Sarcopenia does not worsen survival in patients with cirrhosis undergoing transjugular intrahepatic portosystemic shunt for refractory ascites

Amine Benmassaoud, MD[1,2]; Davide Roccarina, MD[1,2]; Francesco Arico[1,2]; Gioacchino Leandro, MD[3] ;Becky Yu[1,2]; Felix Cheng[1,2]; Dominic Yu, MD[4]; David Patch, MD[1,2]; Emmanuel A. Tsochatzis, PhD[1,2] .

[1]The Royal Free Sheila Sherlock Liver Centre, Royal Free London NHS Trust, London, UK

[2]UCL Institute for Liver and Digestive Health, University College of London, London, UK

[3]National Institute of Gastroenterology, S. De Bellis Research Hospital, Castellana Grotte, Italy

[4]Department of Radiology, Royal Free London NHS Trust, London, UK

Corresponding Author

Dr. Emmanuel Tsochatzis, PhD

Sheila Sherlock Liver Unit and UCL Institute for Liver and Digestive Health

Royal Free Hospital and UCL,

Pond Street,

London, NW3 2QG, UK

Email: e.tsochatzis@ucl.ac.uk

Guarantor of the article

Dr. Emmanuel Tsochatzis

Specific author contributions

AB and ET planned the study; AB, DR, FA, BY, and FC collected the data; AB, GL, DY, DP, and ET interpreted data; AB, DP, and ET drafted the manuscript. AB, DR, FA, GL, BY, FC, DY, DP and ET have approved the final draft of the manuscript.

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Study Highlights

WHAT IS KNOWN

Sarcopenia is associated with increased mortality in patients with cirrhosis

The impact of sarcopenia in patients undergoing TIPSS insertion for refractory ascites is unknown

WHAT IS NEW

Sarcopenia is not associated with worse outcome after TIPSS insertion for refractory ascites

Sarcopenia is not associated with increased incidence of encephalopathy following TIPSS insertion for refractory ascites

Insertion of TIPSS in patients with refractory ascites might lead to improvement in muscle mass

ABSTRACT

Objectives

The impact of sarcopenia in patients undergoing transjugular intrahepatic portosystemic shunt (TIPSS) insertion for refractory ascites is unknown.

Methods

All adult patients who underwent TIPSS insertion for refractory ascites between 2010 and 2018 were included. Skeletal muscle index at L3 was used to determine sarcopenia status.

Results

107 patients were followed for 14.2 months. Sarcopenia was present in 57% of patients. No patient had history of pre-TIPSS hepatic encephalopathy (HE). *De novo* HE occurred in 30% of patients. On MVA, only platelet count and L3-SMI predicted *de novo* HE. On MVA, age and MELD-Na predicted mortality whereas L3-SMI and sarcopenia did not. In patients with repeat imaging, L3-SMI improved significantly post-TIPSS compared to baseline.

Conclusions

Sarcopenia should not be considered as a contra-indication to TIPSS insertion in refractory ascites as it is not associated with *de novo* HE or increased mortality.

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Keywords

Skeletal Muscle Index, Psoas Muscle Index, Hepatic Encephalopathy, Liver transplantation, malnutrition

INTRODUCTION

The insertion of a transjugular intrahepatic portosystemic shunt (TIPSS) has become an effective treatment for refractory ascites in selected patients, with recent data showing improved 1-year transplant free survival (1-5). Sarcopenia, defined as skeletal muscle index (L3-SMI) or total psoas muscle index (L3-PMI) at the third lumbar vertebrae, is a predictor of poor outcome in patients with cirrhosis before and after transplantation(6-9). We investigated the impact of pre-existing sarcopenia, by L3-SMI or L3-PMI, on incidence of *de novo* hepatic encephalopathy (HE), and overall mortality post-TIPSS in a large cohort of consecutive patients who underwent TIPSS insertion for refractory ascites(10, 11).

METHODS

We conducted a retrospective cohort study including all adult patients with cirrhosis who underwent TIPSS insertion for refractory ascites and had baseline cross-sectional abdominal imaging within 6 months before or 2 weeks after TIPSS insertion at our institution between April 01/04/2010 and 01/04/2018. To be considered for TIPSS insertion, patients required repeated large volume paracentesis for at least six months. As per our standard protocol, patients with a prior diagnosis of HE or abnormal EEG were not considered for TIPSS. Patients were identified through a prospective database. Ethics approval was waived as per standard procedure for retrospective studies which fall under the audit category.

Sarcopenia assessment

To measure L3-SMI and L3-PMI at baseline, transverse sections of cross-sectional imaging were analyzed using ImageJ (version 1.51, Wayne Rasband, National Institutes of Health)(6). Previously validated for L3-SMI, a MRI-specific method was employed when necessary (12). All measurements were performed by a single trained physician in a blinded manner. Patients in the lowest quartile of L3-PMI as stratified by sex were considered to be sarcopenic(6). Women and men with L3-SMI under $39cm^2/m^2$ and $50cm^2/m^2$, respectively, were considered to be sarcopenic(8).

Outcome measures

Patients were followed by their treating hepatologist and were seen at least every 6 months. Occurrence of *de novo* HE, defined as clinically evident or at least grade II as per West Haven criteria, was recorded as well as its treatment (13). Liver transplantation and death were recorded.

Statistical analysis

Association between risk factors and *de novo* HE or survival was assessed using multivariate Cox regression reporting hazard ratio (HR). Competing risk analysis was performed for survival considering liver transplantation as a competing event. Statistical analysis was carried using SPSS (version 25.0, IBM, New York, NY, USA) and STATA (version 16, STATA Corp LLC, College Station, TX, USA).

RESULTS

Main characteristics

A total of 165 patients underwent TIPSS insertion for refractory ascites during the study period. After application of inclusion and exclusion criteria, the final cohort was constituted of 107 patients. Baseline characteristics are presented in Table 1. L3-PMI results are presented in supplemental analysis (Supplemental table 1-5). Multivariate logistic regression showed that BMI and sex were associated with baseline sarcopenia.

Change of muscle mass during follow-up

Follow-up cross sectional imaging was available in 41 patients. The median time to the last cross-sectional imaging was 12.7 (IQR 19.3) months. In this subset of patients, L3-SMI increased from 45.2±9.0 cm^2/m^2 to 48.4±11.5 cm^2/m^2 at last imaging (p=0.009). The improvement was more significant in women where L3-SMI increased from 41.3±7.7 cm^2/m^2 to 44.0±9.7 cm^2/m^2 (p=0.013) compared to 47.9±9.1 cm^2/m^2 to 51.5±11.9 cm^2/m^2 (p=0.07) in men.

Hepatic Encephalopathy

Overall, 32 (29.9%) patients suffered from *de novo* HE following TIPSS insertion. Medical therapy with lactulose or combination with rifaximin controlled HE in 27 (84.3%) patients, whereas 4 (12.5%) patients needed TIPSS reduction and 1 (3.1%) TIPSS occlusion. Multivariate cox regression analysis showed that platelets and L3-SMI were associated with *de novo* HE while sarcopenia was not (Table 2).

Mortality

Overall, 34 (31.8%) patients died and 18 (16.8%) were transplanted during follow-up. The 1, 3, and 5-year overall survival rates were 79%, 56%, and 36% respectively. Multivariate analysis presented in table 4 shows that age, MELD-Na and platelet count were independent predictors of mortality, while L3-SMI and sarcopenia were not. Finally, in a competing risk analysis with liver transplantation as a competing event, L3-SMI and sarcopenia were not associated with mortality (Table 3).

DISCUSSION

This is the first study that assessed the impact of sarcopenia on patients undergoing TIPSS insertion for refractory ascites. Although a higher L3-SMI was associated with a lower risk of *de novo* HE, sarcopenia was not. Furthermore, in patients with available repeat cross-sectional imaging, we noted an improvement of L3-SMI over time. We also demonstrated that neither L3-SMI nor L3-PMI were able to predict mortality following TIPSS insertion for refractory ascites.

A recent study concluded that sarcopenia was associated with higher mortality post-TIPSS(12). This particular study spanned 20 years starting in 1993 and therefore included patients with uncovered stents. It also included patients who received TIPSS for various indications and 60% of patients at inclusion had HE (12). At this stage, we believe that our study provides a more accurate depiction of patients undergoing TIPSS insertion for refractory ascites and that baseline sarcopenia should not be seen as a contraindication.

De novo HE occurred in 30% of patients, consistent with previous cohorts(4, 5, 14). Nardelli et al. identified sarcopenia as a risk factor for post-TIPSS HE(11). In their cohort, they had a higher than expected incidence of HE which could be due to the use of larger stents (15). In our cohort, the most commonly used stents measured 8mm. Furthermore, our rates of post-TIPSS HE might have been influenced by our patient selection as no patient with pre-existing HE received a TIPSS.

Our study has several strengths as it provides an updated real-world look at the outcomes of a large cohort of patients with refractory ascites treated with TIPSS to minimize confounding by indication. Furthermore, we used two separate methods to assess sarcopenia, namely L3-SMI and L3-PMI (6, 8), not showing a difference. Our study has limitations inherent to its retrospective nature. An additional limitation is that we did not evaluate patients for minimal HE.

In conclusion, the presence of sarcopenia at baseline should not be seen as a contra-indication to TIPSS insertion in patients with cirrhosis and refractory ascites.

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TABLES

Table 1. Baseline characteristics of patients divided by sarcopenia using L3-SMI.

	All patients (n=107)	Sarcopenia (n=61)	No Sarcopenia (n=46)	p-value
Age, years, SD	55.3 (9.7)	54.9 (10.3)	55.8 (9.0)	0.634
Sex, male n(%)	65 (60.7)	45(73.8)	20 (43.5)	**0.003**
Follow-up, months, IQR	14.2 (31.8)	15.7 (29.5)	13.9 (43.7)	0.283
Etiology, n(%)				0.091
HCV	12 (11.2)	6 (9.8)	6 (13.0)	
ALD	69 (64.5)	43 (70.5)	26 (56.5)	
NAFLD	13 (12.1)	3 (4.9)	10 (21.7)	
Cryptogenic	4 (3.7)	3 (4.9)	1 (2.2)	
Other	9 (8.4)	6 (9.8)	3 (6.5)	
HCV SVR, n(%)	9 (75.0)	5 (83.3)	4 (66.7)	1.000
EtOH Abstinence, n(%)	49 (76.6)	28 (71.8)	21 (84.0)	0.368
Hemodynamic Target, n(%)	92 (94.8)	51 (91.1)	41 (100)	0.071
Stent Diameter, n(%)				0.416
8mm	66 (63.5)	39 (67.2)	27 (58.7)	
10mm	38 (36.5)	19 (32.8)	19 (41.3)	
Gradient pre-TIPS, mmHg, IQR	14 (7)	15 (6)	13 (8)	0.373
Gradient post-TIPS, mmHg, IQR	8 (4)	9 (5)	8 (3)	0.596
Child Pugh Score, IQR	8 (2)	8 (2)	8 (2)	0.768
B, n(%)	96 (89.7)	56 (91.8)	40 (87.0)	
C, n(%)	11 (10.3)	5 (8.2)	6 (13.0)	
Hepatic Encephalopathy, n (%)	0 (0)	0 (0)	0 (0)	1.000
BMI, kg/m^2 , IQR	22.1 (6.2)	21.1 (5.0)	24.3 (6.7)	**0.001**
Platelets, $x10^9/L$, IQR	129 (108)	147 (135)	116 (89)	0.355
INR, IQR	1.3 (0.3)	1.3 (0.3)	1.3 (0.3)	0.755
Serum sodium, mmol/L, SD	135 (5)	135 (4)	136 (5)	0.061
Serum creatinine, µmol/L, IQR	77 (39)	78 (42)	76 (40)	0.930
Serum bilirubin, µmol/L, IQR	18 (22)	18 (21)	18 (24)	0.932
Serum albumin, g/L, SD	34 (5)	34 (5)	34 (5)	0.967
MELD-Na, IQR	11 (8)	11 (8)	12 (6)	0.882
L3-SMI, cm^2/m^2 IQR	44.0 (12.0)	41.0 (10.4)	51.7 (15.7)	**<0.001**
L3-PMI, mm^2/m^2, SD	510.4 (216.8)	475.5 (141.9)	632.2 (193.9)	**<0.001**

Legend: Categorical variables are expressed as numbers (%), continuous variables with a non-normal distribution are expressed as median (IQR), and continuous variables with a normal distribution are expressed as mean (SD), unless otherwise specified. ALD, alcohol-related liver disease; BMI, body mass index; HCV, hepatitis C virus; IQR, interquartile range; INR, international normalized ratio; L3-PMI, total psoas muscle area indexed for height at the third lumbar vertebrae; L3-SMI, skeletal muscle area indexed for height at the third lumbar vertebrae; MELD-Na, model for end stage liver disease with sodium; NAFLD, non-alcoholic fatty liver disease; SD, standard deviation; SVR, sustained virological response; TIPSS, transjugular intrahepatic portosystemic shunt.

Table 2. Predictors of *de novo* hepatic encephalopathy following TIPSS insertion with sarcopenia defined using L3-SMI.

	Univariate cox regression analysis		Multivariate cox regression analysis[§]	
Variables	HR (95% CI)	p-value	HR (95% CI)	p-value
Age, per year	1.00 (0.97-1.04)	0.95	-	-
Male sex	0.66 (0.32-1.37)	0.27	-	-
BMI, per kg/m^2	0.97 (0.90-1.05)	0.41	-	-
Platelets	**0.99 (0.99-1.00)**	**0.01**	**0.99 (0.99-1.00)**	**<0.01**
INR	2.05 (0.68-6.22)	0.21	-	-
Serum creatinine	1.00 (1.00-1.01)	0.68	-	-
Serum bilirubin	**1.02 (1.00-1.04)**	**0.02**	-	-
Serum albumin	1.04 (0.97-1.10)	0.29	-	-
MELD-Na	1.06 (0.99-1.14)	0.08	1.01 (0.99-1.03)	0.25
Child-Pugh Score	1.09 (0.77-1.53)	0.63	-	-
L3-SMI, per cm^2/m^2	**0.96 (0.92-1.00)**	**0.03**	**0.95 (0.91-0.99)**	**0.01**
Sarcopenia$^{L3\text{-}SMI}$	1.77 (0.85-3.67)	0.13	-	-

Legend: BMI, body mass index; CI, confidence interval; HR, hazard ratio; INR, international normalized ratio; L3-SMI, skeletal muscle area indexed for height at the third lumbar vertebrae; MELD, model for end stage liver disease; TIPSS, transjugular intrahepatic portosystemic shunt. [§]Multivariate analysis was conducted using variables with a p-value < 0.1 in the univariate analysis. As a consequence, platelet count and MELD-Na were the only variables entered in the MVA. MELD-Na was chosen over its individual components.

Table 3. Predictors of mortality following TIPSS insertion with sarcopenia defined using L3-SMI.

	Univariate Cox regression analysis		Multivariate Cox regression analysis [§]		Multivariate Cox regression competing risk°	
Variables	HR (95%CI)	p-value	HR (95%CI)	p-value	SHR (95%CI)	p-value
Age, per year	**1.04 (1.00-1.07)**	**0.05**	**1.04 (1.01-1.08)**	**0.02**	**1.04 (1.01-1.07)**	**<0.01**
Male sex	1.05 (0.53-2.07)	0.89	-	-	-	-
BMI, per kg/m^2	1.02 (0.96-1.08)	0.61	-	-	-	-
Platelets	**0.99 (0.99-1.00)**	**0.02**	**0.99 (0.99-1.00)**	**0.05**	**0.99 (0.99-1.00)**	**0.02**
INR	1.38 (0.42-4.51)	0.60	-	-	-	-
Serum creatinine	1.00 (1.00-1.01)	0.17	-	-	-	-
Serum bilirubin	**1.02 (1.00-1.04)**	**0.04**	-	-	-	-
Serum albumin	0.99 (0.93-1.06)	0.83	-	-	-	-
MELD-Na	**1.09 (1.02-1.16)**	**0.01**	**1.08 (1.00-1.16)**	**0.04**	**-**	**-**
Child-Pugh Score	1.21 (0.87-1.66)	0.25	-	-	-	-
L3-SMI,per cm^2/m^2	0.99 (0.96-1.03)	0.70			-	-
Sarcopenia$^{L3\text{-}SMI}$	0.82 (0.42-1.62)	0.57	-	-	-	-

Legend: BMI, body mass index; CI, confidence interval; HR, hazard ratio; INR, international normalized ratio; L3-SMI, skeletal muscle area indexed for height at the third lumbar vertebrae; MELD, model for end stage liver disease; SHR, subdistribution hazard ratio. [§]Multivariate analysis was conducted using variables with a p-value < 0.1 in the univariate analysis. As a consequence, age, platelet count and MELD-Na were the only variables entered in the MVA. MELD-Na was chosen over its individual components. ° Multivariate analysis conducted using competing risk analysis.

Supplemental Table 1. Baseline characteristics of patients divided by presence of baseline imaging.

	All patients (n=165)	Without imaging (n=58)	With imaging (n=107)	p-value
Age, years, SD	56.2 (10.0)	57.7 (10.5)	55.3 (9.7)	0.15
Sex, male n(%)	98 (59.4)	33 (56.9)	65 (60.7)	0.74
Follow-up, months, IQR	11.5 (26.0)	8.9 (24.9)	14.2 (31.8)	0.05
Etiology, n(%)				0.78
HCV	17 (10.3)	5 (8.6)	12 (11.2)	
ALD	107 (64.8)	38 (65.5)	69 (64.5)	
NAFLD	18 (10.9)	5 (8.6)	13 (12.1)	
Cryptogenic	6 (3.6)	2 (3.4)	4 (3.7)	
Other	17 (10.3)	8 (13.8)	9 (8.4)	
HCV SVR, n(%)	10 (58.8)	1 (20.0)	9 (75.0)	0.10
EtOH Abstinence, n(%)	77 (80.2)	28 (87.5)	49 (76.6)	0.28
Hemodynamic Target, n(%)	146 (95.4)	54 (96.4)	92 (94.8)	1.00
Stent Diameter, n(%)				0.50
8mm	99 (61.1)	33 (56.9)	66 (63.5)	
10mm	63 (38.9)	25 (43.1)	38 (36.5)	
Gradient pre-TIPS, mmHg, IQR	14 (6)	14 (6)	14 (7)	0.99
Gradient post-TIPS, mmHg, IQR	8 (5)	8 (6)	8 (4)	0.27
Child-Pugh Score, IQR	8 (2)	8 (2)	8 (2)	0.65
B, n(%)	138 (83.6)	42 (72.4)	96 (89.7)	
C, n(%)	27 (16.4)	16 (27.6)	11 (10.3)	
BMI, kg/m^2, IQR	22.2 (6.5)	23.1 (7.2)	22.1 (6.2)	0.37
Platelets, $x10^9/L$, IQR	125 (98)	124 (77)	129 (108)	0.75
INR, IQR	1.3 (0.2)	1.3 (0.3)	1.3 (0.3)	0.26
Serum sodium, mmol/L, IQR	136 (8)	138 (7)	135 (7)	0.09
Serum creatinine, µmol/L, IQR	86 (50)	102 (57)	77 (39)	**<0.01**
Serum bilirubin, µmol/L, IQR	17 (17)	17 (11)	18 (22)	0.16
Serum albumin, g/L, SD	34 (6)	34 (6)	34 (5)	0.66
MELD-Na, IQR	11 (8)	11 (8)	11 (8)	0.99
L3-SMI, cm^2/m^2 IQR	NA	NA	44.0 (12.0)	NA
L3-PMI, mm^2/m^2, SD	NA	NA	510.4 (216.8)	NA

Legend: Categorical variables are expressed as numbers (%), continuous variables with a non-normal distribution are expressed as median (IQR), and continuous variables with a normal distribution are expressed as mean (SD), unless otherwise specified. ALD, alcohol-related liver disease; BMI, body mass index; HCV, hepatitis C virus; IQR, interquartile range; INR, international normalized ratio; L3-PMI, total psoas muscle area indexed for height at the third lumbar vertebrae; L3-SMI, skeletal muscle area indexed for height at the third lumbar vertebrae; MELD-Na, model for end stage liver disease with sodium; NAFLD, non-alcoholic fatty liver disease; SD, standard deviation; SVR, sustained virological response; TIPSS, transjugular intrahepatic portosystemic shunt.

Supplemental Table 2. Baseline characteristics of patients divided with sarcopenia defined using L3-PMI .

	All patients (n=107)	Sarcopenia (n=28)	No Sarcopenia (n=79)	p-value
Age, years, SD	55.3 (9.7)	56.0 (9.8)	55.1 (9.7)	0.657
Male sex, n (%)	65 (60.7)	17(60.7)	48 (60.8)	1.000
Follow-up, months, IQR	14.2 (31.8)	9.2 (21.7)	16.1 (31.2)	0.186
Cause of cirrhosis, n (%)				0.117
HCV	12 (11.2)	3 (10.7)	9 (11.4)	
ALD	69 (64.5)	19 (67.9)	50 (63.3)	
NAFLD	13 (12.1)	1 (3.6)	12 (15.2)	
Cryptogenic	4 (3.7)	3 (10.7)	1 (1.3)	
Other	9 (8.4)	2 (7.1)	7 (8.9)	
HCV SVR, n (%)	9 (75.0)	2 (66.7)	7 (77.8)	1.000
Alcohol Abstinence, n (%)	49 (76.6)	11 (68.8)	38 (79.2)	0.498
Hemodynamic Target, n (%)	92 (94.8)	23 (92.0)	69 (95.8)	0.601
Stent Diameter, n (%)				**0.035**
8mm	66 (63.5)	22 (81.5)	44 (57.1)	
10mm	38 (36.5)	5 (18.5)	33 (42.9)	
Gradient pre-TIPSS, mmHg, IQR	14 (7)	15 (7)	14 (6)	0.835
Gradient post-TIPSS, mmHg, IQR	8 (4)	8 (4)	9 (4)	0.816
Child-Pugh score, IQR	8 (2)	8 (2)	8 (2)	0.270
Child-Pugh Class B, n(%)	96 (89.7)	26 (92.9)	70 (88.6)	0.724
Child-Pugh Class C, n(%)	11 (10.3)	2 (7.1)	9 (11.4)	
BMI, kg/m^2 , IQR	22.1 (6.1)	18.9 (4.7)	22.8 (5.5)	**<0.001**
Platelets, $x10^9/L$, IQR	129 (108)	177 (145)	112 (102)	**0.009**
INR, IQR	1.3 (0.3)	1.3 (0.3)	1.3 (0.3)	0.160
Serum sodium, mmol/L, SD	135 (5)	135 (4)	136 (5)	0.513
Serum creatinine, µmol/L, IQR	77 (39)	74 (51)	78 (38)	0.528
Serum bilirubin, µmol/L, IQR	18 (22)	17 (16)	18 (26)	0.399
Serum albumin, g/L, SD	34 (5)	35 (9)	34 (7)	0.938
MELD-Na, IQR	11 (8)	11 (7)	12 (7)	0.159
L3-PMI, cm^2/m^2 , SD	5.1 (2.2)	3.5 (0.9)	6.1 (1.6)	**<0.001**

Legend: Categorical variables are expressed as numbers (%), continuous variables with a non-normal distribution are expressed as median (IQR), and continuous variables with a normal distribution are expressed as mean (SD), unless otherwise specified. ALD, alcohol-related liver disease; BMI, body mass index; HCV, hepatitis C virus; IQR, interquartile range; INR, international normalized ratio; L3-PMI, total psoas muscle area indexed for height at the third lumbar vertebrae; MELD-Na, model for end stage liver disease with sodium; NAFLD, non-alcoholic fatty liver disease; SD, standard deviation; SVR, sustained virological response; TIPSS, transjugular intrahepatic portosystemic shunt.

Supplemental Table 3. Predictors of baseline sarcopenia using L3-PMI.

	Univariate logistic regression		Multivariate logistic regression[§]	
Variables	OR (95% CI)	p-value	OR (95% CI)	p-value
Age, per year	1.01 (0.97-1.06)	0.65	-	-
BMI, per kg/m^2	**0.77 (0.66-0.91)**	**<0.01**	**0.78 (0.66-0.92)**	**<0.01**
Platelets	**1.00 (1.00-1.01)**	**0.04**	1.00 (1.00-1.01)	0.61
INR	0.21 (0.03-1.55)	0.13	-	-
Serum creatinine	1.00 (0.99-1.01)	0.57		
Serum bilirubin	0.98 (0.95-1.01)	0.21	-	-
Serum albumin	0.98 (0.90-1.06)	0.62	-	-
MELD-Na	0.95 (0.86-1.04)	0.29	-	-
Child-Pugh Score	0.77 (0.50-1.19)	0.24	-	-

Legend: BMI, body mass index; CI, confidence interval; INR, international normalized ratio; MELD-Na, model for end stage liver disease with sodium; OR, odd ratio. [§]Multivariate analysis was conducted using variables with a p-value < 0.1 in the univariate analysis. As a consequence, BMI and platelet count were the only variables entered in the MVA.

Supplemental Table 4. Predictors of *de novo* hepatic encephalopathy following TIPSS insertion with sarcopenia defined using L3-PMI.

	Univariate Cox regression analysis		Multivariate Cox regression analysis[§]	
Variables	HR (95% CI)	p-value	HR (95% CI)	p-value
Age, per year	1.00 (0.96-1.04)	0.95	-	-
BMI, per kg/m^2	0.97 (0.90-1.04)	0.41	-	-
Platelets	**0.99 (0.99-1.00)**	**0.01**	**0.99 (0.99-1.00)**	**0.02**
INR	2.05 (0.68-6.22)	0.20	-	-
Serum creatinine	1.00 (1.00-1.01)	0.68	-	-
Serum bilirubin	**1.02 (1.00-1.04)**	**0.02**	-	-
Serum albumin	1.03 (0.97-1.10)	0.29	-	-
MELD-Na	1.06 (0.99-1.14)	0.08	1.03 (0.96-1.11)	0.45
Child-Pugh Score	1.09 (0.77-1.53)	0.63	-	-
Sarcopenia$^{L3\text{-}PMI}$	1.20 (0.53-2.67)	0.66	-	-

Legend: BMI, body mass index; CI, confidence interval; HR, hazard ratio; INR, international normalized ratio; L3-PMI, total psoas muscle area indexed for height at the third lumbar vertebrae; MELD, model for end stage liver disease; TIPSS, transjugular intrahepatic portosystemic shunt. [§]Multivariate analysis was conducted using variables with a p-value < 0.1 in the univariate analysis. As a consequence, platelet count and MELD-Na were the only variables entered in the MVA. MELD-Na was chosen over its individual components.

Supplemental Table 5. Predictors of mortality following TIPSS insertion with sarcopenia defined using L3-PMI.

	Univariate Cox regression analysis		Multivariate Cox regression analysis[§]	
Variables	HR (95% CI)	p-value	HR (95% CI)	p-value
Age, per year	**1.04 (1.00-1.07)**	**0.04**	**1.04 (1.01-1.08)**	**0.02**
BMI, per kg/m^2	1.02 (0.95-1.08)	0.61	-	-
Platelets	**0.99 (0.99-1.00)**	**0.01**	**0.99 (0.99-1.00)**	**0.05**
INR	1.38 (0.42-4.51)	0.60	-	-
Serum creatinine	1.00 (1.00-1.01)	0.17	-	-
Serum bilirubin	**1.02 (1.00-1.04)**	**0.04**	-	-
Serum albumin	0.99 (0.93-1.06)	0.83	-	-
MELD-Na	**1.09 (1.02-1.16)**	**0.01**	**1.08 (1.00-1.16)**	**0.04**
Child-Pugh Score	1.20 (0.87-1.66)	0.25	-	-
Sarcopenia$^{L3\text{-}PMI}$	1.20 (0.56-2.58)	0.63	-	-

Legend: BMI, body mass index; CI, confidence interval; HR, hazard ratio; INR, international normalized ratio; L3-PMI, total psoas muscle area indexed for height at the third lumbar vertebrae; MELD, model for end stage liver disease. [§]Multivariate analysis was conducted using variables with a p-value < 0.1 in the univariate analysis. As a consequence, age, platelet count and MELD-Na were the only variables entered in the MVA. MELD-Na was chosen over its individual components.