Validation of body mass index for the diagnosis of malnutrition in patients with liver cirrhosis

Bernard CAMPILLO (1), Jean-Philippe RICHARDET (1), Phuong-Nhi BORIES (2)

(1) Service de Rééducation Digestive, Hôpital Albert Chenevier, Assistance Publique-Hôpitaux de Paris, Créteil ;

SUMMARY

Objectives — Simple clinical tools are needed to detect malnutrition in cirrhotic patients. We have validated optimal body mass index (BMI) cut-offs for the diagnosis of malnutrition in accordance with the importance of ascites.

Methods — BMI, mid-arm muscle circumference (MAMC) and triceps skinfold thickness (TST) were measured before paracentesis in study (SP) and validation (VP) populations of 875 and 294 cirrhotic patients, respectively with no ascite (NA), mild (MA), tense ascities (TA) (NA/MA/TA: SP:327, 270, 278; VP: 111, 69, 114). Preserved nutritional status (SP: 259; VP: 93), malnutrition including severe and moderate malnutrition (SP: 251 and 365; VP: 92 and 109) were defined from MAMC and TST measurements.

Results — Optimal BMI cut-off values were 22, 23 and 25 kg/m² in NA, MA and TA patients, respectively. In the whole SP and VP, sensitivities of these cut-offs were 86.2% and 89.1%, respectively; the corresponding negative predictive values (NPV) for the diagnosis of severe malnutrition were 92.3% and 93.2%; specificities and positive predictive values (PPV) were 87.7% and 89.9%, 92.7% and 93.6%, respectively for the diagnosis of malnutrition. In the entire VP, peripheral oedema did not change sensitivity and NPV of BMI cut-offs for the diagnosis of severe malnutrition and tended to increase specificity and PPV for the diagnosis of malnutrition. 96.7% of the malnourished TA patients in the VP before paracentesis were correctly identified after removal of ascites.

Conclusion — BMI is a reliable parameter to detect malnutrition in cirrhotic patients with the above mentioned cut-offs. Peripheral oedema and removal of ascites do not affect its diagnostic performance.

RÉSUMÉ

Validation de l’indice de masse corporelle pour le dépistage de la dénutrition chez le malade cirrhotique

Bernard CAMPILLO, Jean-Philippe RICHARDET, Phuong-Nhi BORIES

(Gastroenterol Clin Biol 2006;30:1137-1143)

Objectifs — Des outils cliniques simples sont nécessaires pour le dépistage de la dénutrition chez le malade cirrhotique. Nous avons validé les valeurs seuils optimales de l’indice de masse corporelle (IMC) pour le diagnostic de la dénutrition en fonction de l’importance de l’ascite.

Méthodes — L’IMC, le périmètre brachial musculaire (PM) et l’épaisseur cutanée tricipitale (ECT) ont été mesurés avant paracentèse dans une population (P) et un groupe de validation (V) de 875 et 294 cirrhotiques non ascitiques et présentant une ascite modérée ou tendue (NA/AM/AT : P : 327, 270, 278 ; V : 111, 69, 114). Un état nutritionnel conservé (P : 259 ; V : 93), une dénutrition sévère ou modérée (P : 251 et 365 ; V : 92 et 109) étaient définis à partir des mesures du PM et de l’ECT.

Résultats — Les valeurs seuils optimales de l’IMC étaient respectivement 22, 23 et 25 kg/m² chez les malades NA, AM et AT. Dans les groupes P et V les sensibilités de ces seuils étaient respectivement 86,2 % et 89,1 %, les valeurs prédicitives négatives (VPN) 92,3 % et 93,2 % pour le diagnostic de dénutrition sévère ; les spécificités étaient respectivement 87,7 % et 89,9 %, les valeurs prédicitives positives (VPP) 92,7 % et 93,6 % pour le diagnostic de dénutrition. Dans le groupe V, les œdèmes périphériques ne modifiaient pas la sensibilité et la VPN des valeurs seuils de l’IMC pour le diagnostic de dénutrition sévère et tendaient à augmenter la spécificité et la VPP pour le diagnostic de dénutrition. 96,7 % des malades AT dénutris dans le groupe V avant paracentèse restaient classés de façon identique après évacuation de l’ascite.

Conclusion — L’IMC est un paramètre fiable pour le dépistage de la dénutrition chez le malade cirrhotique grâce aux valeurs seuils précédemment définies. Les œdèmes périphériques et l’évacuation de l’ascite n’affectent pas ses performances.

Introduction

There is a growing awareness for a need to detect malnutrition in patients on admission to hospital because it induces complications and affects outcome and cost [1, 2]. This problem is particularly crucial in cirrhotic patients because malnutrition has a high prevalence and represents a negative prognostic factor on survival [3-5]. Detection of malnutrition requires simple and inexpensive tools such as body weight, body mass index (BMI) and changes in body weight; however it is admitted that fluid retention and ascites preclude interpretation of these parameters in such patients. The use of invasive and low-cost bedside methods has limiting factors. Anthropometric parameters as mid-arm muscle circumference (MAMC) and triceps skinfold thickness (TST) are not affected by non-nutritional factors that can confound the interpretation of other indices; they can be measured fairly accurately in patients with advanced liver disease and fluid retention because oedema accumulates to a lesser extent in the upper extremities. Although the major limitation of these anthropometric parameters comes from intra- and inter-observer variabilities, this method seems the most suitable to usual clinical practice and surveys including large populations of patients [6]. Bioelectrical impedance analysis and dual-energy X-ray absorptiometry may also be used but have some limitations in the presence of ascites; in addition, they cannot be extensively used in routine in every patient [7, 8]. Several studies have shown that...
The aim of this study was to validate a simple and accurate clinical tool to detect malnutrition in hospitalized cirrhotic patients. Since BMI is a simple and widely used index of nutritional status in patients without overt fluid retention, we have studied the distribution of BMI values in relation with the presence of ascites in a large series of cirrhotic patients before paracentesis; nutritional status was assessed by anthropometric parameters. We have investigated whether BMI cut-off values could be defined for the diagnosis of malnutrition according to the presence and severity of ascites. Then, these BMI cut-off values were tested for validation in a second group of patients. The effects of peripheral oedema and removal of ascites on the performance of the method were assessed in the latter group.

Patients and methods

Our department is specifically devoted to rehabilitation of patients with chronic liver diseases and receives patients from many hospitals in the Parisian region. All patients admitted in our department with the diagnosis of liver cirrhosis from January 1, 2000 to December 31, 2003 were included in the study population and from January 1, 2004 to April 30, 2005 in the validation population. All these patients had been hospitalized on average for 2-3 weeks prior to admission to our department because of complications of the disease such as gastro-intestinal bleeding, ascites, jaundice, septic complications, encephalopathy or malnutrition. The diagnosis of liver cirrhosis was made on the basis of usual clinical, biological and endoscopic signs of liver disease and/or liver biopsy. Patients with alcoholic liver cirrhosis had ceased alcoholic beverage intake for at least 3 months prior to admission to our department.

Nutritional assessment

Height, weight and other anthropometric parameters were measured within 48 h after admission or slightly later when patients suffered from encephalopathy. The precision of the weight scale used was ± 0.5 kg, that of the height scale was ± 0.005 m. BMI was calculated. Ascites and anthropometric parameters were assessed on the same day before paracentesis and ascites removal.

In addition, peripheral oedema of the legs in the recumbent position was noted in all patients in the validation group. Paracentesis was performed in those with tense ascites a few days after admission, then weight, BMI and ascites were assessed again one week later. When paracentesis was not performed, patients were weighed and the presence of ascites was evaluated once again within one week after admission. Diuretic treatment was used when possible. Mid-arm circumference (MAC) and triceps skinfold thickness (TST) was measured using the non-dominant arm by the same experienced operator who used a tape and a skinfold caliper. Measurements were taken midway between the tip of acromion and the olecranon process with the patients standing in a relaxed position. Measurement of quantitative variables among several groups was performed using ANOVA. When ANOVA showed a statistically significant difference, comparisons between two groups were performed using Bonferroni Dunn’s test. Comparisons of qualitative variables were performed using χ² test. Multivariate analysis was done using a stepwise logistic regression model. The receiver-operating characteristics (ROC) curves were calculated in the study population; areas under the curves as well as 95% CI were calculated and comparison between two curves was performed according to the method described by Hanley and Mc Neil [14, 15]. Sensitivity, specificity, positive and negative predictive values (PPV and NPV, respectively) of different BMI cut-offs were calculated through BMI values distribution in the study population categorized into 3 groups according to the importance of ascites. Optimal cut-off values were chosen to maximize the sum of sensitivity for the diagnosis of severe malnutrition on the one hand and specificity for the diagnosis of malnutrition on the other hand. Optimal BMI cut-offs after being determined in the three groups of patients from the study population, were tested in the validation population. Data were analyzed with Statview software (Statview 5.0 SAS Institute INC. Cary NC 27513, USA).

Results

Description of the populations

Eight hundred seventy-five patients were included in the study population (Child A/B/C, 126/377/372); 327 patients had no detectable ascites, 270 patients, mild ascites and 278 patients, tense ascites. The etiology of cirrhosis was alcohol in 712 patients, hepatitis C in 39 patients, hepatitis B in 16 patients, alcohol associated with hepatitis C in 70 patients, alcohol associated with hepatitis B in 16 patients and other miscellaneous causes in 22 patients (including cryptogenic cirrhosis in 10 cases, primary biliary cirrhosis in 5 cases, biliary obstruction in 2 cases, autoimmune cirrhosis in 3 cases, hemochromatosis in one case, Budd Chiari syndrome in one case). Patients with post-hepatitis C cirrhosis and cirrhosis related to other causes were older than other patients. However there was no difference according to the etiology of cirrhosis regarding Pugh score and nutritional status. Two hundred and fifty five patients had acute alcoholic hepatitis (AAH), 58 patients had hepatocellular carcinoma (HCC). Nutritional status was similar in patients with AAH, HCC and in the remaining patients.

Two hundred ninety-four patients were included in the validation population (Child A/B/C, 43/120/131); 111 patients with no detectable ascites, 69 patients with mild ascites, 114 patients with tense ascites. The etiology of cirrhosis was alcohol in 243 patients, hepatitis C in 8 patients, hepatitis B in 8 patients, alcohol associated with hepatitis C in 27 patients, alcohol associated with hepatitis B in 3 patients, other miscellaneous causes in 5 patients (including cryptogenic cirrhosis in 3 cases, biliary obstruction in one case, autoimmune cirrhosis in one case). Sixty patients had AAH, 32 patients had HCC.

Characteristics of patients

The characteristics of the patients from the study population according to their nutritional status are shown in table 1. A large proportion of patients (70.4%) suffered from malnutrition: 28.7% had severe malnutrition while 41.7% had moderate malnutrition. Severity of ascites paralleled impairment in nutritional status; the prevalence of patients with tense ascites was the highest among patients with severe malnutrition. BMI values decreased with nutritional interventions improve liver function and survival in selected subgroups of malnourished patients with alcoholic liver diseases [9–11]. Therefore, the detection of malnutrition is essential for the management of hospitalized cirrhotic patients.

Clinical outcome

Length of hospital stay, mortality rate during hospital stay and the causes of death in the study population were recorded.
impairment in nutritional status, mean BMI value was the lowest in patients with severe malnutrition.

The characteristics of the patients from the validation population according to their nutritional status are shown in table I: 68.4% of patients suffered from malnutrition, including 31.3% with severe malnutrition and 37.1% with moderate malnutrition. In accordance with the data observed in the study population, severity of ascites paralleled impairment in nutritional status and BMI values decreased with impairment in nutritional status.

The distribution of BMI values according to the nutritional status and the presence of ascites in the study population is shown in table II. Mean BMI values significantly increased with ascites independently of nutritional status, on the other hand, mean BMI values significantly decreased with impairment in nutritional status independently of ascites (F interaction=1.005, P=0.4039). BMI significantly correlated with TST in NA, MA and TA patients (r=0.655, 0.596, 0.549, respectively P<10−4) and MAMC (r=0.622, 0.704, 0.723, respectively P<10−4).

**Receiver operator characteristics (ROC) curves**

Figure 1 shows the ROC curves of BMI values determined in the three groups of the study population defined according to the

Table I. – Characteristics of patients.

Caractéristiques des malades.

<table>
<thead>
<tr>
<th></th>
<th>Study population</th>
<th>Validation population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sev Mal</td>
<td>Mod Mal</td>
</tr>
<tr>
<td>N</td>
<td>251</td>
<td>365</td>
</tr>
<tr>
<td>Age (y)</td>
<td>56.0±11.4</td>
<td>55.5±11.1</td>
</tr>
<tr>
<td>M/F (%)</td>
<td>65.7/34.3</td>
<td>69.6/30.4</td>
</tr>
<tr>
<td>MAMC (cm)</td>
<td>18.5±2.1</td>
<td>21.2±2.1</td>
</tr>
<tr>
<td>TST (mm)</td>
<td>4.2±2.0c</td>
<td>8.0±4.2c</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>20.3±3.2c</td>
<td>23.5±3.7c</td>
</tr>
<tr>
<td>Albumin (g/l)</td>
<td>26.9±5.5</td>
<td>27.5±5.4</td>
</tr>
<tr>
<td>Bilirubin (µmol/l)</td>
<td>73.2±75.0</td>
<td>83.2±104.5</td>
</tr>
<tr>
<td>Prothrombin index (%)</td>
<td>61.2±20.8</td>
<td>59.9±19.2</td>
</tr>
<tr>
<td>Ascites (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No ascites</td>
<td>23.9</td>
<td>26.2</td>
</tr>
<tr>
<td>Mild ascites</td>
<td>39.7</td>
<td>32.9</td>
</tr>
<tr>
<td>Tense ascites</td>
<td>47.9</td>
<td>31.7</td>
</tr>
<tr>
<td>Encephalopathy (%)</td>
<td>12.0</td>
<td>12.1</td>
</tr>
<tr>
<td>Pugh score</td>
<td>9.5±2.2</td>
<td>9.0±2.2</td>
</tr>
<tr>
<td>Child score [%]</td>
<td>19.8</td>
<td>42.9</td>
</tr>
<tr>
<td></td>
<td>28.1</td>
<td>45.1</td>
</tr>
<tr>
<td></td>
<td>32.3</td>
<td>37.9</td>
</tr>
<tr>
<td>Length of hospital stay (days)</td>
<td>45.2±36.4</td>
<td>43.1±37.4</td>
</tr>
</tbody>
</table>

Table II. – BMI values according to nutritional status and the presence of ascites.


<table>
<thead>
<tr>
<th>BMI (kg/m²)</th>
<th>N</th>
<th>Non-ascitic patients</th>
<th>N</th>
<th>Patients with mild ascites</th>
<th>N</th>
<th>Patients with tense ascites</th>
<th>ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe malnutrition N=251</td>
<td>58</td>
<td>18.6±3.0b **</td>
<td>68</td>
<td>20.1±3.1***</td>
<td>125</td>
<td>21.1±3.1***</td>
<td>P&lt;10−4</td>
</tr>
<tr>
<td>Moderate malnutrition N=365</td>
<td>145</td>
<td>22.5±3.6</td>
<td>120</td>
<td>23.5±3.7**</td>
<td>100</td>
<td>24.9±3.2**</td>
<td>P&lt;10−4</td>
</tr>
<tr>
<td>Preserved nutritional status N=259</td>
<td>124</td>
<td>25.8±4.3</td>
<td>82</td>
<td>28.1±5.6**</td>
<td>53</td>
<td>29.1±4.8**</td>
<td>P&lt;10−4</td>
</tr>
<tr>
<td>ANOVA</td>
<td>P&lt;10−4</td>
<td>P&lt;10−4</td>
<td>P&lt;10−4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comparisons between two groups were performed using Bonferroni-Dunn test among groups defined on the basis of the same nutritional status: a: P<10−2; b: P<10−4 and among groups defined on the basis of importance of ascites: *; **; ***: P<10−4.
presence of ascites. The areas under the ROC curves (AUROC) (95% CI) for the diagnosis of severe malnutrition and malnutrition were 0.854 (0.801–0.907) and 0.783 (0.732–0.834) in non-ascitic patients; 0.806 (0.749–0.862) and 0.822 (0.767–0.877) in patients with mild ascites, 0.843 (0.796–0.890) and 0.863 (0.804–0.922) in patients with tense ascites, respectively. Comparisons of the AUROCs in each group showed that there was a significant difference for the diagnosis of malnutrition and severe malnutrition in non-ascitic patients (P=0.016) but not in the other two groups.

### Determination of BMI cut-off values

Tables III and IV show the optimal BMI cut-off values for the diagnosis of malnutrition and severe malnutrition. Performances in the validation population were comparable to those observed in the study population. Considering the whole populations, sensitivity, specificity, PPV and NPV with the adequate BMI cut-off values were: 86.2%, 65.8%, 50.2%, 92.3% in the study population and 89.1%, 70.1%, 58.2%, 93.2% in the validation population for the diagnosis of severe malnutrition; 64.1%, 87.7%, 92.7%, 54.1% in validation population and 66%, 89.9%, 93.6%, 54.1% in validation population for the diagnosis of malnutrition, respectively.

### Effect of peripheral oedema on the performances of BMI cut-off values

The distribution of patients in the validation population according to their nutritional status and the presence of ascites and peripheral oedema is shown in table V. The percentages of patients with peripheral oedema among those without ascites, with mild ascites and with tense ascites were 20.7%, 24.6% and 46.5% (P<0.001), respectively. Performances of BMI cut-off values for the diagnosis of malnutrition and severe malnutrition in the different groups are shown in table VI. In the whole population, peripheral oedema tended to increase specificity and PPV of BMI cut-off values for the diagnosis of malnutrition while sensitivity was comparable for the diagnosis of severe malnutrition irrespective of the presence of peripheral oedema. The sensitivity for the diagnosis of severe malnutrition was 50% in non-ascitic patients with peripheral oedema but this group only included two patients.

### Effect of paracentesis and removal of ascites

Among the 114 patients with tense ascites at the time of admission in the validation group, 102 patients were evaluated. Paracentesis was performed in 85 patients. At the time of the second evaluation, 10 patients were non-ascitic, 42 had mild ascites and 50 still had tense ascites. BMI decreased from 24.0±4.8 to 23.3±4.7 (P<10^-4). Decrease in BMI was 1.9±2.3 in non-ascitic patients, 1.5±1.0 in patients with mild ascites, and 0.4±1.4 in patients with tense ascites (P<10^-4). Upon admission, 61 patients had a BMI value <25 kg/m²; at the time of the second evaluation, 62 patients had a BMI value below the respective cut-off value defined according to the importance of ascites (seven non-ascitic patients had a BMI value <22 kg/m², twenty-four patients with mild ascites had a BMI value <23 kg/m² and thirty-one patients with tense ascites had a BMI value <25 kg/m²).

### Table III

> Performance des valeurs seuils optimales de l’IMC pour le dépistage de la dénutrition dans la population étudiée et le groupe de validation.

<table>
<thead>
<tr>
<th>BMI optimal cut-off</th>
<th>Study population</th>
<th>Validation population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non ascitic</td>
<td>Patients with mild ascites</td>
</tr>
<tr>
<td>Sensitivity IC 95%</td>
<td>0.571 (0.502–0.640)</td>
<td>0.611 (0.542–0.681)</td>
</tr>
<tr>
<td>Specificity IC 95%</td>
<td>0.880 (0.821–0.939)</td>
<td>0.883 (0.861–0.955)</td>
</tr>
<tr>
<td>PPV IC 95%</td>
<td>0.890 (0.836–0.944)</td>
<td>0.926 (0.880–0.972)</td>
</tr>
<tr>
<td>NPV IC 95%</td>
<td>0.548 (0.477–0.619)</td>
<td>0.486 (0.403–0.569)</td>
</tr>
</tbody>
</table>

**PPV**: positive predictive value; **NPV**: negative predictive value

### Table IV

> Performance des valeurs seuils optimales de l’IMC pour le dépistage de la dénutrition sévère dans la population étudiée et le groupe de validation.

<table>
<thead>
<tr>
<th>BMI optimal cut-off</th>
<th>Study population</th>
<th>Validation population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non ascitic</td>
<td>Patients with mild ascites</td>
</tr>
<tr>
<td>Sensitivity IC 95%</td>
<td>0.875 (0.788–0.962)</td>
<td>0.824 (0.733–0.915)</td>
</tr>
<tr>
<td>Specificity IC 95%</td>
<td>0.699 (0.643–0.755)</td>
<td>0.660 (0.599–0.727)</td>
</tr>
<tr>
<td>PPV IC 95%</td>
<td>0.386 (0.301–0.471)</td>
<td>0.459 (0.370–0.548)</td>
</tr>
<tr>
<td>NPV IC 95%</td>
<td>0.963 (0.936–0.990)</td>
<td>0.914 (0.868–0.960)</td>
</tr>
</tbody>
</table>

**PPV**: positive predictive value; **NPV**: negative predictive value

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patients with tense ascites had a BMI value <25 kg/m²). Among the 61 patients initially considered as malnourished, 59 were similarly identified at the time of the second evaluation (96.7%). On the other hand, a preserved nutritional status was first recorded in 41 patients and was confirmed by the second evaluation among 38 of them (92.7%).

Outcome

The mortality rate was 16.6% in the study population. Mean length of hospital stay in the patients who died was 49.6±53.1 days (median: 30 days). The causes of death were septic complications (42.8%), terminal hepatic failure and hepatic coma (33.1%), hepatorenal syndrome (12.4%), hepatocellular carcinoma (4.1%), gastrointestinal bleeding (3.4%) and other causes (4.1%). Univariate analysis showed that the factors associated with mortality were age, Pugh score, the presence of AHH or HCC (P<10^{-4}) and nutritional status (P=0.0022). Multivariate analysis showed that mortality was positively associated with age (OR: 1.094, IC 95%: 1.069-1.120, P<10^{-4}), severe malnutrition (OR: 1.863, IC 95%: 1.189-2.920, P=0.0066), Pugh score (OR: 1.828, IC 95%: 1.625-2.056, P<10^{-4}), HCC (OR: 2.944, IC 95%: 1.428-6.070, P=0.0034). The mortality rate in the validation population was in the same range than in the study population (17%).

Discussion

Anthropometry based on the measurements of MAMC and TST is a reliable bedside method to assess nutritional status in patients with liver cirrhosis, especially in epidemiological studies including a large number of patients. The main factors limiting the method are related to intra- and inter-observer variabilities and to the presence of oedema at the upper extremities, which is seldom observed. When measurements are performed by the same experienced observer, and patients with obvious oedema at the upper limbs are excluded, as it was the case in our study, anthropometry is considered as an accurate method [6, 16-18]. Our two populations were comparable in terms of etiology of cirrhosis, severity of liver failure and impairment in nutritional status. The results of MAMC and TST measurements were analyzed according to standard values taking into account age and sex observed in a North American population for adults aged 18-74 years, because comparable data are not available for the French population whereas these reference values have been established for French adults >74 years [12, 13]. The different origins of healthy reference populations was likely to have no significant effects on our results since patients over 74 years were less than 10% of the entire population. Most patients included in these two populations had a more impaired nutritional status than that reported in previous studies [5, 17, 19]. Our definition of severe malnutrition is supported by its independent prognostic value on outcome. As it has been previously reported, we showed that ascites was the main clinical factor related with impairment in nutritional status [20]. However, because anthropometry is dependent on the experience of the observer and the accuracy of the measurements, there is a need for validated simple and inexpensive tools which could be used everywhere. Subjective global assessment may be a useful tool for screening malnutrition in these patients but it includes parameters such as change in body weight and presence of oedema which can be

Table V. – Distribution of patients according to ascites, nutritional status and peripheral oedema in the validation population.

<table>
<thead>
<tr>
<th>Ascites</th>
<th>Peripheral oedema</th>
<th>Severe malnutrition</th>
<th>Moderate malnutrition</th>
<th>Preserved nutritional status</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-ascitic patients</td>
<td>Present</td>
<td>2</td>
<td>6</td>
<td>15</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Absent</td>
<td>17</td>
<td>28</td>
<td>43</td>
<td>88</td>
</tr>
<tr>
<td>Patients with mild ascites</td>
<td>Present</td>
<td>5</td>
<td>10</td>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Absent</td>
<td>14</td>
<td>25</td>
<td>13</td>
<td>52</td>
</tr>
<tr>
<td>Patients with tense ascites</td>
<td>Present</td>
<td>18</td>
<td>23</td>
<td>12</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>Absent</td>
<td>36</td>
<td>17</td>
<td>8</td>
<td>61</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>92</td>
<td>109</td>
<td>93</td>
<td>294</td>
</tr>
</tbody>
</table>

Table VI. – Performance of BMI (kg/m²) cut-off values in the diagnosis of malnutrition according to the presence of peripheral oedema in the validation population.

<table>
<thead>
<tr>
<th>Malnutrition</th>
<th>BMI</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPV</th>
<th>NPV</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPV</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-ascitic patients</td>
<td>Present &lt;22</td>
<td>50%</td>
<td>100%</td>
<td>100%</td>
<td>78.9%</td>
<td>50%</td>
<td>85.7%</td>
<td>25%</td>
<td>94.7%</td>
</tr>
<tr>
<td>Absent</td>
<td>62.2%</td>
<td>92.9%</td>
<td>90.3%</td>
<td>69.6%</td>
<td>88.2%</td>
<td>77.1%</td>
<td>48.4%</td>
<td>96.4%</td>
<td></td>
</tr>
<tr>
<td>Patients with mild ascites</td>
<td>Present &lt;23</td>
<td>33.3%</td>
<td>100%</td>
<td>100%</td>
<td>16.7%</td>
<td>80%</td>
<td>91.7%</td>
<td>80%</td>
<td>91.7%</td>
</tr>
<tr>
<td>Absent</td>
<td>78.3%</td>
<td>75%</td>
<td>90.9%</td>
<td>52.9%</td>
<td>100%</td>
<td>47.2%</td>
<td>42.4%</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Patients with tense ascites</td>
<td>Present &lt;25</td>
<td>51.2%</td>
<td>100%</td>
<td>100%</td>
<td>33.3%</td>
<td>94.4%</td>
<td>87.9%</td>
<td>81%</td>
<td>96.7%</td>
</tr>
<tr>
<td>Absent</td>
<td>83.0%</td>
<td>62.5%</td>
<td>93.6%</td>
<td>35.7%</td>
<td>86.1%</td>
<td>36%</td>
<td>66%</td>
<td>64.3%</td>
<td></td>
</tr>
<tr>
<td>Total population</td>
<td>Present</td>
<td>46.9%</td>
<td>100%</td>
<td>100%</td>
<td>44.3%</td>
<td>88%</td>
<td>87.8%</td>
<td>73.3%</td>
<td>95.1%</td>
</tr>
<tr>
<td>Absent</td>
<td>75%</td>
<td>85.5%</td>
<td>91.9%</td>
<td>60.9%</td>
<td>89.6%</td>
<td>61.1%</td>
<td>54.1%</td>
<td>92%</td>
<td></td>
</tr>
</tbody>
</table>
independent of nutritional status in cirrhotic patients. Moreover, a previous study has shown that subjective global assessment alone cannot identify patients with low body cell mass although arm muscle circumference and handgrip strength are the most sensitive markers of body cell mass depletion [21]. The composite score used by the Veteran Administration Study Group Investigator is questionable because it includes circulating levels of visceral proteins which are dependent on liver failure [3]. Thus, we showed in our large series of patients that albumin level was not dependent on nutritional status in these patients.

The common opinion is that BMI cannot be used in cirrhotic patients because fluid retention with ascites and oedema precludes interpretation of its value. The results from our large study population showed that BMI was dependent on nutritional status and ascites. BMI decreased with impairment in nutritional status whereas the prevalence of tense ascites increased. Moreover, the correlations between TST, MAMC and BMI show that BMI remains a marker of nutritional status in cirrhotic patients, irrespective of the importance of ascites, as it has been previously shown in subjects without fluid retention [22]. These results suggested that BMI could have acceptable value in the diagnosis of malnutrition provided that adequate cut-off values are defined according to the presence of ascites. Since we searched for a clinical tool which could be used in every patient at the bedside, the presence of ascites was clinically assessed. The risk was to underestimate ascites in non-ascitic patients whereas recognition of tense ascites is obvious. However, the validation of ascitic status by experienced practitioners limited this risk and our results showed that non-ascitic patients had significantly lower BMI values when compared with those with mild ascites, suggesting that patients were properly classified. Areas under the ROC curves showed that BMI had the same performance in the diagnosis of malnutrition, irrespective of the presence of ascites. However, in comparison to patients with ascites, severe malnutrition was better diagnosed than malnutrition in patients with no ascites. The chosen cut-off values aimed at the highest sensitivity for the diagnosis of severe malnutrition and the highest specificity for the diagnosis of malnutrition so that patients with BMI below the cut-off value had an impaired nutritional status. The cut-off point we proposed for non-ascitic patients was higher than that usually admitted (18.5 or 20 kg/m²) for the diagnosis of malnutrition in patients without overt fluid retention [23-25]. Early change in body composition in liver cirrhosis may account for this difference. Increased total body water and decreased body cell mass and/or body fat are reported in Child A patients, before the onset of ascites [26, 27]. The BMI cut-off value of 22 kg/m² in non-ascitic patients, 23 kg/m² in patients with mild ascites, 25 kg/m² in patients with tense ascites provided a sensitivity and specificity higher than 85% in the entire study population and were validated with comparable results in the validation group. This method is appropriate for detection of malnutrition but not for analysis of body composition which can be performed by more sophisticated methods such as bioelectrical impedance analysis or dual-energy X ray absorptiometry [7, 8].

Peripheral oedema is a confounding factor which may limit the interpretation of BMI. As it could be expected, we showed that peripheral oedema was related with ascites. In the validation population, we showed that peripheral oedema did not affect sensitivity.
of BMI cut-offs for the diagnosis of severe malnutrition while specifi-
city of BMI cut-off was observed in non-ascitic patients but the
group of patients severely malnourished, without ascites but with
peripheral oedema, included only two patients. On the other hand,
peripheral oedema did not affect sensitivity of BMI cut-offs for the
diagnosis of severe malnutrition in ascitic patients, especially in
patients with tense ascites, including most patients with peripheral
oedema. Therefore, our results showed that peripheral oedema did
not significantly affect the validity of BMI cut-off values.

Rapid change in body weight caused by paracentesis and
removal of ascites may preclude the interpretation of BMI. Cut-off
values given in this study have been chosen on the basis of weight
measurement upon admission in our department, before para-
centesis was performed. Paracentesis and/or diuretic treatment in
patients who initially suffered from tense ascites resulted in a
decline in BMI value and a change in the ascitic status since
about 10% of patients became non-ascitic and more than 40% had mild ascites. The second assessment of nutritional status took
changes in BMI and cut-off values into account. Initial measure-
ments of MAMC and TST remained valid because of the short
interval between the two evaluation points. We showed that almost
97% of the patients having BMI below the cut-off of 25 kg/m² on
admission and diagnosed as malnourished, remained in the same
category one week later after paracentesis and treatment of ascites
whereas 93% of the patients above this BMI cut-off and conse-
quently not recognized as malnourished remained in the same cat-
gory. Therefore, our results demonstrated that rapid changes in
body weight caused by removal of ascites did not affect assess-
ment of nutritional status based on BMI and ascitic status.

Conclusion

BMI with cut-off values of 22 kg/m² in non-ascitic patients,
23 kg/m² in patients with mild ascites and 25 kg/m² in patients
with tense ascites is a simple and adequate tool to detect malnutri-
tion in cirrhotic patients. These cut-off values yield adequate sensi-
tivities to detect most patients suffering from severe malnutrition
and adequate specificities for patients with moderate or severe
malnutrition. Assessment of nutritional status requires BMI meas-
urement and clinical assessment of ascites. Peripheral oedema and
removal of ascites do not significantly affect the validity of the
method.

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