30 and 24.86, respectively (p= 0.00005*;* Hedges g=-0.93.95% CI [-1.49;-0.36], rpb=-0.47, 95%CI [-0.68;-0.18]). Meanwhile, in the male group, the effect was more pronounced: 24.07 and 27.31, respectively (p=0.001*;* Hedges g=-1.19; 95%CI [-1.89;-0.47], rpb=-0.62, 95% CI [-0.81;-0.33]) (Fig. 4). This fact indicates a significant correlation between sarcopenia and BMI. It is also worth noting the absence of significant differences between patients of different genders in the group with and without sarcopenia (p=0.05 and p=0.06 , respectively).

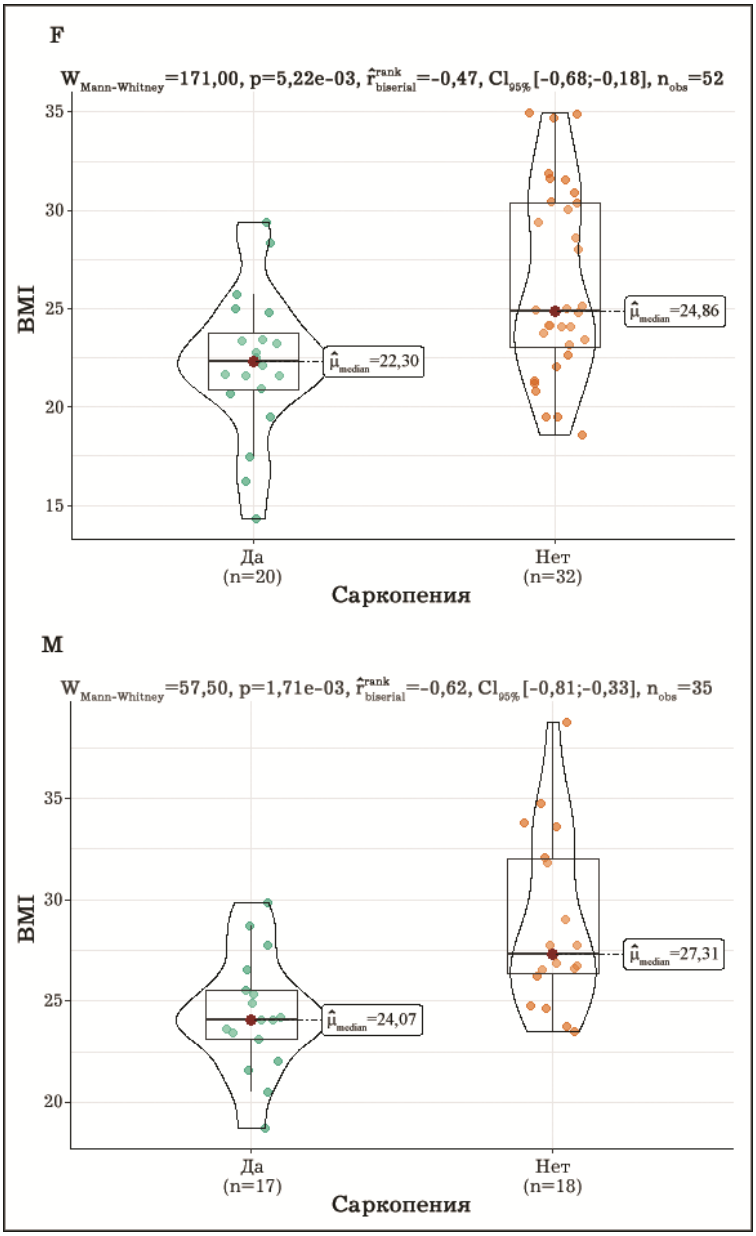

Fig. 4. Correlation between sarcopenia and body mass index in patients with chronic progressive liver diseases without developed sarcopenia and with sarcopenia, in groups by gender. (f, female; m, male)

Sarcopenia in various pathological conditions

Despite the pathophysiologically common nature of the CPLD development (the natural course of the disease), the prognosis and incidence of certain complications often differ depending on the etiological cause of CPLD. In this regard, we assessed the incidence of

sarcopenia in patients of various etiological groups of CPLD. This analysis included 77 (88.5%) patients with CPLD of various etiologies. For this purpose, depending on the etiological factor that led to the CPLD occurrence, seven groups of patients were formed: patients with viral hepatitis (HCV, HBV, HDV and their combination) (n=17; 22%); patients alcoholic liver disease (n=8; 10.3%); patients with autoimmune liver damage (primary biliary cirrhosis, primary sclerotic cholangitis, AIG, immunological crossover syndrome and(or) their combination) (n=19; 24.6%); patient with cancer invasion (n=14; 18.1%); patients with cryptogenic liver disease (n=11; 14.2%); patients with alveococcal invasion (n=3; 3.8%); those with Wilson-Konovalov disease (n=5 patients; 6.4%).

Meantime, the incidence of sarcopenia in these groups was as follows: in 8 patients (22.2%) with viral hepatitis; in 4 patients (11.1%) with alcoholic liver disease; 10 patients (27.8%) with autoimmune liver damage; 8 patients (22.2%) with cancer invasion; in 3 patients (8.3%) with cryptogenic liver damage; 2 patients (5.6%) with alveococcal invasion; in 1 patient (2.8%) with Wilson-Konovalov disease (Fig. 5).

It becomes clear from the analysis that sarcopenia occurred most often among patients with autoimmune hepatitis compared to other groups, and amounted to 27.8%. In addition, an uneven distribution of the incidence of sarcopenia across the different nosological groups was significant ($p=0.028$; $\chi^2=14.1$) (Fig. 5).

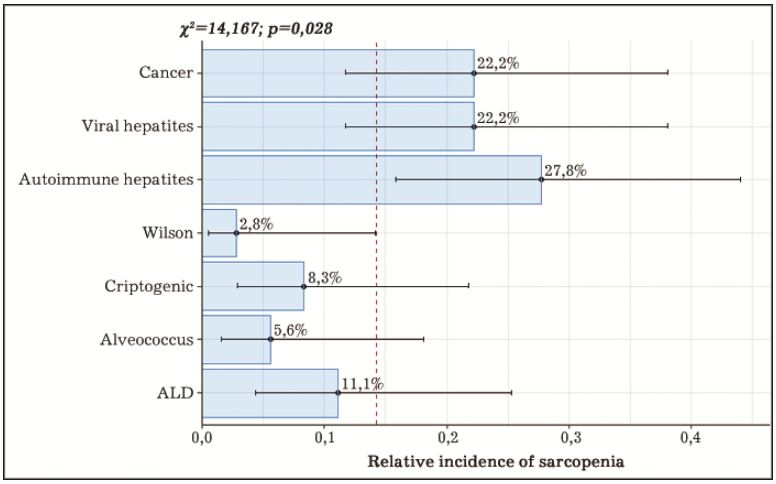

Fig. 5. The incidence of sarcopenia in various etiological groups of chronic progressive liver diseases

The methodology for assessing indexed parameters of sarcopenia in patients suffering from chronic progressive liver diseases of various etiologies is shown in Fig. 6.

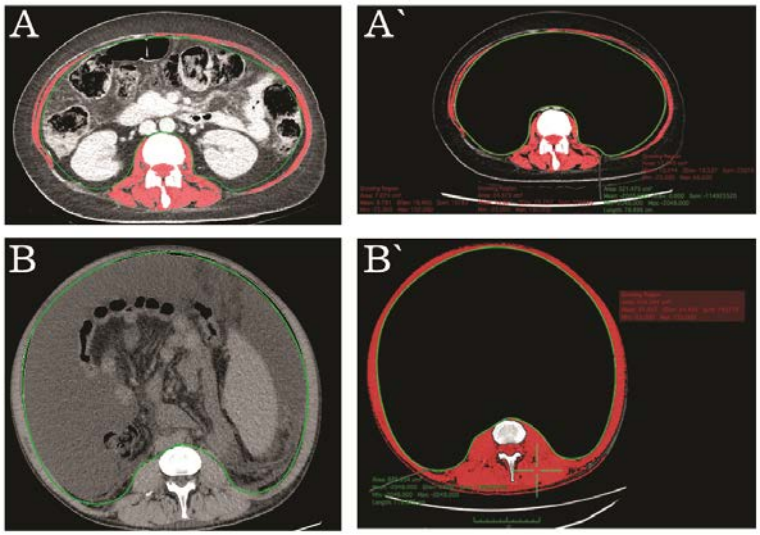

Fig. 6. Segmentation computed tomography analysis of images at L3 level in patients of different etiological groups. A (before segmentation), A' (after segmentation): A 49-year-old female patient with cryptogenic liver cirrhosis complicated by sarcopenia. CTP functional class "C". MELDor. 11. BMI 28. Muscle Area 51.7; SMI 18.3. B (before segmentation), B' (after segmentation): A 41-year-old male patient with liver cirrhosis in the outcome of HCV infection without sarcopenia. CTP functional class "C". MELDor. 25. BMI 25. Muscle Area 225; SMI 67.9.

Decompensation in sarcopenia

Encephalopathy vs sarcopenia

More and more reports on the relationship between HE and sarcopenia is being published nowadays. The “muscle-hepatic axis” theory, which explains a high incidence of HE in response to muscle loss in patients with CPLD, is becoming increasingly relevant [8]. However, the data of the authors are extremely contradictory and often subjected to shortcomings. A number of to-date extensive meta-analyses also indicate the contradictory results obtained.

Given this fact, we conducted our own study enrolling Eastern European population of patients suffering from chronic progressive liver diseases.

In our study, 54 patients (63.5 %) on the waiting list for liver transplantation were diagnosed with encephalopathy of varying severity. Meantime, in the total cohort of patients, we most often diagnosed grade I hepatic encephalopathy, which complicated the course of the underlying disease in 40 patients (47.1 %).

At the same time, despite the fact that the incidence of HE syndrome was more frequent in patients with sarcopenia than in patients without sarcopenia, we found no significant relationship between HE and sarcopenia lesion in the total cohort of patients ($p=0.789$).

The results we have obtained contradict many studies; however, as is known, many links of the pathogenesis of the hepatic encephalopathy development still remain not fully understood today, and its occurrence rates can be considered extremely controversial. No doubt, the subjective nature of assessing the degree of HE itself, based only on the symptomological determination of its severity, can also be considered a significant drawback of this analysis; however, the results of our study

support the continued relevance of the issue of further need to study the relationship of between HE and its dependence on sarcopenia. An important tool in solving this problem can be considered an analysis of the relationship between sarcopenia and the blood level of free ammonia, which is a deterministic marker of the HE severity. However, as is known, this method is not without drawbacks. In this regard, further research in this area remains highly relevant.

MELD versus sarcopenia

A significant development in the study of sarcopenia was, as mentioned above, the introduction of a modified prognostic scale "MELD − Sarcopenia" in 2015. The authors of this paper indicated that among patients on the waiting list, the median survival of those with sarcopenia was statistically significantly different from the patients in whom sarcopenia was not diagnosed (20±3 vs. 95±24 months, $p<0.001$) [7]. It is noteworthy that the authors of this study also used the CT assessment of SMI as a diagnostic criterion for sarcopenia. In conclusion, the authors indicated the expediency of including sarcopenia in the MELD prognostic score in order to more accurately predict mortality on the waiting list in patients with liver cirrhosis [7]. However, this score has not become widely used; moreover, according to investigators from the Netherlands who published the results of their own study of the correlation relationship between sarcopenia and MELD, the studies conducted to assess the MELD-Sarcopenia score were not devoid of significant limitations, including a relatively small sample of patients who underwent liver transplantation and were included in the study [5]. In this regard, we conducted our own analysis of the relationship between MELD and sarcopenia, which did not show a statistically significant relationship between these two phenomena.

We analyzed 87 patients with CPLD of various etiology forms.

The median MELD score was 15 (12;25). By gender, the median MELD scores were as follows: 15 for females, 15.5 for males. The general analysis of the relationship showed that the MELD score did not have a significant relationship with the presence or absence of sarcopenia in patients on the waiting list, the median score was 15 for both the patients with sarcopenia, and those without it, respectively. (p=0.99) (Fig. 7). Meantime, the same pattern was observed in the distribution by gender, during which there were no significant differences between MELD and sarcopenia in the groups of men and women (p=0.69; p=0.65, respectively).

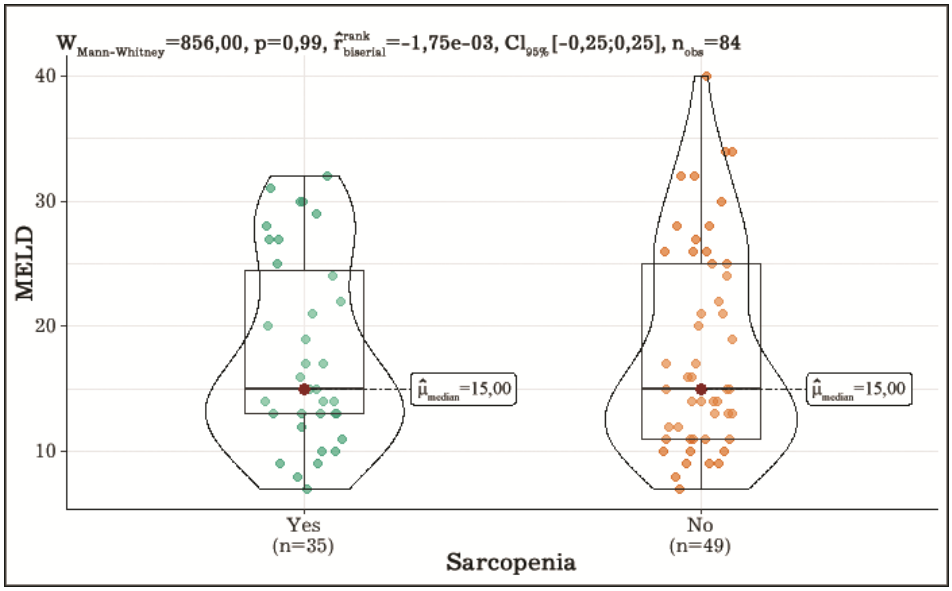

Fig. 7. Comparison of groups without developed sarcopenia and with sarcopenia considering the MELD score in patients with chronic progressive liver disease

Child–Turcotte–Pugh vs Sarcopenia

It is known that the CTP score is used to assess the degree of hepatic decompensation in patients suffering from liver cirrhosis. And although the widely used logarithmic formula for assessing the indicated

severity of MELD decompensation has several advantages over the CTP classification, these two classifications have a completely different principle and are used rather symbiotically than separately. In this regard, in order to conduct a more detailed analysis of hepatic decompensation in patients with CPLD complicated by the sarcopenia development, we also assessed the relationship using the CTP score.

However, the results obtained, as well as those in the analysis using the MELD classification, did not show a significant relationship between sarcopenia and the incidence of hepatic decompensation (p=0.66; $\chi^{2=}$0.832) (Fig. 8).

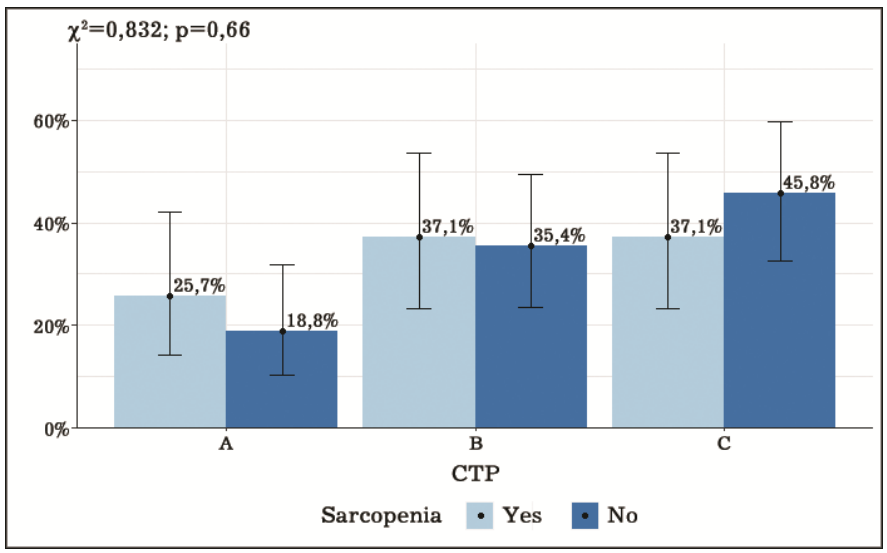

Fig. 8. Correlation between sarcopenia and Child–Turcotte–Pugh Class in patients with chronic progressive liver diseases without developed sarcopenia and with sarcopenia

Thus, the results of our study aimed at determining the relationship between the incidence of liver decompensation in patients with sarcopenia according to the MELD, and CTP scores, as well as a higher incidence of HE syndrome in patients with CPLD complicated by sarcopenia, did not show a significant relationship.

Discussion

Sarcopenia, first described more than 30 years ago, still belongs to the category of severe complications of end-stage liver diseases, which, according to many researchers, significantly worsen the prognosis of both the disease itself, reducing the waiting time for patients on the waiting list, and direct results of liver transplantation itself. However, the results of many authors differ significantly. Meantime, the authors of one of the largest meta-analyses published in 2022 and based on a study of the results of 22 original studies, which included 6965 patients, come to the conclusion that the presence of sarcopenia increases the risk of mortality by 2.6 times. However, with regard to the severity of sarcopenia and MELD, only indirect results have been obtained. In this regard, despite the recommendations of the authors of the review to evaluate MELD only in combination with the assessment of sarcopenia and MELD psoas, convincing evidence of the advantages of these methods has not yet been obtained [13].

In turn, today the effect of the intestinal microbiota on the course of many chronic progressive liver diseases has been proven, more and more studies are being published regarding the effect of microbiome on the results of liver transplantation [14]. At the same time, it is known that “nutritive homeostasis”, which largely depends on the bowel microbiota, also influences the development of the muscular system to some extent or another. A possible hypothetical relationship between the composition of the human microbiome palette and the occurrence of sarcopenia needs to be confirmed. In addition, it is known that the bowel microbiota in patients with various nosological forms of cirrhotic liver damage differs significantly in its taxonomic composition. In turn, taking into account the data obtained, indicating a different degree of correlation between sarcopenia lesions in patients of various nosological groups, it becomes

obvious that a detailed determination of the above correlations would promote the development of a new tool in the arsenal of clinical transplantology for impeding a steady progression of liver cirrhosis. Studies in this direction seem to us extremely necessary.

In conclusion, body mass index plays an important role in the diagnosis of progressive muscle mass loss in patients with chronic progressive liver disease, thereby increasing the risk of post-transplant complications. Further studies in this direction are critical. In turn, we determined statistically significant differences in the occurrence of sarcopenia in patients on the waiting list in various etiological groups of chronic progressive liver diseases, which can also be of great prognostic value. Thus, it becomes clear that the incidence of sarcopenia depends on the nosological form of liver damage and varies widely, which was shown in our study. Therefore, sarcopenia, which complicates the course of chronic progressive liver diseases, can also affect the course of the post-transplant period, which requires further research in this direction. In addition, in our study, we did not find a statistically significant correlation between sarcopenia lesions and the severity of hepatic decompensation in patients with chronic progressive liver diseases, assessed both according to the MELD scale and to the Child-Turcotte-Pugh classification. In this regard, we consider it promising to conduct further research in the field of sarcopenia in patients with chronic progressive liver diseases, based on extensive intercenter and international studies.

Conclusions

1. Body mass index has a significant correlation with the presence of sarcopenia (r_{pb}=-0.48, 95% CI [-0,65;-0.27]). Thus, the median value of the body mass index in patients with developed sarcopenia (Me=23.34) was significantly lower than the median value in the group without

sarcopenia (Me=26.58) ($p<0.0001$). The corresponding mean values in the groups are 23.21; 95%CI [22.06;24.35] and 27.17; 95%CI [25.83;28.52].

2. Meanwhile, it is interesting that in patients with developed sarcopenia, there is a significant moderate relationship between the body mass index and skeletal muscle mass index ($r=0.42$; CI95% [0.10;-0.66]; $p<0.01$) that was not found in patients without sarcopenia ($r=0.21$; CI 95% [0.07;-0.46]; $p=0.14$).

3. In addition, a significant correlation was found between the body mass index and sarcopenia in groups by gender. Median body mass indices in the group of female patients with developed sarcopenia and without it were 22.30 and 24.86, respectively ($p=0.00005$). The corresponding values in the male group were 24.07 and 27.31, respectively ($p=0.001$).

4. In turn, it was found that among various nosological forms, sarcopenia most often complicates the course of liver cirrhosis in patients with its autoimmune etiology, which was identified in 27.8% of patients, and occurs least of all among patients with Wilson-Konovalov disease 2.8% ($p=0.028$).

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