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Assessment of the association between dysphagia and sarcopenia among elderly patients with cirrhosis: Usefulness of the finger-ring test

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ABSTRACT

Aim: Sarcopenic dysphagia has become an urgent matter of debate in our aging society. However, little is known about the relationship between sarcopenia and dysphagia in patients with liver cirrhosis. Our aim was to assess sarcopenia and dysphagia among elderly patients with cirrhosis using two easy-to-use screening tests, i.e., the eating assessment tool-10 and the finger-ring test.

Methods: The eating assessment tool-10, handgrip strength, skeletal muscle mass index, computed tomography, and the finger-ring test were included in our analysis. One hundred patients with cirrhosis and without a history of aspiration pneumonia were divided into the elderly (≥75 years) and non-elderly (<75 years) groups.

Results: In the elderly group, sarcopenia was identified in 56.5% of the patients; of these, 30.4% and 13.0% had eating assessment tool-10 scores of ≥2 and ≥3, respectively. Sarcopenia-related factors correlated significantly with the eating assessment tool-10 scores ($p<0.01$). Multivariate regression analysis revealed that sarcopenia was significantly associated with dysphagia ($p=0.028$; odds ratio, 7.27). Among the elderly patients, the calf size of the non-dominant lower limb was less than the finger-ring circumference in 37.0% of the patients. This group had a significantly higher proportion of patients with an eating assessment tool-10 score of ≥2 than those with a greater calf than finger-ring circumference ($p<0.01$).

Conclusions: Sarcopenia, rather than the hepatic reserve function, is associated with dysphagia among elderly patients with cirrhosis. The finger-ring test might be useful in screening for dysphagia.

1. Introduction

Liver cirrhosis is a late stage of irreversible fibrosis of the liver. Cirrhosis has various causes, and is generally classified as compensated and decompensated cirrhosis (Ge et al., 2016). Patients with decompensated cirrhosis often have complicated refractory ascites and hepatic encephalopathy (HE), which might not respond to systemic treatment (Fukui et al., 2016; Haraguchi et al., 2019). Additionally, these patients often have muscle atrophy and sarcopenia, resulting in a reduced muscle mass and strength, which can lead to a reduced quality of life (Hanai et al., 2015; Hiraoka et al., 2017; Haraguchi et al., 2017). Moreover, exacerbation of sarcopenia negatively affects the prognosis of patients with cirrhosis (Nishikawa et al., 2017). The muscle volume in sarcopenia is usually assessed using dual-energy X-ray absorptiometry, bioelectrical impedance analysis (BIA), or computed tomography (CT). However, these assessments are expensive and not readily available for patient assessment in family medicine clinics. Regarding this, Hiraoka et al. reported the usefulness of the finger-ring test for monitoring a decline in the muscle volume among patients with chronic liver diseases (Hiraoka et al., 2019). Additionally, sarcopenia is a common health problem in the aging population, which itself is increasing rapidly in Japan. Around 18 million of the Japanese population is over 75 years of age, accounting for 18% of the total population in 2020; this population is predicted to rise over 20 million by 2030. According to a proposal based on the survey carried out by the Cabinet Office of the Japanese Government, the "elderly" age was redefined as 75 years or older (Ouchi et al., 2017). Furthermore, the proportion of patients with dysphagia has increased as a function of the aging general population (Tanaka,

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Takahashi, Akishita, Tsuji, Iijima, 2018); accordingly, coping with dysphagia has emerged as an urgent health issue. Dysphagia and aspiration pneumonia are common complications in patients with sarcopenia (Komatsu et al., 2018), indicating the importance of evaluating the swallowing function in patients with cirrhosis. Generally, swallowing video fluorography or the modified water swallowing test is used to assess the swallowing function (Brodsky et al., 2016). However, these tests can possibly induce coughing and aspiration. Considering the global COVID-19 outbreak, conducting these aggressive tests seems difficult; thus, simpler screening tests, such as the finger-ring test, are desirable. In recent years, the eating assessment tool-10 (EAT-10), a questionnaire-based test, has been shown to be a useful screening assessment of the swallowing function in elderly individuals (Belafsky et al., 2008; Wakabayashi et al., 2018). However, the usefulness of the EAT-10 and the finger-ring test for screening for sarcopenia-related dysphagia among patients with cirrhosis has not been reported yet. Therefore, in this study, we aimed to investigate the relationship between sarcopenia and dysphagia (assessed by the EAT-10) and assess the usefulness of the finger ring test in patients with cirrhosis.

2. Materials and methods

2.1. Patients

As shown in Fig. 1, our study included 100 patients with liver cirrhosis who were admitted to the Department of Gastroenterology and Hepatology at the Nagasaki University Hospital between January 2019 and April 2020. All patients were independent in their activities of daily living. We excluded patients who were less than 20 years of age and had a history of aspiration pneumonia, current infection, psychiatric disorder, dementia, Eastern Cooperative Oncology Grade Performance Status Scale Grade 3 or higher, current overt hepatic encephalopathy (HE), history of stroke, neuromuscular disease, and history of chronic heart failure and/or renal failure, which might result in lower edema.

All patients provided written informed consent. Our study protocol conformed to the guidelines of the Declaration of Helsinki, and was approved by the Nagasaki University Ethics Committee (approval no. 20042006). The etiology of liver disease was determined through a combination of clinical, laboratory, radiological, and histological variables. Hepatic reserve was evaluated using the Child–Pugh (CP) score and the albumin-bilirubin (ALBI) grade, which is a new hepatic function assessment tool (Johnson et al, 2015).

For analysis, the participants were divided into the "elderly group" (≥75 years of age) and the "non-elderly group" (<75 years of age). Baseline assessment was performed within 48 h of admission and included the measurement of muscle strength and skeletal muscle mass index (SMI).

2.2. The Finger-ring ("Yubi-wakka") test

The finger-ring test was performed as described previously (Hiraoka et al., 2019). The test measures if the maximum calf circumference of the non-dominant limb, measured in a seated position, is greater than the circumference of a circle formed by the individual's index fingers and thumbs of both hands. Based on the finger-ring test, patients were classified into the following three groups: bigger, just-fits, and smaller (Tanaka et al., 2018).

2.3. Evaluation of skeletal muscle, muscle strength, and sarcopenia

Sarcopenia was diagnosed using the assessment criteria for sarcopenia in liver disease (1st edition) reported by the working group for the creation of sarcopenia assessment criteria in the Japan Society of Hepatology (JSH) (Nishikawa et al., 2016). According to these criteria, sarcopenia was defined by a low handgrip strength and a low SMI. Handgrip strength was measured using the Smedley handgrip dynamometer (TTM, Tokyo, Japan), with the participant in a standing position. Two trials were performed for the right and left hands, and the two highest values were averaged and entered in the analysis. The cutoff values for sarcopenia diagnosis were 26 kg in men and 18 kg in women, according to the JSH criteria (Nishikawa et al., 2016). The SMI was calculated using BIA (InBody 770, InBody Japan, Tokyo, Japan) (Lee et al., 2018) as the sum of the skeletal muscle mass of the arms and legs divided by the square of the individual's height (kg/m^2). The cutoff values of the SMI for sarcopenia diagnosis were 7.0 kg/m^2 in men and 5.7 kg/m^2 in women. A second measure of the SMI was obtained by CT,

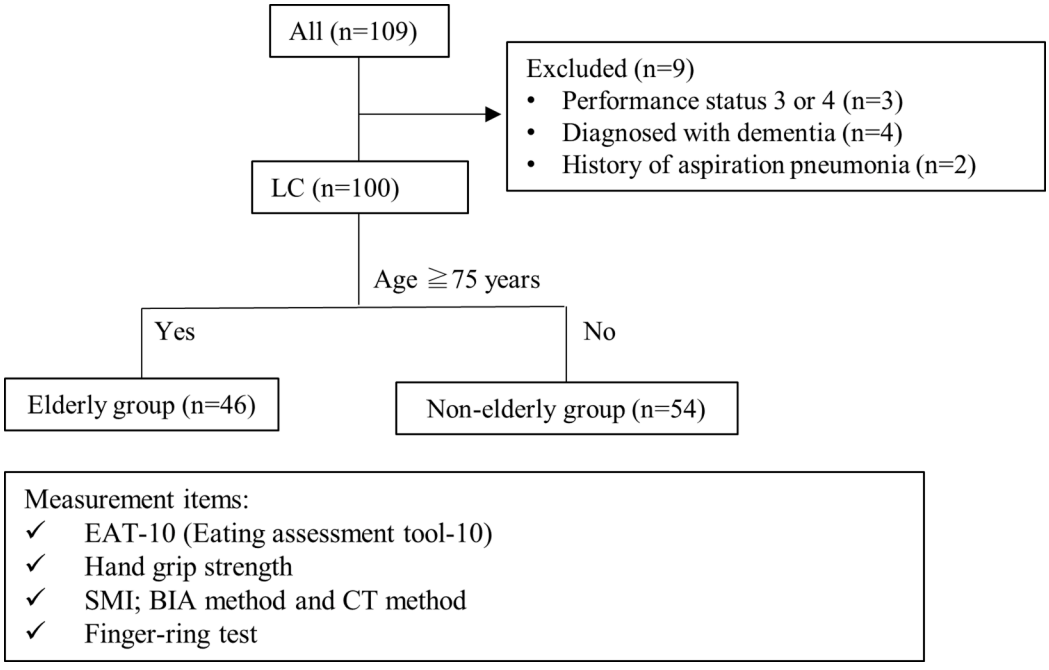

Fig. 1. The flow-diagram of patient enrollment and group allocation. Baseline assessment was performed within 48 h after admission
BIA, bioelectrical impedance analysis; CT, computed tomography; LC, liver cirrhosis; SMI, skeletal muscle mass index.

based on the cross-sectional area of the skeletal muscles (cm^2) at the level of the third lumbar (L3) vertebra. These measures were performed by a trained operator using an image-analysis software (sliceOmatic V4.3, TomoVision, Magog, Quebec, Canada) (Mitsiopoulos et al., 1998). The skeletal muscles at the L3 level included in this calculation were the psoas, erector spinae, quadratus lumborum, transversus abdominis, internal oblique, external oblique, and rectus abdominis muscles. The L3 skeletal muscle area was then normalized to the square of the individual's height (m^2) to obtain the SMI (cm^2/m^2). The cutoff values of the SMI to identify sarcopenia were $\leq$42.0 cm^2/m^2 in men and $\leq$38.0 cm^2/m^2 in women (Nishikawa et al., 2016).

2.4. Evaluation of dysphagia

Dysphagia was assessed using the EAT-10 (Belafsky et al., 2008), a self-administered questionnaire regarding the swallowing function, and a score of $\geq$3 indicated impairment in swallowing (Belafsky et al., 2008; Wakabayashi et al., 2016). An EAT-10 score $\geq$3 has a greater sensitivity (0.85) and specificity (0.82) as compared to video fluoroscopy for identifying oropharyngeal dysphagia (Rofes, Arreola, Mukherjee, & Clavé, 2014).

2.5. Statistical analysis

Data are presented as means and standard deviation (SD). The Fisher's exact tests were used to compare categorical data. Continuous variables were compared between the groups using the Student's *t*-test and the Mann–Whitney *U* test. Furthermore, multiple comparisons were performed using the Mann–Whitney *U* test with Bonferroni correction or the Fisher's exact test. Multivariate regression analysis was used to identify variables that independently predicted the EAT-10 score. A *p*-value $<$0.05 was considered to indicate statistical significance for all tests. Statistical analyses were performed using the JMP version 14.0 software (SAS Institute Japan, Tokyo, Japan).

3. Results

3.1. Characteristics of the study group

The patients' characteristics are reported in Table 1. The mean age in our study population was 71.77 $\pm$ 10.46 years. Of the 100 patients, 46 (including 32 men [57.1%]) were classified into the elderly group, while the remaining were classified into the non-elderly group. The mean age in the elderly group was 81.06 $\pm$ 3.82 years. The performance status was significantly higher among participants in the elderly group than in the non-elderly group ($p<0.0001$). The distribution of the etiologies of cirrhosis among all patients was as follows: non-alcoholic fatty liver disease, alcohol-related causes, hepatitis C virus, hepatitis B virus, and 'other' etiologies in 14 (30.4%), 8 (17.4%), 14 (30.4%), 5 (10.9%), and 5 (10.9%) patients, respectively. The overall distribution of the Child–Pugh scores was as follows: grade A, grade B, and grade C in 34 (73.9%), 8 (17.4%), and 4 (8.7%) patients, respectively. Lastly, 78.2% of the patients had a history of hepatocellular carcinoma (HCC), and the prevalence of HCC was higher in the elderly group than in the non-elderly group ($p=0.02$); however, the recurrence rate of HCC did not differ significantly between the two. Furthermore, there was no differences in the hepatic reserve between the two groups.

In the elderly group, a positive CT-SMI decline was identified in 60.9% of the patients, while a decline in the BIA-SMI, handgrip strength, and sarcopenia was identified in 67.4%, 71.7%, and 56.5% of the patients. These proportions were significantly higher in the elderly group than in the non-elderly group (CT-SMI decline, $p=0.034$; BIA-SMI decline, $p=0.001$; handgrip strength decline, $p<0.0001$; and sarcopenia, $p<0.0001$).

Table 1
Patients' clinical characteristics

	Elderly (n=46)	Non-elderly (n=54)	*p*-value
Age, years (SD)	81.06 (3.82)	64.15 (7.82)	<0.0001
Sex, male / female	32 / 14	37 / 17	0.72
BMI, kg/m^2 (SD)	22.75 (3.12)	23.57 (3.74)	0.40
PS, 0/1/2/3/4	9/26/11/0/0	35/16/3/0/0	<0.0001
Etiology NAFLD/Alcohol/HCV/HBV/others	14/8/14/5/5	14/15/8/8/9	0.10
Platelets, $10^4/\mu L$ (SD)	13.03 (5.07)	14.83 (12.01)	0.77
Total bilirubin, mg/dL (SD)	0.94 (0.56)	2.20 (1.02)	0.053
Albumin, g/dL (SD)	3.6 (0.65)	3.5 (0.55)	0.46
Prothrombin time, % (SD)	86.28 (11.40)	81.83 (25.31)	0.56
Cr, mg/dL (SD)	0.95 (0.29)	1.21 (1.92)	0.20
NH3, μg/dL (SD)	47.57 (30.12)	59.23 (39.80)	0.22
CP classification, CP A/B/C	34/8/4	37/11/6	0.44
History of HCC (%)	36 (78.2)	30 (55.56)	0.02
Recurrence of HCC (%)	22/36 (61.1)	17/30 (56.7)	0.80
SMI, male/female (SD)	6.58 (0.76)/5.26 (0.57)	6.13 (0.87)/7.21 (0.92)	0.0056/0.0025
handgrip strength, male/female (SD)	24.54 (4.81)/14.89 (2.99)	30.81 (7.54)/18.90 (3.50)	0.001/0.0053
Positive for BIA-SMI decline (%)	33 (71.7)	21 (38.8)	0.0007
Positive for CT-SMI decline (%)	29 (60.9)	21 (38.9)	0.034
Positive for handgrip strength decline (%)	32 (69.6)	17 (31.6)	<0.0001
With sarcopenia (%)	26 (56.5)	9 (16.67)	<0.0001

BIA, bioelectrical impedance analysis; BMI, body mass index; CP, Child–Pugh classification; Cr, creatinine; CT, computed tomography; HBV, hepatitis B virus; HCC, hepatocellular carcinoma; HCV, hepatitis C virus; NAFLD, nonalcoholic fatty liver disease; SMI, skeletal muscle index; PS, ECOG Performance Status.

3.2. Inter-group comparison of the EAT-10 score

In the non-elderly group, more than 90% of the patients had an EAT-10 score of 0 and only 8.9% had a score of $\geq$1. In the elderly group, 52.2% of the patients had a score of $\geq$1 (Fig. 2a and b), with 32.6% having a score of $\geq$2 and 13.0% having a score of $\geq$3. These proportions in the EAT-10 score were significantly different between the two groups (Fig. 2c).

3.3. Association between the EAT-10 score and sarcopenia-related factors

We examined the association between the EAT-10 score and sarcopenia-related factors and the hepatic reserve in the elderly group and among all the patients. As shown in Fig. 3, the proportion of the patients in the elderly group with sarcopenia (Fig. 3a), with a decline in the handgrip strength (Fig. 3b) or in the SMI (Fig. 3c: BIA and 3d: CT) was significantly higher among patients with an EAT-10 score of $\geq$1 than among those with a score of 0. As seen in the supplementary figures, among all patients, the proportion of patients with sarcopenia-related factors was also significantly higher among patients with an EAT-10 score of $\geq$1 than among those with a score of 0 (supple Fig. 1-a–1d). No association was observed between the EAT-10 score and the hepatic reserve, such as the CP score or the ALBI grade, in the elderly group and among all the patients (Fig. 4 and supplementary Figure 2).

We further assessed the correlation between the EAT-10 score and the clinical characteristics in patients with or without sarcopenia. In multivariate regression analysis, only sarcopenia ($p=0.018$) was retained as a factor independently associated with an EAT-10 score of $\geq$ 2 (Table 2) in the elderly group. Among all patients, the EAT-10 score was significantly correlated with sarcopenia ($p=0.0004$) and age ($p=0.004$), with both factors being retained as factors independently associated with an EAT-10 score of $\geq$ 2 (sarcopenia, $p=0.009$; age, $p=0.016$; Table 3). However, sarcopenia was not significantly correlated

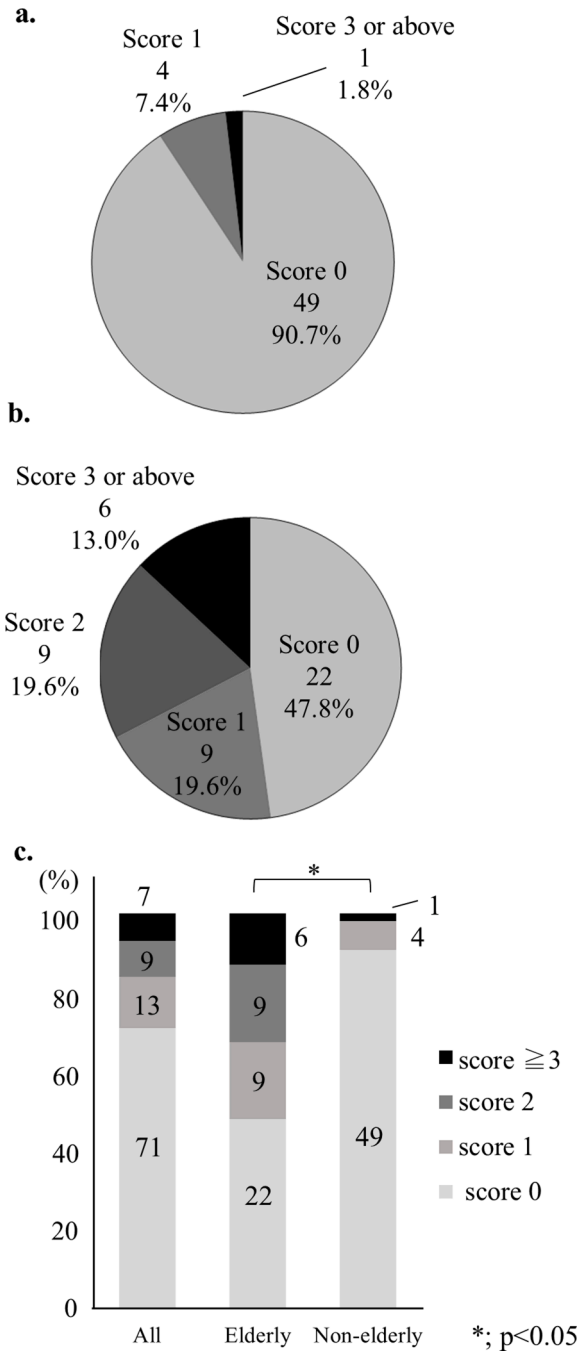

Fig. 2. Comparison of the EAT-10 score between the elderly and non-elderly groups.
Among all patients, >90% had a score of 0 in the non-elderly group (a). Among patients in the elderly group, 15 patients (32.6%) had a score of ≥2 and 6 patients (13.0%) had a score of ≥3 (b). The proportion of patients with a score of ≥3 was significantly higher in both groups (c)

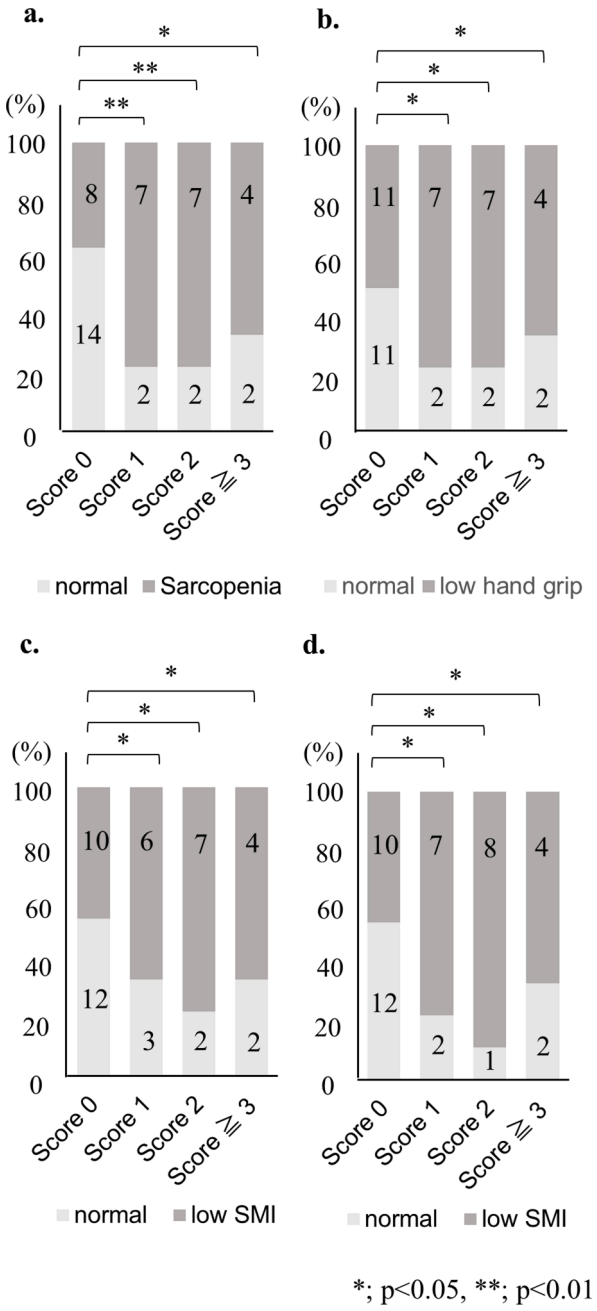

Fig. 3. Relationship between the EAT-10 score and sarcopenia-related factors in the elderly group
The proportions of patients with sarcopenia (a), decline in the handgrip strength (b), and decline in the SMI (c and d) were significantly higher among patients with an EAT-10 score of ≥1 than in those with a score of 0.
SMI, skeletal muscle mass index

with an EAT-10 score of ≥ 3 among all the patients (univariate analysis, p=0.055; multivariate analysis, p=0.062) (supplementary table 1).

3.4. Association between the EAT-10 score and the finger-ring test

The association between the EAT-10 and the finger-ring test among all patients is shown in Fig. 5a–c and Table 4. Overall, the patient distribution according to the finger-ring test was as follows: 46 (46.0%), 28 (28.0%), and 26 (26.0%) patients were classified into the bigger, just-fit, and smaller groups (Fig. 5a). The proportion of patients with an EAT-10 score of ≥ 2 was significantly higher in the smaller group than in either the just-fit or the smaller groups ($p<0.01$; Fig. 5b). The proportion of patients with an EAT-10 score of ≥ 3 was significantly higher in the smaller group than in the just-fit or bigger groups ($p<0.01$; Fig. 5c). Among all patients, the EAT-10 score was significantly correlated with the outcomes of the finger-ring test ($p=0.0004$) and age ($p=0.0025$), with both factors being retained as factors independently associated with an EAT-10 score of ≥ 2 (Table 4).

In the elderly group, the patient distribution according to the finger-ring test was as follows: 21 (45.7%), 8 (17.4%), and 17 (36.9%) patients were classified into the bigger, just-fit, and smaller groups (Fig. 5d). The

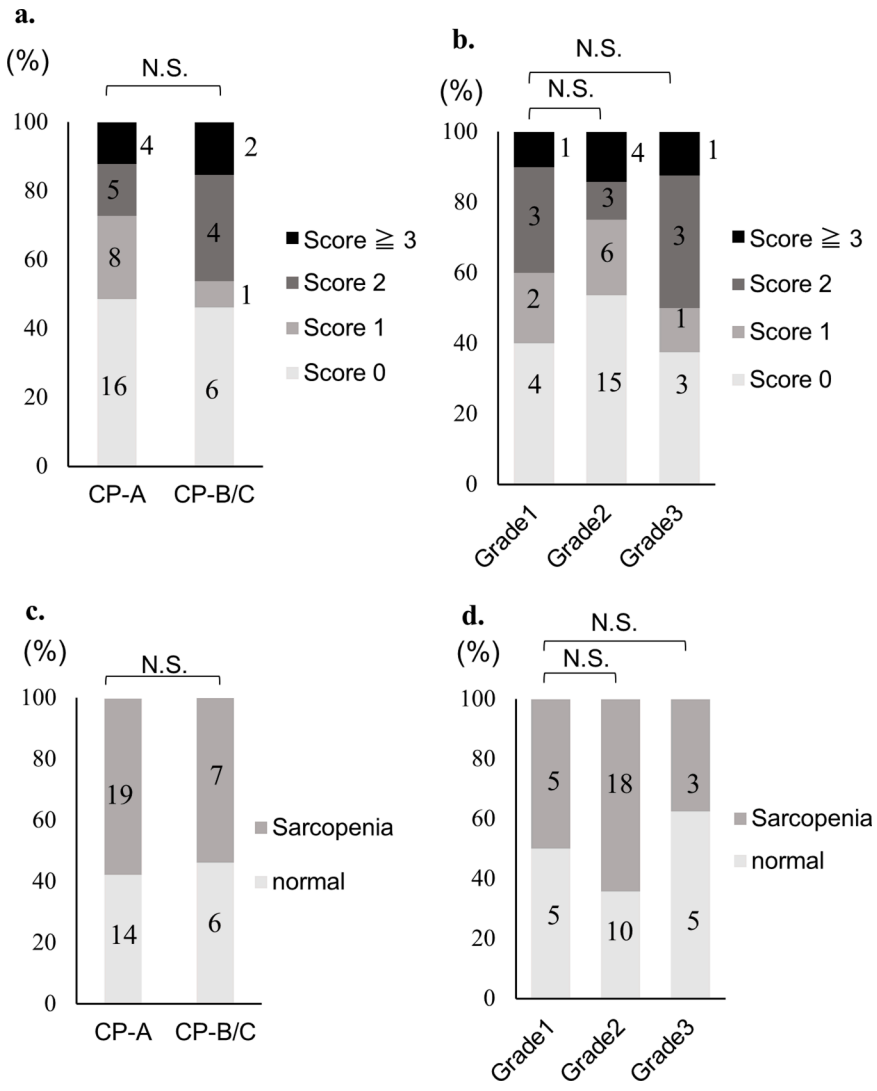

Fig. 4. Relationship between the EAT-10 score or sarcopenia and the CP grade in the elderly group.
Regarding dysphagia, 4 patients (12.1%) with CP-A had an EAT-10 score of ≥3 and 2 patients (15.4%) with CP-B/C group had an EAT-10 score of ≥3 (a). Furthermore, one (10.0%), four (14.3%), and one (12.5%) patients with ALBI Grade 1, Grade 2, and Grade 3, respectively, had an EAT-10 score of ≥3 (b). Regarding sarcopenia, 19 patients (57.5%) with CP-A and 7 patients (53.8%) with CP-B/C had sarcopenia (c). Furthermore, 5 (50.0%), 18 (64.3%), and 3 (37.5%) patients with ALBI Grade 1, Grade 2, and Grade 3, respectively, had sarcopenia (d).

Table 2
Correlation between an EAT-10 score of ≥ 2 and clinical factors in the elderly group

	Univariate			Multivariate		
Covariate	*p*-value	Odds ratio	95% CI	*p*-value	Odds ratio	95% CI
Age (years)	0.20	0.90	0.76–1.06	0.13	0.86	0.71–1.05
Sex (F/M)	0.54	1.43	0.32–6.45	0.85	0.87	0.18–4.03
With Sarcopenia	0.071	2.93	0.76–11.24	0.028	7.27	1.23–42.76
CP grade (BC/A)	0.42	2.22	0.49–10.16	0.58	1.61	0.30–8.62
HCC	0.41	0.45	0.09–2.06	0.21	3.48	0.26–26.28

CI, confidence interval; CP, Child–Pugh classification; F, female; M, male; HCC, hepatocellular carcinoma

Table 3
Correlation between an EAT-10 score of ≥ 2 and clinical factors among all patients

	Univariate			Multivariate		
Covariate	*p*-value	Odds ratio	95% CI	*p*-value	Odds ratio	95% CI
Age (years)	0.0033	1.13	1.04–1.22	0.012	1.10	1.01–1.21
Sex (F/M)	0.98	1.01	0.31–3.21	0.92	0.94	0.23–3.69
With Sarcopenia	0.0009	7.96	2.33–27.19	0.014	6.64	1.47–29.96
CP grade (BC/A)	0.74	1.21	0.37–3.99	0.39	1.84	0.45–7.46
HCC	0.76	1.34	0.39–4.66	0.15	3.40	0.65–17.78

CI, confidence interval; CP, Child–Pugh classification; F, female; M, male; HCC, hepatocellular carcinoma

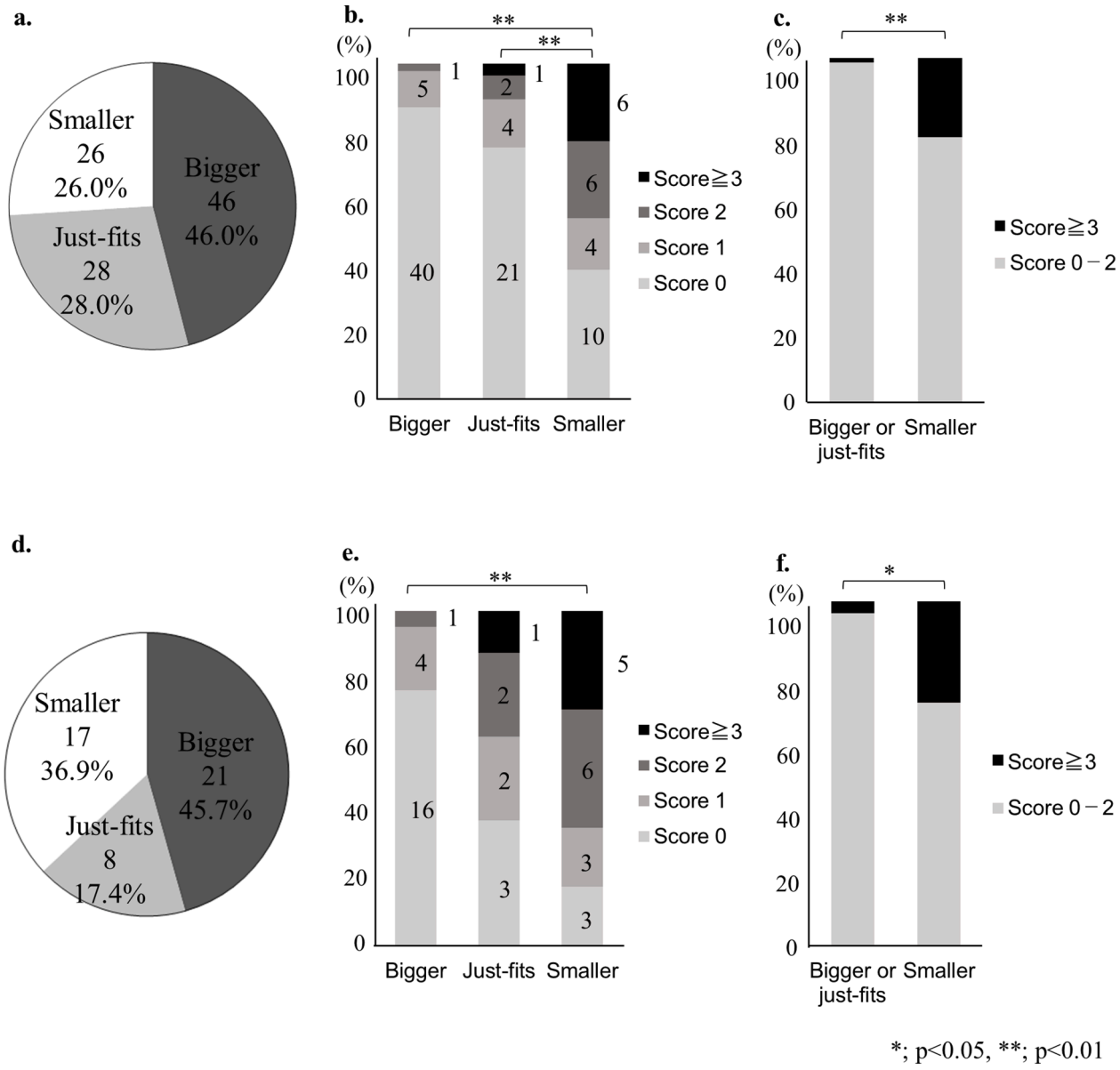

Fig. 5. Relationship between the EAT-10 score and the finger-ring test
Among all patients, 26 (26.0%) were classified into the 'smaller' group, which was defined by a calf size of the non-dominant leg smaller than the finger-ring circumference (A). The proportion of patients with an EAT-10 score of ≥2 was higher in the smaller group than in either the 'just-fit' or 'bigger' groups (B). In the elderly group, 17 patients (36.9%) were classified into the 'smaller' group (C). The proportion of patients with an EAT-10 score of ≥2 was significantly higher than in the 'bigger' group among all patients (D)

Table 4
Correlation between an EAT-10 score of ≥ 2 and the finger-ring test, age, and sex among all patients

Multivariate Covariate	*p*-value	Odds ratio	95% CI
Age (years)	0.025	1.14	1.03–1.25
Sex (F/M)	0.88	1.10	0.26–4.71
Finger-ring test (smaller or just fits/bigger groups)	0.004	25.9	2.94–189.90

CI, confidence interval; F, female; M, male.

proportion of patients with an EAT-10 score of ≥2 was significantly higher in the smaller group than in the bigger group ($p<0.01$; Fig. 5e). Furthermore, >30% of the elderly patients in the just-fit group had an EAT-10 score of 2. The proportion of patients with an EAT-10 score of ≥ 3 was significantly higher in the smaller group than in the just-fit or bigger groups ($p<0.05$; Fig. 5f).

4. Discussion

We evaluated the association between dysphagia and sarcopenia in patients with cirrhosis. Sarcopenia is one of the most common complications of several chronic diseases, including chronic liver disease. Hanai et al., identified sarcopenia as a complication in more than 50% of the patients with cirrhosis (Hanai et al., 2015). Sarcopenia has also been reported as a prognostic risk factor of survival in patients with liver cirrhosis (Hiraoka et al., 2018). Furthermore, dysphagia has become a

serious health problem in Japan, as a function of the super-aged society. It is known that the risk of dysphagia increases over the age of 70 years (Teramoto et al., 2008). Recently, sarcopenia-related dysphagia has received much attention (Wakabayashi et al., 2017), and a position paper on sarcopenia and dysphagia was published in 2019 (Fujishima et al., 2019). Currently, screening and intervention methods for sarcopenia-related dysphagia are being explored. However, little is known about the relationship between liver cirrhosis and dysphagia.

In our study, we observed that patients in the elderly group had higher EAT-10 scores than patients in the non-elderly group. However, there was no significant difference in the hepatic reserve between the two groups. We also observed that sarcopenia was significantly associated with dysphagia. These results suggest that sarcopenia may be a more important risk factor of dysphagia in patients with cirrhosis than in those with an adequate hepatic reserve. Although it is generally known that there is a correlation between the hepatic reserve and sarcopenia (Hiraoka et al., 2019), we did not identify a correlation between the two in our study. Unlike skeletal muscles, muscles associated with swallowing are closely related to respiratory movement and are less prone to muscle atrophy (Fujishima et al., 2019). Therefore, it is possible that compared to sarcopenia, the hepatic reserve has a lesser effect on dysphagia. Meanwhile, there were no significant differences in the proportion of sarcopenia-related factors between patients with an EAT-10 score of 1 or 2 and patients with a score of $\geq$3. The relationship between the swallowing function and sarcopenia remains unclear. Therefore, further studies are warranted to clarify the relationship between the extent of dysphagia and the severity of sarcopenia.

Regarding the assessment of dysphagia, the water-swallowing test and the volume-viscosity swallow test are two well-known bedside screening tools (Brodsky et al., 2016; Rofes et al., 2014). However, these tests require intraoral examination or cough induction. During the COVID-19 pandemic, the Society of Swallowing and Dysphagia of Japan has called attention to examination methods that might cause aerosol generation, such as videofluorography (Kimura et al., 2020). However, in our study, we found that 13% of the elderly patients were diagnosed with dysphagia, suggesting that patients with cirrhosis may have also suffered from dysphagia and sarcopenia. Therefore, it might be preferable to use the EAT-10 to continue assessing swallowing functions in patients with cirrhosis during the COVID-19 pandemic.

In our elderly group, we also observed a significant correlation between the EAT-10 score and the finger-ring test. Although the EAT-10 is a useful screening tool for dysphagia, it includes a number of items that makes it difficult for elderly patients to answer appropriately. By contrast, the finger-ring test does not require any instruments and is simple to perform. As the population continues to age, developing simple-to-use and economical tests, such as the finger-ring test, to screen for dysphagia will be required for the effective surveillance of patients with liver cirrhosis (Tanaka et al., 2018). Our findings provide some evidence of the usefulness of the finger-ring test to screen for not only sarcopenia, but also for dysphagia. Based on our findings, elderly patients with cirrhosis who are classified into the just-fit or smaller groups in the finger-ring test should be screened for dysphagia and sarcopenia.

This study has several limitations, which should be acknowledged. First, our study was a single-center, retrospective, cross-sectional study. The causal relationship between sarcopenia and dysphagia was unclear due to the cross-sectional nature of our study. Therefore, caution should be paid to the interpretation of our data. Second, the proportion of male patients was relatively high in our study population; therefore, results may be biased by sex-specific effects. Additionally, the number of patients with an EAT-10 score of $\geq$ 3 was very small that it was difficult to investigate the correlation between an EAT-10 score of $\geq$ 3 and the finger ring test using multivariate analysis. Future studies with lesser gender differences and a larger number of patients are required. Our evaluation also lacked objective assessments of dysphagia, such as tongue pressure measurement. Therefore, further examination would be needed to fully clarify the association between sarcopenia and dysphagia. Additionally, we have not investigated the degree of frailty or sleep disturbance that affects the quality of life in patients. Despite these limitations, our research also has strengths that are important to note. To the best of our knowledge, this is the first study to evaluate the association between sarcopenia and dysphagia among elderly patients with cirrhosis. Because dysphagia results in poor nutrition, its prevention among patients with cirrhosis is necessary to improve health outcomes.

In conclusion, sarcopenia is associated with dysphagia among patients with liver cirrhosis. Our results indicate that surveillance for dysphagia is important among elderly patients with cirrhosis and that the finger-ring test may be useful in screening for dysphagia and sarcopenia in this clinical population.

Author statement

Masafumi Haraguchi, Hisamitsu Miyaaki, and Kazuhiko Nakao wrote this manuscript. Masafumi Haraguchi, Hisamitsu Miyaaki, Ryu Sasaki, and Satoshi Miuma designed the protocol. Masafumi Haraguchi, Masanori Fukushima, Yutaka Nakamura, Syouhei Narita, Kousuke Matsumoto, Masanori Fukushima, and Ryu Sasaki are conducting the study. Masafumi Haraguchi and Ryu Sasaki performed statistical analyses. All authors have contributed to the study concept and design.

Author contributions

MH, HM, and KN wrote this manuscript. MH, HM, RS, and SM designed the protocol. MH, MF, YN, SN, KM, MF, and RS conducted the study. MH and RS performed the statistical analyses. All authors have contributed to the study concept and design.

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Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.archger.2021.104430.

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