The psoas muscle transversal diameter predicts mortality in patients with cirrhosis on a waiting list for liver transplantation A retrospective cohort study

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The psoas muscle transversal diameter predicts mortality in patients with cirrhosis on waiting-list for liver transplantation: a retrospective cohort study

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Running title: psoas and liver transplantation

Highlights

- Transversal psoas thickness index (TPTI) is measured on an umbilicus-targeted CT.
- TPTI was independently associated with mortality.
- TPTI is easy, quick, cheap, and highly reproducible, reliable by a non-expert operator.
- TPTI could be a marker of muscle mass and function.

Abbreviations list:

ADPM, axial diameter of psoas muscle

APTI, axial psoas thickness index

AUC, area under the curve

BMI, Body mass index

BIA, bioimpedance analysis

CI, confidence interval

CT, computed tomography

DEXA, dual-energy X-ray absorptiometry

INR, International Normalized Ratio

MAMC, midarm muscle circumference

MELD, Model For End-Stage Liver Disease

MRI, magnetic resonance imaging

ROC, receiving operating characteristic

SD, standard deviation

TDPM, transversal diameter of psoas muscle

51 TPTI, transversal psoas thickness index

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53 Conflict of interest statement: none. The authors have no conflict of interest to declare.

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ABSTRACT

Objective: Malnutrition impairs prognosis in liver cirrhosis. Aims: to determine: if transversal (TPTI) and axial (APTI) psoas thickness indices predict mortality in cirrhotic patients; feasibility and reproducibility of psoas muscle transversal (TDPM) and axial (ADPM) diameters measurements. **Research Methods & Procedures:** Retrospective study. Inclusion criteria: cirrhosis on liver transplantation waiting list, abdominal CT scan within the three months preceding list inscription. TDPM and ADPM were measured on a single umbilicus-targeted CT image by non-expert and expert operators. TPTI or APTI (mm/m) were calculated as: TDPM or ADPM/height (m). Statistics: mortality prediction and associated variables: area under the receiver operating characteristic curve (AUC) and Cox proportional hazard models assessed. TPTI and APTI interobserver agreement: kappa (k) correlation test. **Results:** 173 patients were included. Low TPTI was associated with increased mortality: AUC=0.66 [95% confidence interval, 0.51–0.80]. TPTI was the only factor associated with mortality (hazard ratio=0.87, 95% confidence interval 0.76–0.99, P=0.034). There was an almost perfect interobserver agreement between the two operators: TDPM, k=0.97; ADPM, k=0.94; P<0.0001. **Conclusion(s):** TPTI measured on umbilicus-targeted CT scan before inscription on waiting-list for liver transplantation predicts mortality of cirrhotic patients. TPTI measurement is easy and reliable, even by a non-trained operator, then highly feasible in the daily clinical practice.

Keywords: muscle mass; malnutrition; computed tomography scan; liver failure

INTRODUCTION

Chronic liver diseases are often complicated with malnutrition [1], that impairs the prognosis [2,3]. Nevertheless, because of rapid fluid shifts and altered water compartmentalization due to ascites and oedema, standard methods of nutritional assessment (weight loss, body mass index, biological markers, i.e. albumin, transthyretin, or multicomposite scores) are not usable. Also, body composition assessment methods, such as bioimpedance analysis (BIA) or dual-energy X-ray absorptiometry (DEXA) [4,5] are not applicable to patients with liver cirrhosis (BIA) [6], or not routinely applicable in the daily clinical practice (DEXA) [7]. Liver cirrhosis is associated with significant changes in body composition: the prevalence of muscle mass loss is estimated to be 20-60% [8,9]; muscle mass loss is an independent prognostic factor in cirrhosis [10]. Mid-arm muscle circumference is an independent predictor of survival in patients with liver cirrhosis [11], but its interobserver variability limits its use in the daily practice. In the last decade, the development of cross sectional imaging techniques, such as computed tomography (CT) or magnetic resonance imaging (MRI) [12], is very promising to assess muscle mass. Developed from studies conducted in oncology [13], disease prognosis could be assessed by the whole muscle cross sectional area measured on a third lumbar vertebra (L3)-targeted CT normalized by height. This L3 skeletal muscle index predicted mortality after liver transplantation [14-16], and recently in cirrhotic patients on waiting-list for liver transplantation [17,18]. However this technique could be time-consuming. Therefore there is a need to develop simpler and easier methods to assess muscle mass, doable for all in the daily clinical practice. Psoas muscle measurement could appear as a reliable marker to assess cirrhosis prognosis. Recently, Golse et al suggested that psoas muscle area better predicts post-liver transplantation 1-year survival than L3 skeletal muscle index, but they did not assess the predictive role of transversal psoas muscle thickness [19]. Durand et al showed that the measurement of the transversal psoas muscle thickness by CT images targeted on the umbilicus, standardized to height, was an independent

predictive factor for mortality in cirrhotic patients with refractory ascites on waiting-list for liver transplantation [20]. However these results were never confirmed by an independent study, nor in a whole population of cirrhotic patients on waiting-list for liver transplantation. Therefore, the main aim of this retrospective study was to determine whether the measurement of the transversal or axial diameter of the psoas muscle on an abdominal CT predicted mortality in patients with cirrhosis on waiting-list for liver transplantation. The secondary aims were to determine the feasibility and reliability of the measurements of transversal or axial psoas muscle diameters by a non-trained operator.

METHODS

Study design

A monocentric observational retrospective study was conducted in the Department of Liver Transplantation and the Hepatic diseases Unit of the Rennes University Hospital (CHU Rennes), Rennes, France. Our unit is a tertiary referral centre for liver transplantation in France.

Patients' recruitment

All patients with liver cirrhosis registered on the waiting-list for liver transplantation for isolated cirrhosis from 01/01/2011 to 31/12/2014 were eligible. The date of 01/04/2011 was chosen because CT-scan images are included in the CHU Rennes computerized medical records only since this date. To be included, patients must have undergone an abdominal CT scan within the 3 months before registering on the waiting-list for liver transplantation. Exclusion criteria were hepatocellular carcinoma as the indication for liver transplantation, multi-organ transplant, and temporary contraindication to transplantation during the follow-up. The study protocol conformed to the ethical guidelines and the 1975 Declaration of Helsinki as reflected in a priori exemption by the appropriate institutional review committee.

Study endpoints

The primary endpoint was the occurrence of death on waiting-list for liver transplantation. As previously published [14], patients removed from the transplantation waiting list because of the worsening of their liver cirrhosis were considered as deaths. The secondary endpoint was the reliability of the measurements of transversal (TDPM) and axial (ADPM) diameters of the psoas muscle by a non-trained operator.

Measurement of psoas muscle diameters

The measurements of the axial and transverse diameters of the right psoas were performed on one single CT scan image targeted on the umbilicus. We chose to assess psoas muscle diameters on umbilicus-targeted scan, because the study by Taguchi et al [21] indicated that axial and/or transversal psoas thickness at the umbilicus level was more associated with mortality than at the L3 level, in patients with metastatic urothelial carcinoma; Durand et al used this method in cirrhotic patients; the recent study by Golse et al [19] compared L3-targeted psoas muscle area to SMI, but they did not assess the predictive role of the axial or transversal diameters of the psoas muscle. The assessment was performed by one single non expert-operator (AH), a gastroenterologist fellow without any specific skill in radiology. For the first 50 patients, the measurements were checked by a radiologist specialized in Gastrointestinal Imaging, blinded of the first operator's measurement. The operators were blinded from the demographics and clinical data including mortality on liver transplantation list. The axial diameter of psoas muscle (ADPM) was determined as the longest antero-posterior diameter and expressed in millimetre (mm) (**Figure 1**). The transversal diameter of the psoas muscle (TDPM) was defined as the diameter perpendicular to the axial diameter (**Figure 1**). Axial psoas thickness index (APTI), was expressed as mm/m, and calculated as: ADPM (mm)/height (m). Transversal psoas thickness index (TPTI) was expressed as mm/m, and calculated as: TDPM (mm)/height (m).

Data collection

The list of patients fulfilling the eligibility criteria was obtained by extraction from the Cristal® software, the computerized biomedicine agency database. The data were then collected by consultation of computerized files and included age, gender, body weight, height, aetiology of cirrhosis, year of cirrhosis diagnosis, presence of ascites (none, refractory), presence of hepatic encephalopathy, serum albumin, serum bilirubin, prothrombin time, serum sodium level, and serum creatinine. Clinical and laboratory data were obtained at the registration on liver

transplantation list. Child Pugh and Model for End-Stage Liver Disease (MELD) scores were calculated.

Statistical analysis

Variables are expressed as mean ± standard deviation (SD) or percentage. Means were compared with Student t or Wilcoxon test as appropriate. Univariate analysis was performed by Cox proportional hazards model with a significance level of $P<0.05$. Variables significant ($P<0.2$) in univariate analysis were included in the multivariate analysis. To select the optimal cut-off of psoas muscle index associated with the primary endpoint, receiver operating characteristic (ROC) curve and the Youden method were used. Survival rates of subgroups of patients were calculated with Kaplan Meier method, and compared by the log-rank test. Patients transplanted and removed of transplantation list because they had an improvement of the liver disease or for personal decision were censored. Interobserver agreement of the measurements of axial (ADPM) and transversal (TDPM) diameters of the psoas muscle were analysed by kappa correlation test. Data were analysed using SPSS version 22 (SPSS Inc., Chicago, IL, USA). P value less than 0.05 was considered significant with a two-tailed test.

RESULTS

Patients' selection

The study flow chart is shown in **Figure 2**. Among the 175 eligible patients, 173 were enrolled into the study and included in the final analysis.

Patients' characteristics and outcomes

The characteristics of the 173 included patients at the time of their registration on liver transplantation list are detailed in **Table 1**. The most frequent aetiology of liver cirrhosis was alcoholic (71%). Most of cirrhoses were CHILD C (66%). The mean MELD score at registration was 21.2±8.1. Forty-seven percent of cirrhoses were complicated with refractory ascites. During the mean follow-up of 5.6±6.2 month, 143 patients were transplanted (82.7%) and 13 died (7.5%). The remaining 17 patients (9.8%) were removed from the waiting-list because of disease improvement or personal decision. The mean time length on waiting-list before accessing to liver transplantation was 5.3±6.4 month. The mean time length on waiting-list before death was 7.3±6.8 month.

Relation between psoas muscle thickness and mortality

The univariate analysis including the patients' characteristics at registration (gender, age, body mass index), disease variables (aetiology of cirrhosis, CHILD and MELD scores, ascites, hepatic encephalopathy, plasma bilirubin, albumin, prothrombin time, creatinine, and sodium), APTI and TPTI, is shown in **Table 2**. The CHILD score, the MELD score, refractory ascites, plasma creatinine and sodium, and TPTI, were significantly associated with death or exclusion of transplant list for worsening of the liver cirrhosis (**Table 2**). In the Cox multivariate analysis, only TPTI was independently and significantly ($P<0.05$) associated with mortality (**Table 3**). TPTI was associated with mortality: AUC=0.66 [95% confidence interval, 0.51–0.80] (**Figure**

3A). According to the optimal cut-off for predicting the occurrence of death with the ROC curve, muscle mass loss was defined as TPTI<15.2 mm/m and normal muscle mass as TPTI ≥15.2 mm/m; then a low muscle mass was associated with higher mortality (log rank test: p<0.01) (**Figure 3B**). Thirty-three percent of cirrhotic patients had low muscle mass at registration on waiting-list for liver transplantation, and had an overall mortality of 14% (*vs*. 4% in the normal muscle mass group).

Feasibility and interobserver agreement of the measurements of transversal (TDPM) and axial (ADPM) diameters of the psoas muscle

TDPM and ADPM measurements were easily performed in 100% of patients by the non-trained operator (AH). There was an almost perfect interobserver agreement: kappa coefficient correlations between the two operators-blinded TDPM and ADPM measurements (n=50) were respectively: k=0.97, p<0.0001; k=0.94, p<0.0001. This very good agreement between two operators of opposite levels of radiologic expertise suggests the reliability of the measurements by a non-trained operator.

DISCUSSION

In this cohort of 173 patients with liver cirrhosis on waiting-list for liver transplantation, a low TDPM measured on an umbilicus-targeted CT scan image and normalized by height (i.e. TPTI) was independently associated with mortality. The increase of 1 mm/m of the TPTI was associated with a 13% decrease in death risk. This study confirms that the assessment of muscle mass from an abdominal CT scan is an accurate method to assess mortality in liver cirrhosis patients on waiting-list for liver transplantation. Our study clearly showed that the measurement of the transversal diameter of the right psoas muscle is an easy (i.e. no need for dedicated software such as for the measurement of L3 skeletal muscle index), quick, cheap (i.e. no additional costs as abdominal CT are routinely performed before registration on liver transplantation list), and highly reproducible method, and most of all, reliable by a non-expert operator, i.e. without any specific radiological competence. These make the TDPM the elective tool, accessible for all, to assess the liver cirrhosis prognosis for the daily clinical practice of Liver Disease, Radiology, and Liver Transplantation Departments.

Our study confirms the findings by Durand et al [20], but in a whole population of cirrhotic patients waiting for liver transplantation. Indeed, Durand et al only studied TPTI impact on mortality on liver transplantation waiting list in a subgroup of liver cirrhosis patients with refractory ascites and MELD<25 [19]. We found that the optimal TPTI cut-off to predict mortality was 15.22 mm/m with an AUC of 0.66. Comparable thresholds have been reported in the literature [16,20]. The recent study by Golse al [19] compared predictability for 1-year liver transplantation survival with different muscle indexes measured on a CT-scan cross section between L3 and the fourth lumbar vertebra: AUC values of right and left psoas muscle area, psoas muscles area normalized by height or body surface area, and the L3 skeletal muscle index, varied between 0.72 and 0.75. Psoas muscles area alone (below 1561 mm^2 in men, or below 1464 mm^2 in women) best predicted survival [19]. This method looks like as less easy and more

time-consuming that the measurement of TPTI based on the right psoas only. The predictive role of the transversal diameters of the psoas muscles was not assessed by Golse et al [19]. More studies are needed in larger populations of cirrhotic patients to validate the optimal cut-off of TPTI or other muscle mass indexes, and most importantly the best indicator of muscle mass associated with long term prognosis. In all published studies, including the one presented here, the AUC values below 0.80 of the different muscle indexes suggested that the mortality prediction could be improved by associating muscle indexes prognostic with other variables associated with mortality such as refractory ascites or MELD, as previously suggested [8,20]. Indeed a MELD-psoas score outperformed MELD score alone to predict mortality on liver transplant list in subgroups restricted to patients with refractory ascites [19], and previous history of variceal haemorrhage [8]. Future studies should focus on determining whether the combination of several predictive factors, e.g. TPTI and MELD score, could improve the mortality prediction after liver transplantation.

In our study, contrary to TPTI, MELD score alone was not associated ($P<0.08$) with mortality in the multivariable analysis. This was expected, because, since the MELD score is used to determine patients' priority to liver transplantation, the time to access to transplantation and the mortality on the waiting-list have been reduced. Therefore patients with higher MELD scores have a much shorter waiting time on transplantation list, thus better survival, than patients with lower MELD scores. However, the MELD score fails to identify patients with malnutrition or muscle mass loss, who, despite their poor prognosis related to malnutrition, are attributed a low MELD score, and therefore are not eligible for priority liver transplantation. In 2012, the French 'Agence de Biomédecine' (Bio-Medicine Agency) reported that 20% of liver cirrhosis with a low MELD score were registered on waiting-list for liver transplantation. These included patients with cirrhosis complications, such as refractory ascites, encephalopathy, hepatorenal syndrome, hepatopulmonary syndrome, or malnutrition. In these cases, except for malnutrition,

the appeal to expert component allows deciding priority liver transplantation according to disease severity. Despite presumed muscle mass loss-related poor prognosis, malnutrition is not considered as a liver transplantation priority indication. Thanks to TPTI measurement, early identification of cirrhosis complicated with malnutrition, i.e. muscle mass loss, should allow triggering an early nutritional intervention with the aim to improve patients' outcome on waiting list for liver transplantation.

Anthropometric methods such as mid-arm muscle circumference should be abandoned because of their interobserver variability to assess muscle mass. Also in cirrhotic patients with ascites, bioimpedance analysis lacks of reliability [4-7]. However BIA-derived phase angle could be useful to assess cirrhotic patients' prognosis [21-23]. Beside radiologic assessment of muscle mass, the clinical assessment of muscle function, e.g. by handgrip strength measurement, could be of interest because of its prognostic value [24]. This remains to be demonstrated in liver cirrhosis patients on waiting-list for liver transplantation.

In our study, contrary to TPTI, APTI was not predictive of mortality. We have no clear explanation for this observation. This may be because the TDPM is more sensitive in case of catabolic situations associated to decreased protein synthesis such as malnutrition or reduced physical activity. The psoas muscle is involved in the ability of standing up, staying in the upright position, and walking. Therefore, we believe that TPTI could be a marker of muscle mass, as well as muscle function, both being related to prognosis [13-20;24-25]. This remains to be demonstrated in further studies.

In this retrospective study, the mechanisms underlying the relation between low psoas muscle transversal diameter and mortality were not explored. However we could hypothesize that increased mortality is due to a defect of immune response in relation with the decrease in protein reserves. This assumption is supported by our finding (data not shown) that infectious complications are the first cause of mortality (30% of deaths) on waiting-list for liver

transplantation, and that nine out of the ten patients who died from infections had a low TDPM at registration on transplantation list.

. *Study limitations*. The retrospective and monocentric design of the study exposed to the risk of bias. Nevertheless the characteristics of the study population were very similar to those of similar studies [17,19], and the proportion of missing data was less than 3%. Umbilicus-targeted CT scan could suffer from a lack of precision, particularly in the case of umbilical hernia, sacralisation of the L5 vertebrae, lumbar wedge fractures, and pronounced lordosis, frequent situations in the presence of ascites. However a lack of precision and a greater risk of error are also observed when analysing L3/L4-targeted images, in cases of degenerative bone diseases, i.e. vertebral osteoporosis, or lordosis related to ascites.

In conclusion, the transverse psoas muscle index measured by umbilicus-targeted CT scan is a predictive factor of mortality in cirrhotic patients on waiting-list for liver transplantation. This easy, cheap, reproducible, and reliable method is routinely feasible even by non-trained staff. Prospective randomized controlled trials should assess whether a dedicated nutritional intervention combining nutrition support and physical rehabilitation in liver cirrhosis patients with low muscle mass could improve the clinical outcome of liver cirrhosis patients before and after liver transplantation.

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Statement of authorship:

AH, ML, EBJ and RT conceived and designed the study, carried out the collection of data, interpreted the data, performed the statistical analyses, and drafted the manuscript. PHD

designed the study, and carried out the collection of data. CZ, LL, and MR carried out the collection of data. KB and DG carried out the collection of data, and drafted the manuscript.

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386

Table 1 – Liver cirrhosis patients' baseline characteristics, at the time of their inscription on liver transplantation list (n=173).

	Missing (n)	
Male / female – n (%)	0	135 (78) / 38 (22)
Age (year) – mean ± SD	0	54.7 ± 10.3
Body mass index – mean ± SD	0	26.2 ± 4.7
Etiology of cirrhosis – n (%)	0	
Alcohol		123 (71.1)
Metabolic		13 (7.5)
HBV		3 (1.7)
HCV		13 (7.5)
Others[#]		21 (12.1)
Duration of disease – mean ± SD		48 ± 56
Child-Pugh score – mean ± SD	4	10.1 ± 2.2
A – n (%)	0	17 (10)
B– n (%)		41 (24)
C– n (%)		115 (66)
Severe/ Refractory ascites	0	81 (47)
Plasma bilirubin (μmol/l) – mean ± SD	2	129 ± 54
Plasma albumin (g/l) – mean ± SD	2	31.5 ± 6.2
Prothrombin time (%) – mean ± SD	0	44 ± 19
MELD score – mean ± SD	0	21.2 ± 8.1
Plasma creatinine (μmol/l) – mean ± SD	0	85.5 ± 50.3
Plasma sodium (mmol/l) – mean ± SD	0	135 ± 5
APTI (mm/m) – mean ± SD	0	22.6 ± 3.6
TPTI (mm/m) – mean ± SD	0	17.0 ± 4.1

[#] Others included biliary cirrhosis, autoimmune hepatitis, sclerosing cholangitis, hemochromatosis. APTI, Axial Psoas Thickness Index; CI, confidence interval; HR, hazard ratio; MELD, Model for End-Stage Liver Disease; SD, standard deviations; TPTI, Transversal Psoas Thickness Index.

Table 2 – Univariate analysis of variables associated with mortality on waiting-list for liver transplantation according to univariate Cox analysis (n=173). Mortality was defined as the occurrence of death on waiting-list for liver transplantation; as previously published [14], patients removed from the transplantation waiting list because of the worsening of their liver cirrhosis were considered as deaths.

	Alive n=160	Dead n=13	HR [95% CI]	*P*-value
Male / female – n (%)	126 (78) / 34 (22)	9 (69) / 4 (31)	1.38 [0.77 – 2.49]	0.28
Age (year) – mean ± SD	54.4 ± 10.0	58.5 ± 6.0	1.06 [0.98 – 1.14]	0.13
Body mass index – mean ± SD	26.0 ± 4.6	27.7 ± 5.2	1.08 [0.96 – 1.22]	0.19
Etiology of cirrhosis – n (%) Alcohol Metabolic HBV HCV Others[#]	 114 (71.3) 12 (7.5) 3 (1.9) 11 (6.9) 20 (12.5)	 9 (69) 1 (8)0 2 (15) 1 (8)	 Reference 1.12 [0.14 – 8.96] 0.00 [0.00 - inf] 1.24 [0.26 – 5.81] 0.53 [0.07 – 4.24]	 0.97 0.49 0.93 0.98 0.78
Duration of disease – mean ± SD	48 ± 57	39 ± 41	0.99 [0.98 – 1.00]	0.36
Child-Pugh score – mean ± SD A – n (%) B– n (%) C– n (%)	10 ± 2.2 17 (11) 39 (24) 104 (65)	10.6 ± 1.1 0 (0) 2 (15) 11 (85)	1.45 [1.08 – 1.96] - - -	0.014 - - -
Severe/ Refractory ascites	49 (30.6%)	8 (61.5%)	4.34 [1.31 – 14.30]	0.016
Plasma bilirubin (µmol/l) – mean ± SD	134.1 ± 159.0	68.4 ± 39.8	1.00 [0.99 – 1.01]	>0.99
Plasma albumin (g/l) – mean ± SD	31.5 ± 6.1	30.6 ± 6.4	0.95 [0.86 – 1.04]	0.29
Prothrombin time (%) – mean ± SD	44.3 ± 19.2	44.5 ± 10.2	0.97 [0.93 – 1.01]	0.11
MELD score – mean	21.2 ± 8.3	19.9 ± 3.3	1.12 [1.01 –	0.033

± SD			1.25]	
Plasma creatinine (μmol/l) – mean ± SD	83.8 ± 50.3	105.3 ± 46.7	1.02 [1.01 – 1.03]	<0.001
Plasma sodium (mmol/l) – mean ± SD	135 ± 5	133 ± 7	0.90 [0.81 – 0.99]	0.034
APTI (mm/m) – mean ± SD	22.6 ± 3.5	22.4 ± 3.6	0.91 [0.76 – 1.09]	0.30
TPTI (mm/m) – mean ± SD	17.1 ± 4.1	14.8 ± 3.8	0.84 [0.74 – 0.96]	0.009

[#] Others included biliary cirrhosis, autoimmune hepatitis, sclerosing cholangitis, hemochromatosis. APTI, Axial Psoas Thickness Index; CI, confidence interval; HR, hazard ratio; MELD, Model for End-Stage Liver Disease; SD, standard deviations; TPTI, Transversal Psoas Thickness Index.

Table 3 - Variables associated with mortality on liver transplantation list according to multivariate Cox analysis (n=173). For continuous variables (Transversal Psoas Thickness Index (TPTI), Model for End-Stage Liver Disease (MELD) score, and plasma sodium), the hazard ratio (HR) are expressed for 1-point increase.

Variables	**HR**	**95% confidence interval**	***P*-value**
TPTI per mm/m	0.87	0.76 – 0.99	0.034
MELD score per unit	1.10	0.99 – 1.22	0.08
Plasma sodium per mmol/l	0.94	0.85 – 1.04	0.26
Refractory ascites yes *vs.* no	2.93	0.83 – 10.30	0.094

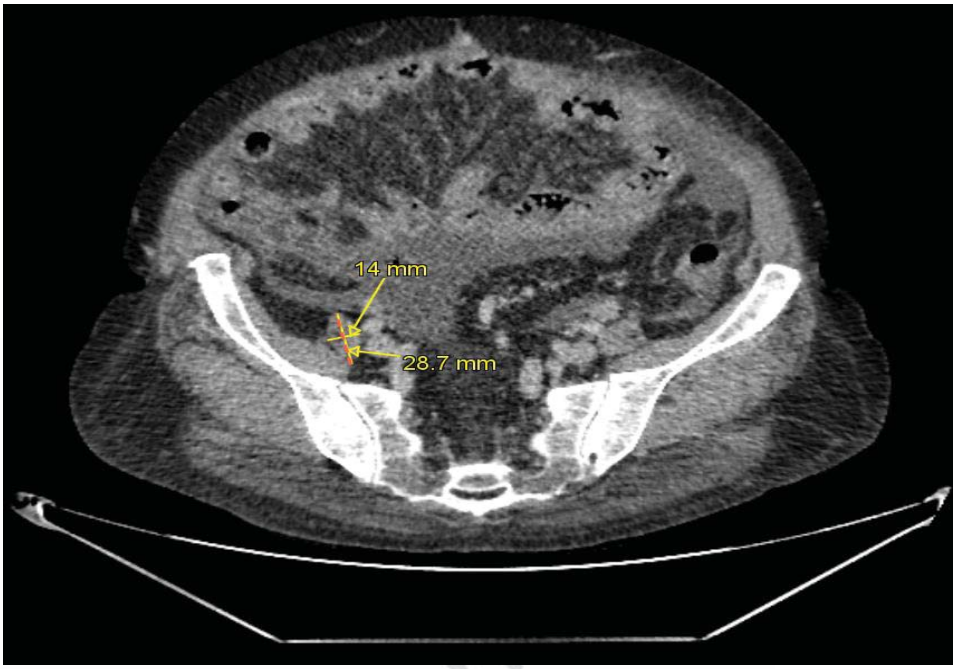
Figures legends

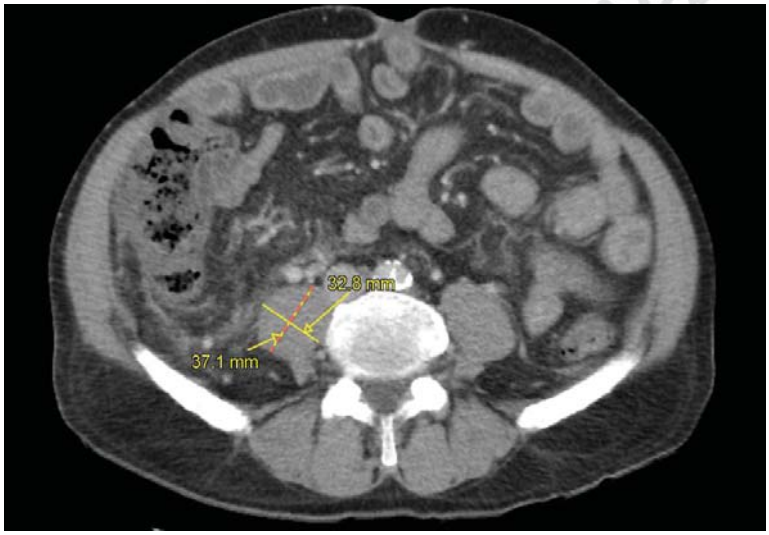
Figure 1 - Right psoas muscle diameters measured on a CT scan image targeted on the umbilicus. Axial diameter of the psoas muscle (ADPM) is represented by the dotted line. Transversal diameter of the psoas muscle (TDPM) is represented by the full line.

Figure 2 - Study flow chart.

Figure 3 - Predictive value of Transversal Psoas Thickness Index (TPTI) on mortality of liver cirrhosis patients on waiting-list for liver transplantation (n=173). (A) Area under the receiver operating characteristic curves (AUC). A low TPTI is associated with increased mortality. AUC=0.66 [95% confidence interval, 0.51–0.80]. (B) Kaplan Meier curves indicating the probability of survival in patients with muscle mass loss (green line) or without muscle mass loss (blue line). Muscle mass loss was defined as Transversal Psoas Thickness Index (TPTI) <15.2 mm/m, as determined in (A); n=173; log rank test, P<0.01.

Figure 1





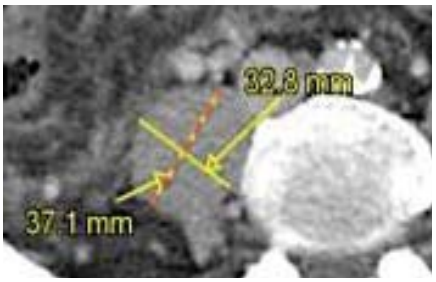


Figure 2

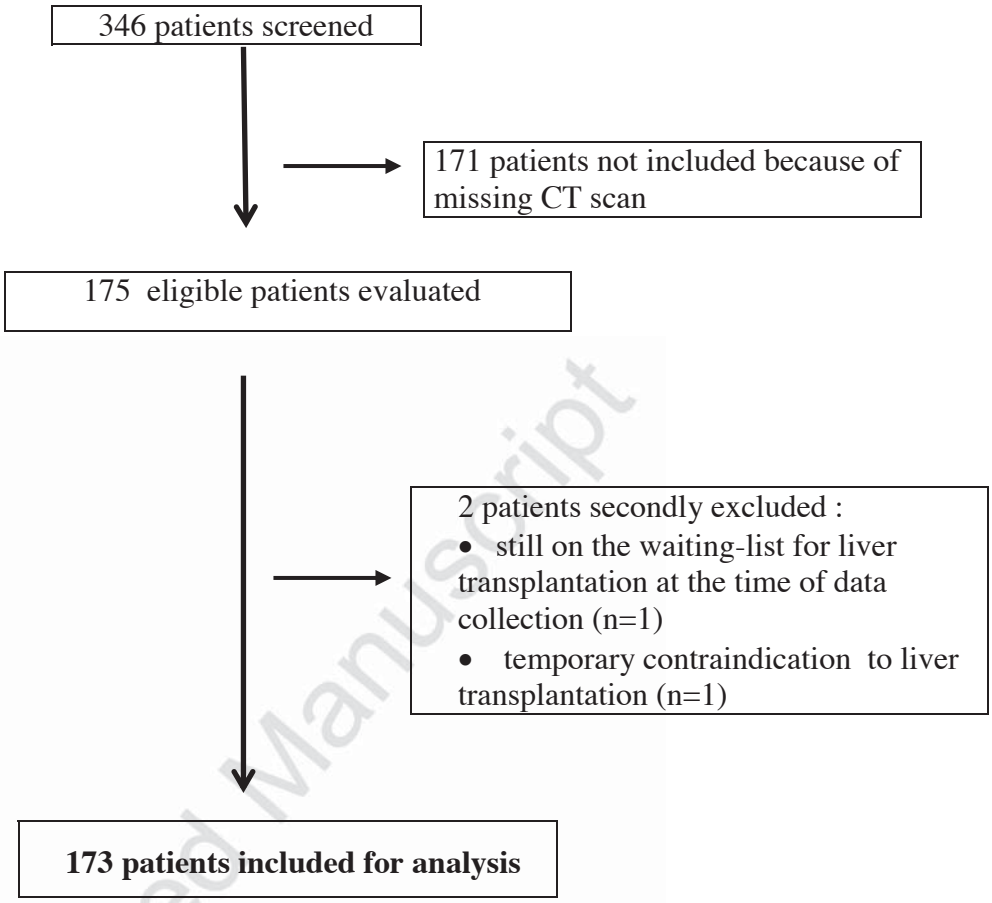
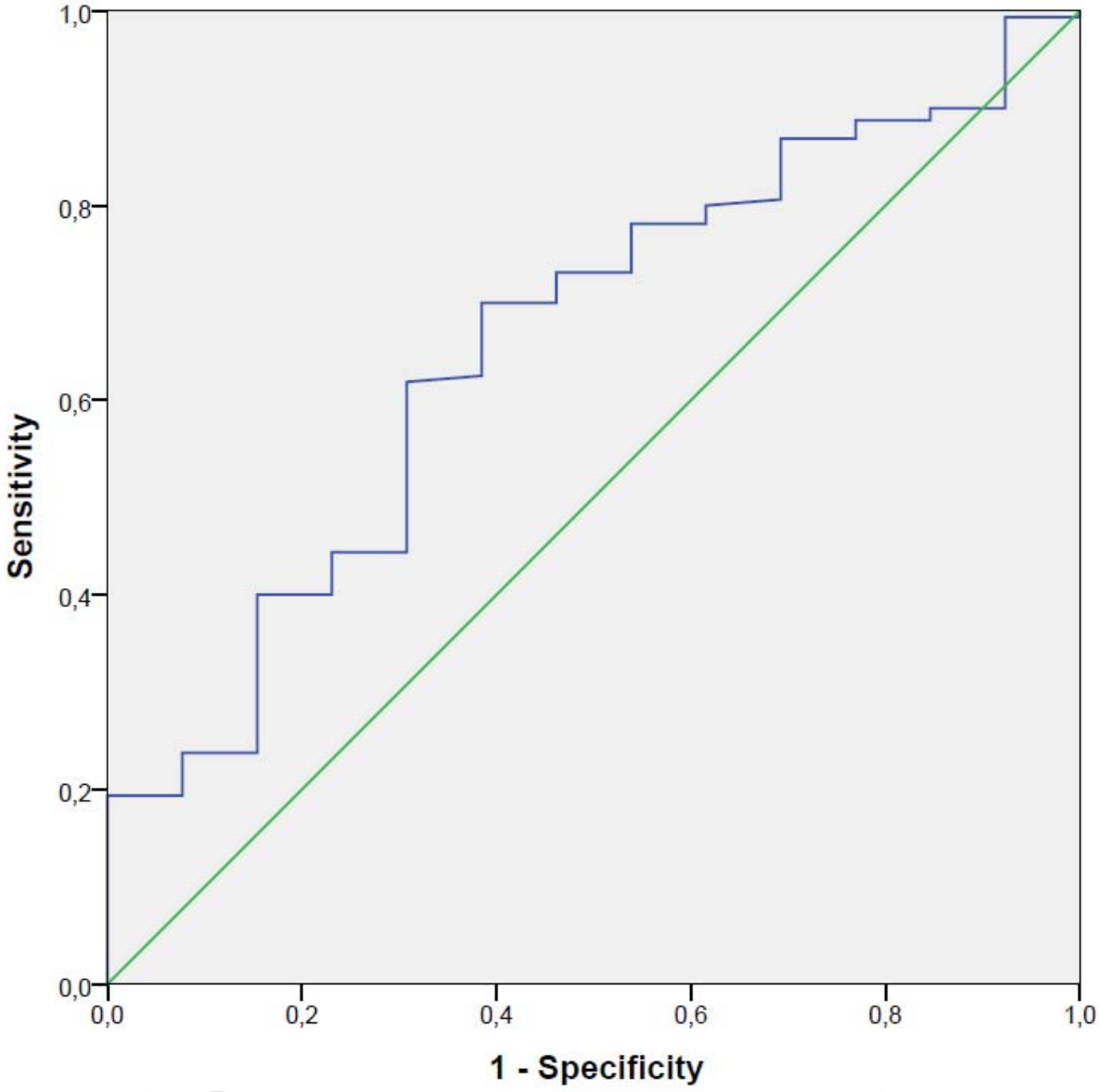


Figure 3

A



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