Myosteatosis is an independent risk factor for overt hepatic encephalopathy after transjugular intrahepatic portosystemic shunting

Wenfeng Shi[a,*], Hua Yin[b,*], Zhijian Yu[c,*], Yong Li[d], Xiao Bai[d], Sirui Fu[d], Chongyang Duan[e], Weiguo Xu[d] and Yang Yang[d]

Objective The relationship between skeletal muscle and adipose tissue compositions and risk of overt hepatic encephalopathy (OHE) following transjugular intrahepatic portosystemic shunt (TIPS) treatment needs to be investigated.
Methods A total of 282 patients were collected from two medical centres. The median time of follow-up was 48.23 + 1.36 months and the first-year results of all patients after TIPS therapy were collected. The muscle and adipose tissue indices were quantified at the third lumbar vertebra level. Sarcopenia and myosteatosis were defined according to previous researches. Receiver operating characteristic curves, chi-square test, univariate and multivariate logistic regression analyses were employed to investigate the potential association between muscle and adipose indices, sarcopenia, myosteatosis and the risk of developing post-TIPS OHE.
Results All skeletal muscle indices, adipose tissue indices and sarcopenia had limited associations with post-TIPS OHE. Myosteatosis (148 cases, 52.5%, 55 with OHE, 37.2%) was identified as an independent risk factor for post-TIPS OHE. with $P < 0.001$ in Chi-square test, $P < 0.001$, odds ratio (OR): 2.854, 95% confidence interval (CI): 1.632–4.993 in univariate logistic regression analyses, and $P = 0.007$, OR: 2.372, 95% CI: 1.268–4.438 in multivariate logistic regression analyses, respectively.
Conclusion Our results showed that myosteatosis was proven as an independent risk factor for the development of post-TIPS OHE. Eur J Gastroenterol Hepatol 36: 897–903

Introduction

The occurrence of variceal haemorrhage and refractory ascites represent significant and perilous complications in individuals afflicted with portal hypertension stemming from cirrhosis. The use of transjugular intrahepatic portosystemic shunt (TIPS) can effectively reduce portal venous pressure through a minimally invasive approach, thus effectively treating variceal bleeding and hepatocirrhosis ascites [1–3]. However, compared with first-line standard therapy (drugs and endoscopic therapy, large-volume paracentesis and albumin infusion), which primarily focuses on symptomatic treatment, TIPS therapy is only reserved as a secondary option for salvaging cases in which initial standard therapy has proven ineffective. One of the primary causes of this paradox can be attributed to a prevalence of hepatic encephalopathy, particularly overt hepatic encephalopathy (OHE), after TIPS therapy [4–6]. Therefore, it is critical to explore the risk factors of TIPS-related OHE to reduce the occurrence of OHE. Several observational studies have conducted preliminary investigations into the precipitants associated with post-TIPS OHE, such as age, liver functions, serum sodium levels, diameter of stent, and portosystemic pressure gradient, etc [1,7–9]. However, the aforementioned studies predominantly centre on conventional clinical factors, with scant attention paid to skeletal muscle and adipose tissue modifications. Presently, some studies propose that the alterations in the skeletal muscle and adipose tissue structure are independent risk factors that contribute to cirrhosis-related OHE [10–12]. Therefore, additional research is required to investigate their influence on the development of TIPS-related OHE.

Alterations of skeletal muscle and adipose tissue are prevalent among individuals diagnosed with cirrhosis [13]. The detection of said diseases is favoured through the utilisation of computed tomography (CT) [14,15].

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[a]Department of General Medicine, [b]Clinical Research Management office, [c]Department of Otolaryngology, [d]Zhuhai Interventional Medical Centre, Zhuhai People's Hospital (Zhuhai Clinical Medical College of Jinan University), Zhuhai and [e]Department of Biostatistics, School of Public Health, Southern Medical University, Guangzhou, China

Correspondence to Dr. Yang Yang, MD, Zhuhai Interventional Medical Centre, Zhuhai People's Hospital (Zhuhai Hospital affiliated with Jinan University), No. 79 Kangning Road, 519000 Zhuhai, Guangdong Province, China

Tel: +86 0756 2158217; fax: +86 0756 2158217;
e-mail: yang1023yang2020@sina.com

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*Wenfeng Shi, Hua Yin and Zhijian Yu contributed equally to the writing of this article.

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Recent researches have investigated alterations in skeletal muscle and adipose tissue in relation to post-TIPS OHE, such as sarcopenia. Nevertheless, there is a lack of consensus regarding the association between sarcopenia and TIPS-related OHE [16,17]. Furthermore, although prior studies have demonstrated that myosteatosis and adipopenia exhibit independent associations with both OHE and mortality among individuals diagnosed with cirrhosis [11,13,18]. The precise relationship between myosteatosis and adipopenia and the onset of post-TIPS OHE remains unclear. Therefore, it is imperative to conduct further investigations regarding the interplay of skeletal muscle and adipose tissue factors and their plausible correlation with OHE subsequent to TIPS.

The aim of our study was to evaluate the correlation between the compositions of skeletal muscle and adipose tissue and the OHE in patients who underwent TIPS procedures. Through this assessment, we intend to ascertain novel independent risk factors that are associated with the development of post-TIPS OHE.

Methods

Patient selection

Between 1 January 2013 and April 30, 2021, a total of 282 patients who received TIPS treatment from two medical centres were collected in our study. All patients included in the study met the specified criteria: (1) Patients were diagnosed with cirrhosis accompanied by portal hypertension. (2) Patients who experienced uncontrolled bleeding or rebleeding following initial treatment with vasoactive drugs and endoscopic therapy. (3) Patients with refractory ascites, and they undergo large-volume paracentesis prior to TIPS therapy to prevent the influence of ascites on BMI assessment. (4) Individuals who are over the age of 18 or under 75 years old. The exclusion criteria were delineated as follows: (1) Model of end-stage liver disease (MELD) score up to 18 points or Child-Pugh score of at least 13 points. (2) Hepatocellular carcinoma that does not meet the Milano criteria for liver transplantation. (3) Total portal vein thrombosis, or severe medical comorbidities including severe right ventricular failure, congestive heart failure, severe valvular cardiac insufficiency; severe pulmonary hypertension; and uncontrolled systemic infection or septicaemia. (4) Patients with psychiatric comorbidities.

The retrospective study received approval from the Ethics Review Committee of the Zhuhai People's Hospital, with the assigned approval number being LW-2021-11. The requirement for informed consent was waived because the retrospective nature of this study. Prior to analysis, the data of all patients were rendered anonymous.

Data collection

The baseline clinical data were obtained from the databases of two medical centres. We selected the following clinical indicators as co-factors for skeletal muscle and adipose tissue analyses: sex, BMI, age, preoperative portal pressure gradient, serum sodium, ammonia, urea nitrogen, MELD score, liver cancer, diabetes. The measurement of dry body weight was conducted under conditions of ascites depletion [19] to evaluate BMI.

The CT images at the third lumbar vertebra level were collected within 2 weeks before TIPS treatment and quantified in square centimetres using a semi-automated software application (SliceOmatic V 5.0, Tomovision, Montreal, Quebec, Canada). The Hounsfield unit thresholds of −29 to +150, −190 to −30, and −150 to −50 were utilised to quantify and identify the cross-sectional area of skeletal muscles, subcutaneous and intramuscular adipose tissue, and visceral adipose tissue, as reported in previous studies [10,14,16]. The cross-sectional area of the respective muscles and adipose tissues was measured on the imaging scan. Subsequently, these area values are divided by the body surface area in square metres to obtain the index values in cm^2/m^2 [20]. Finally, various skeletal muscle and adipose tissue indices were computed for each patient, including the psoas muscle index (Fig. 1a), the erector spinae muscle index (Fig. 1b), the quadratus lumborum muscle index (Fig. 1c), the index of transversus abdominis, internal and external obliques muscle of abdomen (Fig. 1d), the rectus abdominis muscle index (Fig. 1e), the total skeletal muscle index (SMI) (Fig. 1f), the total adipose tissue index (Fig. 2a), the subcutaneous adipose tissue index (Fig. 2b), the visceral adipose tissue index (Fig. 2c), and the intramuscular adipose tissue index (Fig. 2d). To define myosteatosis, the muscle attenuation mean of total skeletal muscle, measured in Hounsfield units, was also recorded.

The cut-off values used to defined sarcopenia and myosteatosis were determined as follows: According to current literatures, individuals with sarcopenia can be defined by a total SMI of less than 39 cm^2/m^2 for women and less than 50 cm^2/m^2 for men, as measured at the third lumbar level [10,17]. Similarly, individuals with myosteatosis can be defined by a CT value of the entire muscle area of less than 41 Hounsfield units for patients with a BMI up to 24.9, and less than 33 Hounsfield units for those with a BMI greater than or equal to 25 [21].

TIPS procedure and follow-up

Prior to TIPS placement, anaemia (haemoglobin level > 7 g/dL) and coagulopathy (PT < 20 s) were managed using red blood cell suspension and fresh frozen plasma. Fluoroscopy was utilised to guide the puncture procedure. The polytetrafluoroethylene-covered stents were implemented during the TIPS procedure for all patients with a diameter of 8 mm. The determination of balloon diameter primarily relied on the adherence to established guidelines [22,23] regarding the adequacy of the portosystemic pressure gradient modifications. The preoperative and postoperative portosystemic pressure gradient of all patients was measured during the TIPS procedure.

None of the patients included in the study had regularly and consistently used lactulose and rifaximin after TIPS treatment. All patients were subjected to regular follow-up assessments, which involved either telephonic interviews or hospital visits, conducted at 3-month intervals. Doppler ultrasonography and laboratory investigations were conducted at 3-month intervals. The OHE was characterised based on the diagnostic criteria established by West Haven, specifically when the severity level was equal to or greater than Grade II. In the event of any

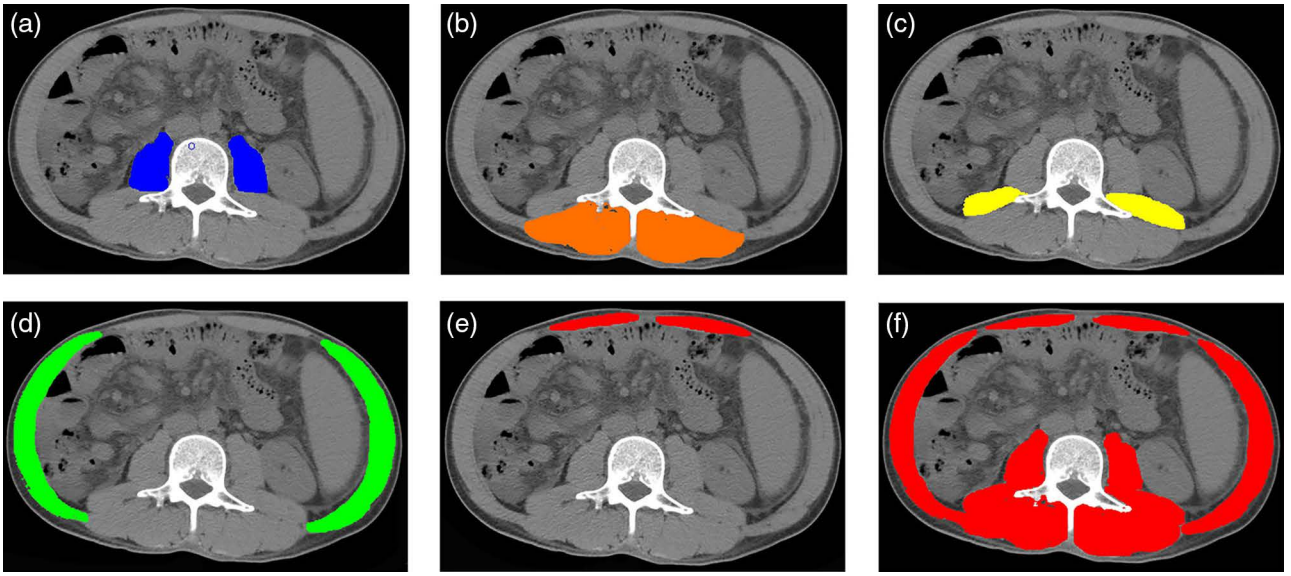

Fig. 1. The skeletal muscle indices. The psoas muscle index (a); the erector spinae muscle index (b); the quadratus lumborum muscle index (c); the index of transversus abdominis, internal and external obliques muscle of abdomen (d); the rectus abdominis muscle index (e); and the total skeletal muscle index (f).

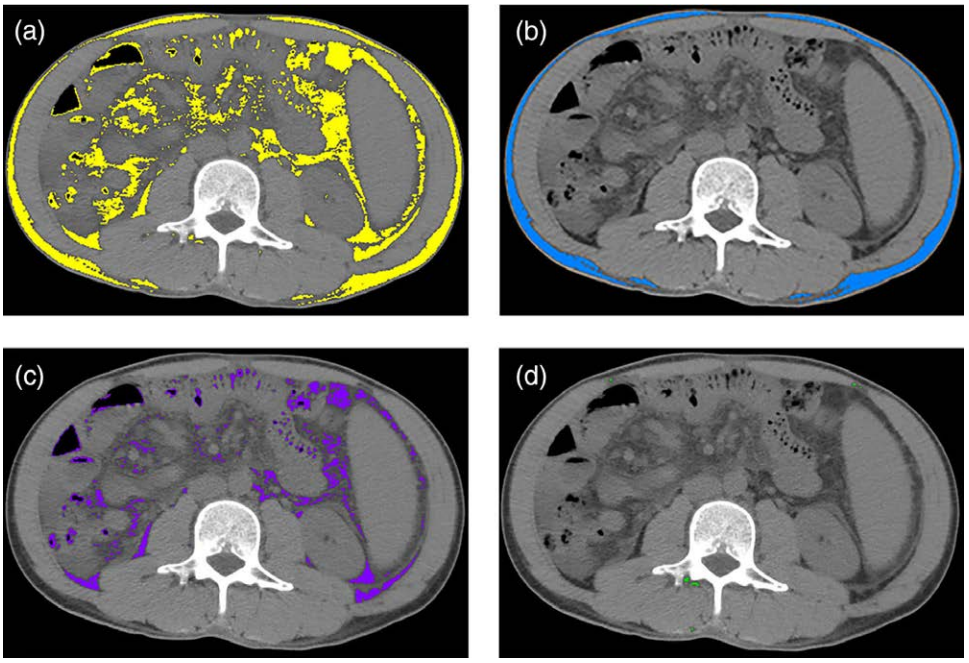

Fig. 2. The adipose tissue indices. the total adipose tissue index (a); the subcutaneous adipose tissue index (b); the visceral adipose tissue index (c); and the intramuscular adipose tissue index (d).

observed alterations in mental status, it is imperative for the family members of patients to promptly notify medical professionals. The follow-up duration is at least 1 year for the included patients (30 April 2022).

Statistical analyses

Quantitative data was presented in the form of means accompanied by SD, and was compared using either the Student's *t*-test or the Wilcoxon rank sum test, depending on whether or not the data was normally distributed. The categorical variables were presented in terms of frequency and analysed using either Pearson's chi-square or Fisher's exact test.

Receiver operating characteristic (ROC) curve analyses and univariate logistic regression analyses were conducted to assess the predictive capabilities of skeletal muscle and adipose tissue indices in determining the development of post-TIPS OHE. The relationships between TIPS-related OHE and sarcopenia as well as myosteatosis were evaluated using the Chi-square test, univariate and multivariate logistic regression analyses.

Calculation of adjusted odds ratios (ORs) and 95% confidence intervals (CIs) was performed. A two-tailed

P-value of 0.050 or less was used to determine statistical significance. The statistical software SAS version 9.4 (SAS Institute, Cary, North Carolina, USA) was utilised to perform variable analyses.

Results

Patients characteristics

Our study cohort consisted of 282 patients (78 patients with OHE and 204 patients without OHE). Table 1 presents an overview of the demographic, clinical, and biochemical features of the patients. All patients were followed for at least 12 months, the median follow up time is 48.23 + 1.36 months, and first-year results of all patients after TIPS therapy were collected. A total of 42 patients were excluded from the study due to reasons such as being lost to follow-up (18 cases), undergoing liver transplantation (3 cases), or experiencing mortality within 1 year without the occurrence of OHE (21 cases) (Fig. 3). The TIPS treatment was executed effectively in all patients, and no immediate complications related to the procedure, such as hemobilia, hemoperitoneum, or acute stent thrombosis, were observed within 24 h following TIPS therapy.

Table 1. Baseline characteristics of patients

Variables	With OHE (N = 78)	Without OHE (N = 204)	*P*-value
Age (years)	53.33 ± 10.75	50.37 ± 10.81	0.040[a]
Sex(N)			0.627
Male	65	163	
Female	13	41	
Height (cm)	165.34 ± 6.38	165.09 ± 7.36	0.790
Weight (Kg)	59.92 ± 10.90	60.27 ± 9.53	0.792
BMI	21.88 ± 3.58	22.04 ± 2.69	0.680
TIPS reason (N)			0.213
Bleeding	66	185	
Ascites	12	19	
Aetiology (N)			0.306
Hepatitis	55	143	
Alcohol	11	18	
Cholestatic	3	5	
Others	9	38	
Pre-PPG[b] (mmHg)	24.00 (20.00–28.00)	23.00 (19.00–28.00)	0.396
Serum sodium[b] (mmol/L)	140.00 (136.00–142.00)	140.95 (139.00–142.00)	0.008[a]
Ammonia[b] (μmol/L)	54.95 (39.26–77.43)	42.75 (31.50–56.36)	<0.001[a]
Creatinine[b] (μmol/L)	77.00 (61.50–86.00)	77.00 (62.00–89.00)	0.704
Urea nitrogen[b] (μmol/L)	5.00 (3.68–6.90)	4.90 (3.80–6.28)	0.846
MELD score[b]	10.35 (8.79–13.10)	9.89 (8.32–12.12)	0.058
LC (N)			0.481
Yes	14	28	
No	64	176	
DM (N)			0.281
Yes	21	41	
No	57	163	

DM, diabetes; LC, liver cancer; MELD, model of end-stage liver disease; Pre-PPG, preoperative portosystemic pressure gradient.
[a]With a statistical difference.
[b]Non-normally distributed quantitative data were expressed as median (interquartile range).

Associations between muscle and adipose tissue indices and post-TIPS OHE

The area under the ROC curves (AUC) values of skeletal muscle and adipose tissue indices were determined and recorded as follows: the psoas muscle index (PMI): 0.552; the quadratus lumborum muscle index: 0.488; the erector spinae muscle index: 0.511 (Fig. 4a); the transversus abdominis, internal and external obliques muscle of abdomen index: 0.546; the rectus abdominis muscle index: 0.531; the total SMI: 0.507 (Fig. 4b); the total adipose tissue index: 0.550; the subcutaneous adipose tissue index: 0.561; the visceral adipose tissue index: 0.530; and the intramuscular adipose tissue index: 0.549 (Fig. 4c). Furthermore, the outcomes were also corroborated by the univariate logistic regression analyses conducted on the indices of skeletal muscle and adipose tissue, as presented in Supplementary Table 1, supplemental digital content 1, *http://links.lww.com/EJGH/A998*.

Associations between sarcopenia and myosteatosis and post-TIPS OHE

To investigate the impact of sarcopenia and myosteatosis on post-TIPS OHE, the chi-square test, univariate and multivariate logistic regression analyses were performed.

In the context of sarcopenia (208 cases, 73.8%, 60 with OHE, 28.8%): *P*-value of 0.552 during the chi-square test (Supplementary Table 2, supplemental digital content 1, *http://links.lww.com/EJGH/A998*); and *P*-value of 0.456 (OR: 1.261, 95%CI: 0.685–2.321) during the univariate logistic regression analyses (Table 2).

In the context of myosteatosis (148 cases, 52.5%, 55 with OHE, 37.2%), the chi-square test yielded a *P*-value of <0.001 (Supplementary Table 3, supplemental digital

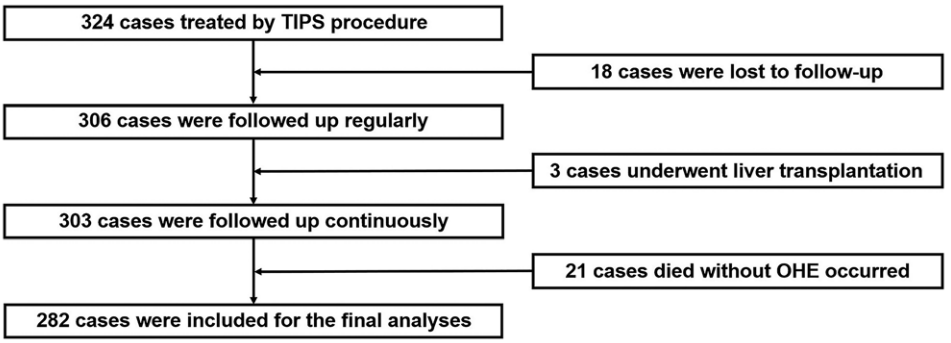

Fig. 3. Patient selection flowchart. We screened 324 patients from two hospitals. After inclusion and exclusion criteria were applied, 282 patients were included in the study.

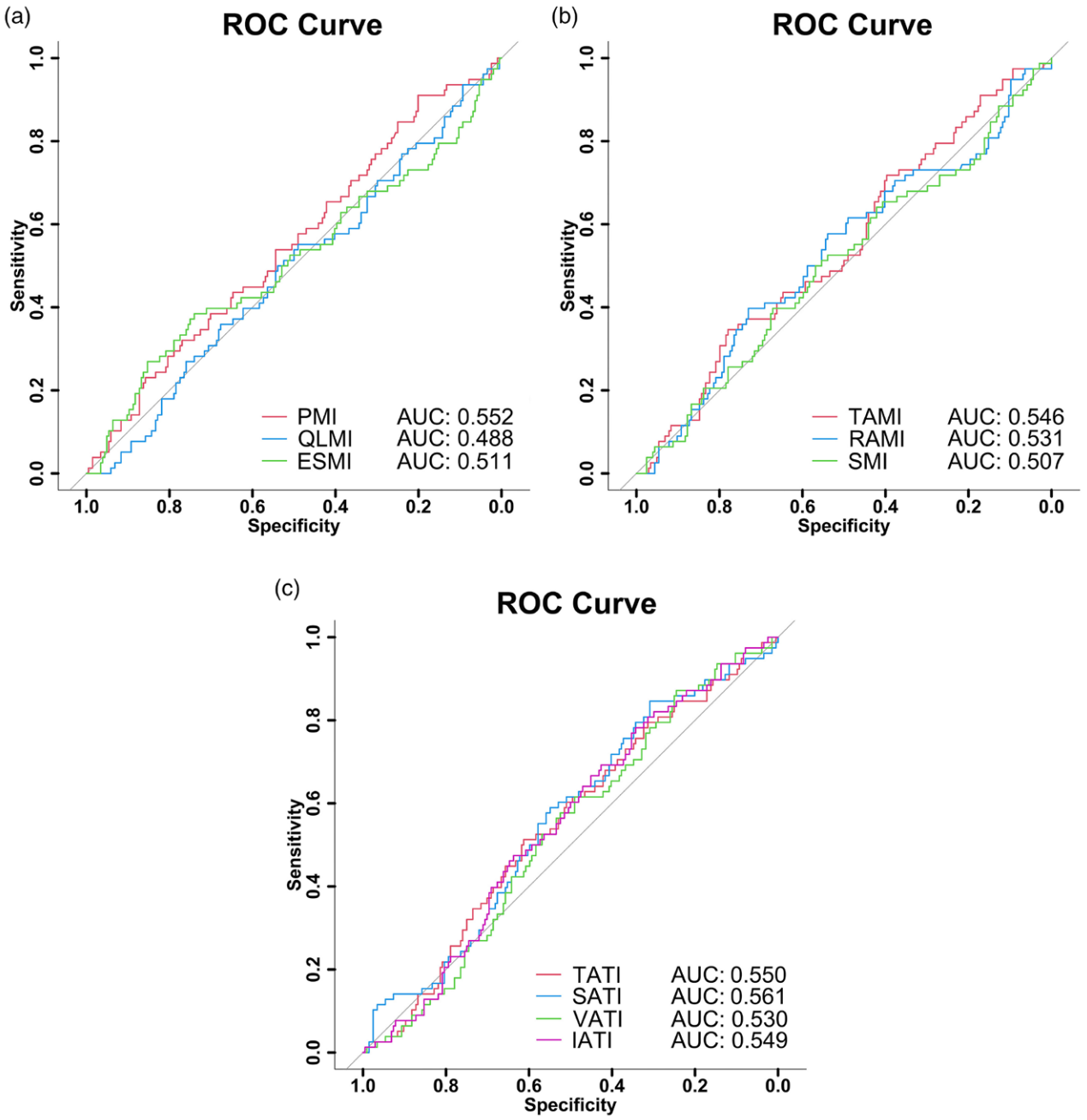

Fig. 4. Receiver operating characteristic curve of all skeletal muscle and adipose indices. The receiver operating characteristic curves of the psoas muscle index (PMI), the quadratus lumborum muscle index (QLMI) and the erector spinae muscle index (ESMI) (a); The receiver operating characteristic curves of the index of transversus abdominis, internal and external obliques muscle of abdomen (TAMI), the rectus abdominis muscle index (RAMI) and the total skeletal muscle mass index (SMI) (b); The receiver operating characteristic curves of the total adipose tissue index (TATI), the subcutaneous adipose tissue index (SATI), the visceral adipose tissue index (VATI) and the intramuscular adipose tissue index (IATI) (c).

content 1, *http://links.lww.com/EJGH/A998*). In addition, the univariate logistic regression analyses indicated *P*-values of <0.001 (OR: 2.854, 95% CI: 1.632–4.993) (Table 2), and the multivariate logistic regression analyses also showed a *P*-value of 0.007 (OR: 2.372, 95% CI: 1.268–4.438) (Table 3).

Discussion

The high incidence of post-TIPS hepatic encephalopathy presents a quandary regarding the decision of TIPS therapy. Therefore, the prediction of post-TIPS OHE demonstrates a pressing challenge. However, most existing studies mainly focus on conventional clinical factors, such as serum sodium, ammonia, diameter of stent, and portosystemic pressure gradient, to explore their correlation with the incidence of OHE [7,9,24–26]. Moreover, some studies have also examined the relationship between minimal hepatic encephalopathy (mHE) and post-TIPS OHE [27,28]. However, the diagnosis of mHE is challenging, as there are no universally accepted diagnostic criteria. Local standards and expertise are required, and

Table 2. Univariate logistic regression analysis for sarcopenia and myosteatosis

	OR	95% CI	*P*-value
Myosteatosis	2.854	1.632–4.993	<0.001[a]
Sarcopenia	1.261	0.685–2.321	0.456
Sex	0.795	0.400–1.580	0.513
BMI	0.981	0.898–1.073	0.679
Age	1.026	1.001–1.052	0.041[a]
Pre-PPG	1.010	0.972–1.049	0.612
Serum sodium	0.890	0.826–0.960	0.002[a]
Ammonia	1.019	1.009–1.029	<0.001[a]
Urea nitrogen	0.995	0.910–1.088	0.913
MELD score	1.114	1.009–1.230	0.032[a]
LC	1.375	0.681–2.776	0.374
DM	1.465	0.799–2.686	0.217

CI, confidence interval; DM, diabetes; LC, liver cancer; MELD, model of end-stage liver disease; OR, odds ratio; Pre-PPG, preoperative portosystemic pressure gradient.
[a]Statistically significant differences.

Table 3. Multivariate logistic regression analyses for myosteatosis

	OR	95% CI	*P*-value
Myosteatosis	2.372	1.268–4.438	0.007[a]
Age	1.014	0.986–1.043	0.331
Serum sodium	0.915	0.845–0.990	0.028[a]
Ammonia	1.017	1.006–1.028	0.002[a]
MELD score	1.053	0.945–1.174	0.351

CI, confidence interval; MELD, model of end-stage liver disease; OR, odds ratio.
[a]Statistically significant differences.

some tests involve psychometric and neuropsychological assessments. Given the difficulty of using retrospective data in our study to evaluate mHE, further exploration is needed to understand the association of mHE. In addition to above issues, all of them failed to consider the significance of alterations of skeletal muscle and adipose tissue before TIPS therapy. Based on our results, myosteatosis was found to be an independent risk factor related to post-TIPS OHE.

Recent studies have indicated a potential correlation between ammonia metabolism and sarcopenia, myosteatosis, as well as adipopenia [12,13,18]. Therefore, further investigation is required to explore the association between the aforementioned ailments and TIPS-related OHE. Initially, the skeletal muscle and adipose tissue indices were assessed. Our results showed that none of the indices pertaining to muscle and adipose tissue exhibit a discernible cut-off value in relation to post-TIPS OHE, as evidenced by AUC values that is in close proximity to 0.5. Furthermore, it was observed that all *P*-values of the aforementioned indices were greater than 0.1 during the univariate logistic regression analysis. These results suggest that the predictive effect of each muscle and adipose tissue index alone for post-TIPS OHE is relatively limited.

Second, the association between sarcopenia and post-TIPS OHE is a topic of debate. The findings of our study indicate that there was no statistically significant association between sarcopenia and post-TIPS OHE. Our results align with those of Amine *et al*. [17], only utilisation of stents with a diameter of 8 mm in our research. In contrast to the results of Nardelli *et al*. [16], the authors of this study have identified sarcopenia as a potential risk factor for the development of post-TIPS hepatic encephalopathy. This discrepancy in results may be attributed to the utilisation of stents with larger diameters in Nardelli's study.

Third, with regards to myosteatosis, current studies have shown that myosteatosis is an independent risk factor associated with OHE and mortality in patients with cirrhosis [29, 30]. However, there is a lack of research correlating myosteatosis with post-TIPS OHE or TIPS-related mortality. In this study, we chose OHE as the primary endpoint initially. Our study suggests that myosteatosis represents an independent risk factor for TIPS-related OHE. Recent researches have found that myosteatosis can serve as an indicator for muscle quality [31]. The modifications of muscle quality may negatively affect muscle function by disrupting metabolism [9,10] and altering the secretion of myokines, such as tumour necrosis factor-α and interleukin-6 [21], which can lead to an increase in ammonia levels. Furthermore, the presence of fatty muscle infiltration is a component of the frailty syndrome, which may lead to a reduction in the body's reserve function and its ability to withstand stressors among these patients [12], making OHE more likely to occur. Therefore, as part of the complex of metabolic liver disease, diabetes, frailty, and systemic inflammation, patients with myosteatosis may also be at high risk of post-TIPS OHE.

The present investigation has several limitations. Initially, the findings were derived from a limited sample size. Further external validation cohorts were required to validate the conclusions due to variances in radiological characteristics and technical challenges across various medical facilities. Second, it is worth noting that the incidence of OHE may vary depending on the diameter of the stent used, with 8-mm and 10-mm stents having different influences [4]. Therefore, it is necessary to conduct further investigations to determine the applicability of our results to patients who have undergone the placement of 10-mm stents. Third, due to the challenges associated with evaluating minimal hepatic encephalopathy, our investigation solely focussed on the analysis of OHE. It is recommended that future research endeavours incorporate data pertaining to minimal hepatic encephalopathy. Finally, due to the retrospective design, it was challenging to ensure that all patients who experienced OHE before TIPS were included in the study. Therefore, further discussion is needed to determine if these patients still have an impact on the results.

Conclusion

Each skeletal muscle and adipose tissue indices, along with the sarcopenia, may had no significant association with

post-TIPS OHE. The myosteatosis is a novel independent risk factor related to post-TIPS OHE.

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Conflicts of interest

There are no conflicts of interest.

References

1 Tripathi D, Stanley AJ, Hayes PC, Travis S, Armstrong MJ, Tsochatzis EA, *et al*. Transjugular intrahepatic portosystemic stent-shunt in the management of portal hypertension. *Gut* 2020; 69:1173–1192.
2 Zuo L, Lv Y, Wang Q, Yin Z, Wang Z, He C, *et al*. Early-recurrent overt hepatic encephalopathy is associated with reduced survival in cirrhotic patients after transjugular intrahepatic portosystemic shunt creation. *J Vasc Interv Radiol* 2019; 30:148–153.e2.
3 Lv Y, Qi X, He C, Wang C, Yin Z, Niu J, *et al*. Covered TIPS versus endoscopic band ligation plus propranolol for the prevention of variceal rebleeding in cirrhotic patients with portal vein thrombosis: a randomised controlled trial. *Gut* 2018; 67:2156–2168.
4 Bureau C, Thabut D, Oberti F, Dharancy S, Carbonell N, Bouvier A, *et al*. Transjugular intrahepatic portosystemic shunts with covered stents increase transplant-free survival of patients with cirrhosis and recurrent ascites. *Gastroenterology* 2017; 152:157–163.
5 Yang Y, Fu S, Cao B, Hao K, Li Y, Huang J, *et al*. Prediction of overt hepatic encephalopathy after transjugular intrahepatic portosystemic shunt treatment: a cohort study. *Hepatol Int* 2021; 15:730–740.
6 Liver EAFT. EASL clinical practice guidelines on the management of hepatic encephalopathy. *J Hepatol* 2022; 77:807–824.
7 Coronado WM, Ju C, Bullen J, Kapoor B. Predictors of occurrence and risk of hepatic encephalopathy after tips creation: a 15-year experience. *Cardiovasc Intervent Radiol* 2020; 43:1156–1164.
8 Lin X, Gao F, Wu X, Cai W, Chen X, Huang Z. Efficacy of albumin–bilirubin score to predict hepatic encephalopathy in patients underwent transjugular intrahepatic portosystemic shunt. *Eur J Gastroenterol Hepatol* 2021; 33:862–871.
9 Zou L, Lv Y, Wang QH, Yin Z, Wang Z, He C, *et al*. Early-recurrent overt hepatic encephalopathy is associated with reduced survival in cirrhotic patients after transjugular intrahepatic portosystemic shunt creation. *J Vasc Interv Radiol* 2019; 30:148–153.
10 Nardelli S, Lattanzi B, Merli M, Farcomeni A, Gioia S, Ridola L, *et al*. Muscle alterations are associated with minimal and overt hepatic encephalopathy in patients with liver cirrhosis. *Hepatology* 2019; 70:1704–1713.
11 Rodrigues SG, Brabandt B, Stirnimann G, Maurer MH, Berzigotti A. Adipopenia correlates with higher portal pressure in patients with cirrhosis. *Liver Int* 2019; 39:1672–1681.
12 Bhanji RA, Moctezuma-Velazquez C, Duarte-Rojo A, Ebadi M, Ghosh S, Rose C, *et al*. Myosteatosis and sarcopenia are associated with hepatic encephalopathy in patients with cirrhosis. *Hepatol Int* 2018; 12:377–386.
13 Alatzides GL, Haubold J, Steinberg HL, Koitka S, Parmar V, Grueneisen J, *et al*. Adipopenia in body composition analysis: a promising imaging biomarker and potential predictive factor for patients undergoing transjugular intrahepatic portosystemic shunt placement. *Br J Radiol* 2023; 96:20220863.
14 De Luca M, Addario L, Lombardi A, Imparato M, Fontanella L, Addario M, *et al*. Adipopenia is the rapid screening tool that best predicts mortality in patients with decompensated cirrhosis: results of a prospective study. *J Gastrointestin Liver Dis* 2021; 30:94–102.
15 Yip C, Dinkel C, Mahajan A, Siddique M, Cook GJ, Goh V. Imaging body composition in cancer patients: visceral obesity, sarcopenia and sarcopenic obesity may impact on clinical outcome. *Insights Imaging* 2015; 6:489–497.
16 Nardelli S, Lattanzi B, Torrisi S, Greco F, Farcomeni A, Gioia S, *et al*. Sarcopenia is risk factor for development of hepatic encephalopathy after transjugular intrahepatic portosystemic shunt placement. *Clin Gastroenterol Hepatol* 2017; 15:934–936.
17 Benmassaoud A, Roccarina D, Arico F, Leandro G, Yu B, Cheng F, *et al*. Sarcopenia does not worsen survival in patients with cirrhosis undergoing transjugular intrahepatic portosystemic shunt for refractory ascites. *Am J Gastroenterol* 2020; 115:1911–1914.
18 Gioia S, Ridola L, Cristofaro L, Merli M, Faccioli J, Riggio O, *et al*. The improvement in body composition including subcutaneous and visceral fat reduces ammonia and hepatic encephalopathy after transjugular intrahepatic portosystemic shunt. *Liver Int* 2021; 41:2965–2973.
19 Merli M, Zelber-Sagi S, Dasarathy S, Montagnese S, Genton L, Plauth M, *et al*. EASL clinical practice guidelines on nutrition in chronic liver disease. *J Hepatol* 2019; 70:172–193.
20 Paternostro R, Lampichler K, Bardach C, Asenbaum U, Landler C, Bauer D, *et al*. The value of different CT-based methods for diagnosing low muscle mass and predicting mortality in patients with cirrhosis. *Liver Int* 2019; 39:2374–2385.
21 Tan L, Ji G, Bao T, Fu H, Yang L, Yang M. Diagnosing sarcopenia and myosteatosis based on chest computed tomography images in healthy Chinese adults. *Insights Imaging* 2021; 12:163.
22 Liver E AFT. EASL clinical practice guidelines for the management of patients with decompensated cirrhosis. *J Hepatol* 2018; 69:406–460.
23 Garcia Tsao G, Abraldes JG, Berzigotti A, Bosch J. Portal hypertensive bleeding in cirrhosis: risk stratification, diagnosis, and management: 2016 practice guidance by the American Association for the Study of Liver diseases. *Hepatology* 2016; 65:310–335.
24 Weintraub JL, Mobley DG, Weiss ME, Swanson E, Kothary N. A novel endovascular adjustable polytetrafluoroethylene-covered stent for the management of hepatic encephalopathy after transjugular intrahepatic portosystemic shunt. *J Vasc Interv Radiol* 2007; 18:563–566.
25 Yang Y, Liang X, Yang S, He X, Huang M, Shi W, *et al*. Preoperative prediction of overt hepatic encephalopathy caused by transjugular intrahepatic portosystemic shunt. *Eur J Radiol* 2022; 154:110384.
26 Sihang C, Xiang Y, Xinyue C, Jin Z, Xue H, Wang Z, *et al*. CT-based radiomics model for preoperative prediction of hepatic encephalopathy after transjugular intrahepatic portosystemic shunt. *Brit J Radiol* 2022; 95:20210792.
27 Ehrenbauer AF, Schneider H, Stockhoff L, Tiede A, Lorenz C, Dirks M, *et al*. Predicting overt hepatic encephalopathy after TIPS: value of three minimal hepatic encephalopathy tests. *Jhep Rep* 2023; 5:100829.
28 Gabriel MM, Kircheis G, Hardtke S, Markwardt D, Buggisch P, Mix H, *et al*.; HepNet HE-Register Study Group. Risk of recurrent hepatic encephalopathy in patients with liver cirrhosis: a German registry study. *Eur J Gastroenterol Hepatol* 2021; 33:1185–1193.
29 Bhanji RA, Moctezuma-Velazquez C, Duarte-Rojo A, Ebadi M, Ghosh S, Rose C, *et al*. Myosteatosis and sarcopenia are associated with hepatic encephalopathy in patients with cirrhosis. *Hepatol Int* 2018; 12:377–386.
30 Ebadi M, Tsien C, Bhanji RA, Dunichand-Hoedl AR, Rider E, Motamedrad M, *et al*. Skeletal muscle pathological fat infiltration (myosteatosis) is associated with higher mortality in patients with cirrhosis. *Cells* 2022; 11:1345.
31 Lattanzi B, Nardelli S, Pigliacelli A, Di Cola S, Farcomeni A, D'Ambrosio D, *et al*. The additive value of sarcopenia, myosteatosis and hepatic encephalopathy in the predictivity of model for end-stage liver disease. *Dig Liver Dis* 2019; 51:1508–1512.