Oral nutritional supplements (ONSs) for cirrhotic patients undergoing liver resection assessed by ultrasound measurement of rectus femoris and anterior tibialis muscles thickness. Randomized clinical trial

ABSTRACT

**Purpose:** We evaluated the effects of postoperative administration of (ONSs) on the liver function and the outcome of cirrhotic patients using ultrasound (US) assessment of rectus femoris (RF) and anterior tibialis (AT) muscles.

**Patients and Methods:** Forty-three malnourished adult hepatic patients who underwent major liver resections were recruited in this study. In the conventional diet (CD) group, the patients took water at postoperative day (POD) 0 and routine soft diet starting from POD1. In the ONS group, a commercially elemental diet was started from POD1 for 7 days postoperatively, with a target endpoint of 35-40 kcal/kg and 1.2-1.5 g/kg of protein per day. US assessment of the RF and AT muscles was done preoperatively and at POD3 and 7, including anterior-posterior (AP) diameter, lateral-lateral (LL) diameter, and cross-sectional area (CSA). Muscles' echogenicity was defined by the Heckmatt scale. The outcome of the patients was also recorded.

**Results:** Consumption of ONS preserved the measured RF and AT characteristics (AP and LL diameters and CSA) in the ONS group at POD3 and 7 compared to the CD group. Heckmatt scale was significantly increased at POD3 and 7 in the CD group compared to the ONS group. Both total protein and albumin levels at POD3 and 7 were significantly lower in the CD group compared to the ONS group \(P = 0.02, 0.03\) and \(0.05, 0.04\), respectively). Serum phosphate was significantly lower at POD7 in the ONS group than the CD group \((p = 0.04)\). There were significant decreases in the ICU stay and time of passing flatus (h) in the ONS group comparing with the CD group \((P = 0.045\) and \(P = 0.00\), respectively).

**Conclusions:** ONS maintains muscle mass and echogenicity of RF and AT along with better liver function and intestinal function recovery.

**Key words:** Liver resection; muscles ultrasound; ONS
Introduction

Malnutrition in hepatic patients results from a variable combination of decrease intake, altered macronutrient metabolism, maldigestion, malabsorption, and hyper metabolic state. Hepatic patients, particularly with decompensated cirrhosis, usually experience weight loss and muscle wasting as well as protein-energy malnutrition, which often result in sarcopenia. Muscle mass loss leads to muscle weakness, which interferes with postoperative weaning from mechanical ventilation and results in poor outcome. In chronic liver disease, severe protein-calorie malnutrition adversely affects liver regeneration after liver resection surgeries; however, perioperative oral nutritional supplement (ONS) in patients with impaired liver function play a fundamental rule in the outcome, encourage postoperative enteral nutrition, preserve the immunity, and maintain the integrity of the gastrointestinal tract. European Society for Clinical Nutrition and Metabolism encourages the use of ONS if the patients are unable to safeguard appropriate oral intake. Using nutritional assessment tools, such as anthropometric and biometric measures, in patients with advanced liver diseases is difficult owing to complications such as ascites and inflammation. Measuring muscle mass by ultrasound (US) techniques is a reliable, accessible, low-cost, and applicable technique. In this study, we estimated the influence of early postoperative ONS in malnourished cirrhotic patients undergoing liver resection via US evaluation of the mass and morphological alteration of anterior tibialis (AT) and rectus femoris (RF) muscles. We also evaluated the impact of ONS on liver function, infectious complications, and outcome.

Patients and Methods

This prospective double-blind trial was conducted in the Department of Anesthesia and Intensive Care at the National Liver Institute, Menoufia University. The study protocol was approved by the National Liver Institute Review Board (IRB number 00156/2019) and registered in the Pan African Clinical Trial Registry (www.pactr.org; No.: PACTR201907570828748). Written consent was obtained from all the recruited patients. There were 43 adult hepatic patients, categorized as Child-Pugh A or B, undergoing major liver resections for liver tumors (either primary or secondary), with a modified BMI below 23 with mild ascites or 22 with no ascites, and triceps skinfold (TSF) and mid-arm muscle circumference (MAMC) below the 5th percentile, i.e., who were considered malnourished. Three patients dropped out of the study as the surgery was aborted since the patients were inoperable. Exclusion criteria included refusal of the patient to be involved in the study, treatment with corticosteroids, and neuromuscular diseases. Participants were randomized to either receiving conventional diet (CD group) or oral nutritional supplementation (ONS group). Using randomization table generated by permuted block technique with variable block size.

In the CD group, the patients took some water at postoperative day (POD) 0 and started with soft routine diet at POD1, after assessment of the abdominal sound on the morning of POD0.

In the ONS group, after the assessment of abdominal sound, ONS was started from the morning of POD1 for at least 7 days postoperatively. The target endpoint for ONS was 35-40 kcal/kg and 1.2-1.5 g/kg of protein per day. We started with small volume of ONS and gradually increased it according to the patient’s tolerance. A commercially available elemental diet was supplemented with high energy, high protein ONS, high energy to meet the energy needs in a low volume of diet and allow optimum fluid restriction (2 kcal/mL), and high protein to meet the elevated protein requirement in a low volume of diet (10 g protein/100 mL).

For all patients, general anesthesia was induced using 2 mg/kg propofol, 2–4 µg/kg fentanyl, and 0.6 rocuronium, and maintained using a balanced anesthetic technique, involving sevoflurane at 0.7–1 minimum alveolar concentration (MAC), and a mixture of air and oxygen (FiO₂: 0.4). The central venous catheter was inserted with ultrasound guidance (Sonosite, Nanomex, UK) through the right internal jugular approach. We administered crystalloid solution (6 mL/kg/h) to maintain the central venous pressure (CVP) at 5 cm H₂O or less to reduce the blood loss. At the end of the surgery, the patients were extubated after fulfillment of the criteria of extubation. Standard low molecular weight (LMW) heparin used as a prophylactic against deep vein thrombosis. The hemodynamic parameters were recorded before induction, intraoperatively, and postoperatively. Blood samples were taken for routine biochemistry analysis, including the liver function tests. The rate of infectious complications, ICU stay, and intestinal function recovery, postoperative abdominal distention, postoperative nausea and vomiting, and time of flatus passing were also recorded.

Nutritional status was evaluated preoperatively using subjective global assessment (SGA), TSF, body mass index (BMI), and MAMC. For all patients, US assessment of the RF and AT muscles was conducted preoperatively and at POD3 and 7. We used a US device with a 5- to 7.5-MHz linear probe. The US technique used in this study was based on that used previously by Pasta G et al. Lateral-lateral (LL) diameter,
cross-sectional area (CSA), and anterior-posterior (AP) diameter were recorded for both muscles. Qualitative parameter (echogenicity) was determined using the Heckmatt scale (Normal echogenicity corresponds to score of 1; a higher grade of echogenicity and higher score correlates with a higher severity of myopathy).[^8]

**Statistical analysis**
The Kolmogorov–Smirnov test was used to assess the normality of the data. Data were represented as mean ± SD, with 95% confidence intervals (95%CI) where appropriate. SPSS version 15 (SPSS Inc., Chicago, IL, USA) was used to conduct all the statistical analyses. Independent t-test was used for comparisons between the two studied groups. P value < 0.05 was considered as statistically significant. Fisher’s exact test and Chi-square test were used to compare the qualitative variables.

**Sample size and power of the study**
We are planning a study of a continuous response variable from independent control and experimental subjects with 1 control(s) per experimental subject. In a previous study, the response within each subject group was normally distributed with standard deviation (1.384).[^9]

If the true difference in the experimental and control means is (1.537) cm², in the primary outcome which is the cross-sectional area of the (Rectus Femoris) assessed by the US between the experimental group (ONS) and control group (CD) group we will need to study 18 experimental subjects and 18 control subjects to be able to reject the null hypothesis that the population means of the experimental and control groups are equal with probability (power) 90%. The Type I error probability associated with this test of this null hypothesis is 0.05.[^9]

**Results**
Forty patients completed the study, with 20 patients in each group. Three patients were dropped out of the study [Figure 1]. All patients were fully complied with the required oral supplement dose according to there corresponding group. The gender and age distribution were comparable between the two study groups. Child score, lobe resected, and SGA were comparable with no statistically significant difference. With respect to the anthropometric data, we observed no significant differences between the BMI of both groups at all periods of measurements; however, we observed a significant decrease in the values of MAC, TSF, and HGS for the CD group at POD7 (P = 0.04, 0.01, and 0.06, respectively; Table 1). Preoperative levels of total protein and albumin were comparable between the studied groups. Postoperatively, the total protein and albumin levels were significantly lower in the CD group compared to the ONS group. Preoperative and postoperative levels of blood urea nitrogen (BUN) and transferrin were comparable between the two study groups [Table 2]. Preoperative serum phosphate level was comparable between the two groups until POD7 when it decreased significantly in the ONS group compared with the CD group.

Preoperative CSA and AP and LL diameters of the RF muscles were comparable between the two study groups; however, at POD7, these values were significantly reduced in the CD group. In addition, at POD3, the CSA of the RF muscles was significantly lower in the CD group. The preoperative Heckmatt scores for RF muscles was comparable between both the groups; however, at POD3 and POD7, these scores were significantly higher in the ONS group compared with the CD group.

Compared to the CD group, the ONS group exhibited significantly lower values for ICU stay and time of passing flatus (h) (P = 0.045 and P = 0.00, respectively; Table 4). There was no statistically significant difference between the two groups with respect to the number of patients suffering from infection and postoperative nausea and vomiting. None of the patients suffered from abdominal distention after feeding [Table 4].
The images were taken in the ICU Department of the National Liver Institute, Menoufia University.

Discussion

We evaluated the effects of postoperative ONS versus CD in hepatic patients who underwent hepatic resection using US assessment of the quantitative and qualitative changes in the RF and AT muscles. The main outcome of our study was the ability of ONS to maintain muscle mass and echogenicity of RF and AT muscles with better liver function and intestinal function recovery, which corroborated the results of previous clinical studies on ICU patients.\textsuperscript{12,10}

Patients with liver cirrhosis exhibit insufficient glycogen reserves, due to liver dysfunction, along with an increased consumption of amino acids, which enhances the release of amino acids from the skeletal muscles, which, in turn, leads to sarcopenia. Another contributing cause of sarcopenia in these patients is hyperammonemia.\textsuperscript{11}

Proteins such as prealbumin, transferrin, and albumin are negative acute-phase proteins. Their levels alter due to different stress levels. So, they are not a good marker for assessment of the nutrition status.\textsuperscript{12} Anthropometric measurements are unreliable and inaccurate tools for assessment of the nutrition state of cirrhotic patients with edema and ascites.\textsuperscript{13} On the other hand, bioelectrical impedance analysis (BIA) correlated well with the patient's Child-Pugh score.\textsuperscript{14} SGA for the assessment of nutritional state is commonly used to assess malnutrition in hepatic patients. Being a subjective tool, its interpretations vary across different examiners.\textsuperscript{15} In cirrhotic patients, handgrip Strength (HGS) has been shown to provide better assessment than the SGA.\textsuperscript{16} Ultrasoundography has a better...
correlation with the MRI and the CT scan findings, with the merit of being less expensive and involving no radiation exposure. Pathological muscle changes, such as fatty infiltration, atrophy, and intramuscular fibrosis, can be assessed using ultrasound. These morphological derangements in the muscle may occur due to muscle edema from capillary leak or inflammation, which occurs initially due to fibrosis and fatty degeneration, followed by loss of muscle myofibrils and muscle contour, along with a decline in the performance of the muscle.

Using US technique, we detected a significant loss in the muscle mass (AT and RF) and increase in the echogenicity score in CD group than the ONS group. These observations were associated with a prolonged ICU stay. Our results corroborated those of Puthucheary ZA et al., who reported that alterations in muscle architecture correlated with increased ICU stay and bad outcome. [2] Grimm A et al. used the US technique for muscle assessment in patients with severe sepsis and concluded that the use of US technique holds great potential for muscle examination and can be used to obtain data about morphological derangement of muscles in these types of patients. They also reported that US is more preferable than invasive methods, such as muscle biopsy. 

Grutherford W et al. reported that decrease in muscle mass was negatively correlated with ICU stay.

Providing nutrition to critically ill patients is aimed at preserving their muscle mass. Thus, it is essential to find an easily applicable method to measure the changes in the muscle mass during this critical period. Ultrasonography can be used to measure muscle mass even in the presence of edema and fluid retention. Here, we evaluated the efficiency of the US technique as a novel tool for the assessment of the nutritional status and muscle mass while providing nutrition support in hepatic patients. Puthucheary ZA demonstrated that US-assisted measurement of significant decrease in the muscle mass is associated with myofiber necrosis and muscular fascia inflammations. [2] Mourtzakis M and Wischmeyer P encouraged the use of the US technique for the assessment of skeletal muscles to quantify muscle wasting. Lower limb muscles facilitate a better muscle mass assessment compared with upper limbs owing to the type of their fiber, which shows early changes. For our study, we selected the RF and AT muscles.

Our study demonstrated that the administration of ONS improved liver function and intestinal function recovery. It has

**Table 3: Muscle ultrasound in the studied groups**

| Variable        | Time   | CD group (n = 20) Mean ± SD | ONS group (n = 20) Mean ± SD | P value |
|-----------------|--------|-----------------------------|-----------------------------|---------|
| RF: CSA (cm²)   | T0     | 4.47 ± 1.38 ± 1.53 ± 1.33   | 4.85 ± 1.50 ± 1.53 ± 1.50   | 0.02 NS |
|                 | T1     | 3.78 ± 1.25 ± 1.45 ± 1.45   | 4.75 ± 1.44 ± 1.44 ± 1.45   | 0.29 NS |
|                 | T2     | 3.71 ± 1.33 ± 1.47 ± 1.47   | 4.74 ± 1.46 ± 1.46 ± 1.46   | 0.27 NS |
| RF: AP diam. (mm)| T0   | 1.51 ± 0.51 ± 0.50 ± 0.50   | 1.50 ± 0.50 ± 0.50 ± 0.50   | 0.91 NS |
|                 | T1     | 1.32 ± 0.43 ± 0.42 ± 0.42   | 1.48 ± 0.41 ± 0.40 ± 0.40   | 0.21 NS |
|                 | T2     | 1.25 ± 0.40 ± 0.39 ± 0.39   | 1.49 ± 0.40 ± 0.39 ± 0.39   | 0.04 NS |
| RF: LL diam. (mm)| T0   | 3.96 ± 0.59 ± 0.58 ± 0.58   | 4.18 ± 0.63 ± 0.63 ± 0.63   | 0.26 NS |
|                 | T1     | 3.73 ± 0.61 ± 0.60 ± 0.60   | 4.00 ± 0.68 ± 0.68 ± 0.68   | 0.18 NS |
|                 | T2     | 3.57 ± 0.51 ± 0.50 ± 0.50   | 3.99 ± 0.49 ± 0.49 ± 0.49   | 0.03 NS |
| RF: Echogenicity | T0     | 1.05 ± 0.22 ± 0.21 ± 0.21   | 1.05 ± 0.22 ± 0.21 ± 0.21   | 0.40 NS |
|                 | T1     | 1.20 ± 0.41 ± 0.40 ± 0.40   | 1.20 ± 0.40 ± 0.40 ± 0.40   | 0.16 NS |
|                 | T2     | 2.40 ± 0.94 ± 0.93 ± 0.93   | 1.60 ± 0.92 ± 0.92 ± 0.92   | 0.00 NS |
| AT: CSA (cm²)   | T0     | 7.524 ± 1.61 ± 1.60 ± 1.60  | 7.516 ± 1.22 ± 1.21 ± 1.21  | 0.99 NS |
|                 | T1     | 6.83 ± 1.32 ± 1.30 ± 1.30   | 7.50 ± 1.25 ± 1.24 ± 1.24   | 0.10 NS |
|                 | T2     | 6.52 ± 1.34 ± 1.33 ± 1.33   | 7.37 ± 1.33 ± 1.32 ± 1.32   | 0.05 NS |
| AT: AP diam. (mm)| T0   | 2.20 ± 0.58 ± 0.57 ± 0.57   | 2.21 ± 0.49 ± 0.48 ± 0.48   | 0.98 NS |
|                 | T1     | 1.87 ± 0.51 ± 0.50 ± 0.50   | 2.15 ± 0.49 ± 0.48 ± 0.48   | 0.08 NS |
|                 | T2     | 1.79 ± 0.50 ± 0.49 ± 0.49   | 2.11 ± 0.49 ± 0.48 ± 0.48   | 0.05 NS |
| AT: LL diam. (mm)| T0   | 4.61 ± 0.53 ± 0.52 ± 0.52   | 4.84 ± 0.62 ± 0.61 ± 0.61   | 0.21 NS |
|                 | T1     | 4.39 ± 0.52 ± 0.51 ± 0.51   | 4.72 ± 0.62 ± 0.61 ± 0.61   | 0.08 NS |
|                 | T2     | 4.23 ± 0.53 ± 0.52 ± 0.52   | 4.73 ± 0.61 ± 0.60 ± 0.60   | 0.00 NS |
| AT: Echogenicity | T0     | 1.10 ± 0.22 ± 0.21 ± 0.21   | 1.05 ± 0.22 ± 0.21 ± 0.21   | 0.16 NS |
|                 | T1     | 2.25 ± 0.64 ± 0.63 ± 0.63   | 1.55 ± 0.55 ± 0.54 ± 0.54   | 0.00 NS |
|                 | T2     | 2.25 ± 0.79 ± 0.78 ± 0.78   | 1.80 ± 0.69 ± 0.68 ± 0.68   | 0.06 NS |

CD: Conventional diet; ONS: Oral nutritional supplement; T0: preoperative; T1: postoperative day3 (POD3); T2: POD7; S.D: Standard deviation; *significance with other group; (P < 0.05) NS: Not significant; RF: Rectus femoris; AT: anterior tibialis (CSA-AP-LL) cross section area anterio- posterior and lateral diameter; *significance with other group; (P < 0.05); NS: not significant.

**Table 4: Patients characteristic and outcome**

| Variable              | CD group (n = 20) Mean ± SD | ONS group (n = 20) Mean ± SD | P value |
|-----------------------|-----------------------------|-----------------------------|---------|
| Age (years)           | 57.25 ± 5.821               | 54.50 ± 6.60                | 0.17 NS |
| Sex (M/F)             | 17/3                        | 16/4                        | 1 NS    |
| RT/LL                 | 15/5                        | 17/3                        | 0.69 NS |
| Child A/B             | 15/5                        | 15/5                        | NA      |
| SGA A/B               | 17/3                        | 19/1                        | 0.31 NS |
| Surgery time (hrs.)   | 4.55 ± 0.841                | 4.25 ± 1.164                | 0.36 NS |
| Operative blood loss (ml) | 918.50 ± 464.48           | 1006.50 ± 227.81            | 0.45 NS |
| PRBCs unit transfusion| 1.15 ± 1.22                 | 1.10 ± 1.29                 | 0.90 NS |
| Time of pass flatus (hrs.) | 17.50 ± 4.174              | 11.10 ± 2.94                | 0.00 NS |
| pts.(n) of infection  | 7/13                        | 4/16                        | 0.48 NS |
| PONV (No. of pts.)    | 6/14                        | 8/12                        | 0.74 NS |
| ICU stay (days)       | 3.40 ± 1.569                | 2.55 ± 0.94                 | 0.045 NS |

Data expressed as mean ± SD; CD: Conventional diet group; ONS: Oral nutritional supplement group; RT: Right lobe; LT: Left lobe; SGA: Subjective global assessment. PRBCs: Packed red blood cell transfusion. PONV: Postoperative nausea and vomiting; NA: Not applicable; S.D: Standard deviation; *significance with other group; (P < 0.05); NS: not significant.
previously been shown that perioperative supplementation of branched-chain amino acid in HCC patients undergoing liver resection improved the liver function.\textsuperscript{[25]} Chen L \textit{et al.} previously reported that administration of ONS improved the outcome of the patients.\textsuperscript{[26]}

Our results showed that ONS administration helped in maintaining muscle mass and echogenicity. In contrast to our findings, Casaer MP \textit{et al.} demonstrated that decrease in lean body mass is not affected by type of nutritional support.\textsuperscript{[27]}

Furthermore, our results showed the ONS group exhibited lower serum phosphate levels, which might indicate better liver regeneration. Hypophosphatemia occurs after hepatectomy as phosphate anion is essential for nucleotide synthesis and hepatocellular growth.\textsuperscript{[28]}

Nutritional supplements provided after liver resection as additives of an ordinary diet improve the nutritional status and plays a fundamental role in hepatic regeneration and outcome. Enteral feeding maintains the integrity of the gastrointestinal tract, so it is often preferred over parenteral nutrition. Richter \textit{et al.} demonstrated better outcomes in post-hepatic resection patients who received enteral feeding.\textsuperscript{[29]}

As liver regeneration is affected by the nutritional status, sufficient nutritional intake can be indispensable for liver regeneration and outcome after major hepatectomy.\textsuperscript{[30]}

There were certain limitations of our study. First, the follow-up period for our patients was very short. The elongation of the follow-up period could assist in assessment of long-term effects of ONS on the muscle mass. Second, we did not compare ultrasound parameters with other tools, such as BIA.

From our study, we concluded that early ONS administration following liver resection in hepatic patients facilitates maintenance of muscle mass. A better liver function may indicate proper regeneration as well as reduced ICU stay with better intestinal function recovery. US technique holds great potential for qualitative and quantitative measure of the muscles, which could, in turn, be used as a tool for nutritional assessments in hepatic patients.

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**Conflicts of interest**
There are no conflicts of interest.

**References**

1. Bemeur C, Desjardins P, Butterworth RF. Role of nutrition in the management of hepatic encephalopathy in end-stage liver failure. J Nutr Metab 2010;2010:1-12. doi: 10.1155/2010/489823.
2. Puthucheary ZA, Rawal J, McPhail M, Connolly B, Ratnayake G, Chan P, \textit{et al.} Acute skeletal muscle wasting in critical illness. JAMA 2013;310:1591-600.
3. Zhang QK, Wang ML. The management of perioperative nutrition in patients with end stage liver disease undergoing liver transplantation. Hepatobiliary Surg Nutr 2015;4:336-44.
4. Hosoda N, Nishi M, Nakagawa M, Hiramatsu Y, Hiki K, Yamamoto M. Structural and functional alterations in the gut of parenterally or enterally fed rats. J Surg Res 1989;47:129-33.
5. Plauth M, Cabrè E, Riggio O, Assis-Camilo M, Pirlich M, Kondrup J, \textit{et al.} DGEM (German Society for Nutritional Medicine); ESPEN (European Society for Parenteral and Enteral Nutrition). ESPEN guidelines on enteral nutrition: Liver disease. Clin Nutr 2006;25:285-94.
6. Galindo Martin CA, Monares Zepeda E, Lescas Méndez OA. Bedside ultrasound measurement of rectus femoris: A tutorial for the nutrition support clinician. J Nutr Metab 2017;2017:1-5. doi: 10.1155/2017/2767232.
7. Pasta G, Nanni G, Molini L, Bianchi S. Sonography of the quadriceps muscles: Examination technique, normal anatomy, and traumatic lesions. J Ultrasound 2010;13:76-84.
8. Heckmatt IZ, Pier N, Dubowitz V. Real-time ultrasound imaging of muscles. Muscle Nerve 1988;11:56-65.
9. Birkett N, Day S. Internal pilot studies for estimating sample size. Stat Med 1994;13:2455-63.
10. Paris MT, Mourtzakis M, Day A, Leung R, Watharkar S, Kozar R, \textit{et al.} Validation of bedside ultrasound of muscle layer thickness of the quadriceps in the critically ill patient (VALIDUM Study). JPEN J Parenter Enteral Nutr 2017;41:171-80.
11. Dasarathy S. Consilience in sarcopenia of cirrhosis. J Cachexia Sarcopenia Muscle 2012;3:225-37.
12. Cheung K, Lee SS, Raman M. Prevalence and mechanisms of malnutrition in patients with advanced liver disease, and nutrition management strategies. Clin Gastroenterol Hepatol 2012;10:117-25.
13. Johnson TM, Overgard EB, Cohen AE, DiBaise JK. Nutrition assessment and management in advanced liver disease. Nutr Clin Pract 2012;28:15-29.
14. Fernandes SA, Bassani L, Nunes FF, Aydos ME, Alves AV, Marroni CA. Nutritional assessment in patients with cirrhosis. Arq gastroenterol 2012;49:19-27.
15. Detsky AS, McLaughlin JR, Baker JP, Johnston N, Whittaker S, Mendelson RA, \textit{et al.} What is subjective global assessment of nutritional status? JPEN J Parenter Enteral Nutr 1987;11:8-13.
16. Alves-da-Silva MR, Reverbel da Silveira T. Comparison between handgrip strength, subjective global assessment, and prognostic nutritional index in assessing malnutrition and predicting clinical outcome in cirrhotic outpatients. Nutrition 2005;21:113-7.
17. Reeves ND, Maganaris CN, Narici MV. Ultrasonographic assessment of human skeletal muscle size. Eur J Appl Physiol 2004;91:116-8.
18. Grimm A, Teschner U, Porzelius C, Ludewig K, Zielske J. Muscle ultrasound for early assessment of critical illness neuromyopathy in severe sepsis. Crit Care 2013;17:2-11.
19. Gruther W, Benesch T, Zorn C, Paternostro-Sluga T, Quittan M, Fialka-Moser V, \textit{et al.} Muscle wasting in intensive care patients: Ultrasound observation of the quadriceps femoris muscle layer. J Rehabil Med 2008;40:185-9.
20. Hiesmayr M. Nutrition risk assessment in the ICU. Curr Opin Clin Nutr Metab Care 2012;15:174-80.
21. Sabatino A, Regolisti G, Bozzoli L, Fani F, Antoniotti R. Reliability of bedside ultrasound for measurement of quadriceps muscle length: a cross sectional observational study. J Ultrasound Med 2015;34:1724-30.
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