Editorial

The optimal imaging diagnostic method of sarcopenia in liver transplantation: an unresolved issue

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Liver cirrhosis is the end stage of multiple liver diseases with a high morbidity and mortality. Complications related to cirrhosis, including variceal bleeding, ascites, spontaneous bacterial peritonitis, and hepatic encephalopathy, have been widely recognized (1-3). However, malnutrition, another common complication, has not been fully recognized in clinical practice. Indeed, classical prognostic models, such as Child-Turcotte-Pugh and model for end-stage liver disease (MELD), are lacking an objective assessment of malnutrition in cirrhotic patients (4-6).

Depletion in skeletal muscle mass, also known as sarcopenia, is a feature of malnutrition (7). Sarcopenia is a prognostic factor independently of the MELD score in patients waiting for liver transplantation (8). Recently, a meta-analysis by van Vugt *et al.* (9) showed that sarcopenia was associated with increased mortality on the liver transplantation waiting list (pooled hazard ratio =1.72, P=0.05) and after liver transplantation (pooled hazard ratio =1.84, P=0.02). Studies also found that sarcopenia impaired the quality of life, increased the incidence of complications, and worsened the outcome following liver transplantation (10).

Until now, several different imaging tools, such as computed tomography (CT), magnetic resonance imaging (MRI), dual-energy X-ray absorptiometry (DEXA), ultrasonography (US), and approaches for measuring sarcopenia have been developed for evaluating skeletal muscle mass in patients waiting for liver transplantation. In this present editorial for the special issue, we briefly reviewed the findings of studies using different imaging tools and approaches.

CT

Total psoas muscle area (TPMA)

Englesbe *et al.* (11) measured the TPMA at the level of the fourth lumbar vertebrae (L4). A total of 163 liver transplant recipients were included. Cox regression analysis showed that TPMA was significantly associated with post-transplantation mortality (when TPMA decreased 1,000 mm^2, hazard ratio =3.7, P<0.0001). Masuda *et al.* (12) measured the TPMA at the level of the third lumbar vertebrae (L3). A total of 204 liver transplant recipients were included. The diagnostic criteria for sarcopenia were defined: TPMA <800 cm^2 in male and <380 cm^2 in female. Multivariate analysis showed that only sarcopenia was an independent prognostic factor (hazard ratio =2.06, P=0.047).

Skeletal muscle index (SMI)

Montano-Loza *et al.* (13) measured skeletal muscle area (SMA) at the L4 level. Skeletal muscle index (SMI) was calculated using the formula: SMI = SMA/height^2. A total of 112 cirrhotic patients were included. The diagnostic criteria for sarcopenia were defined: SMI <52.4 cm^2/m^2 in male and <38.5 cm^2/m^2 in female. The results showed that sarcopenia was significantly associated with higher mortality (hazard ratio =2.11, P=0.02). Similarly, Tandon *et al.* (14) also measured SMA at the same level and calculated SMI in 142 liver transplant recipients. The diagnostic criteria for sarcopenia were the same as that by Montano-Loza *et al.* The results also showed that sarcopenia was a significant risk factor for mortality (hazard ratio =2.36, P=0.009).

Transversal psoas muscle thickness (TPMT)

Durand *et al.* (8) used the TPMT/height for evaluating sarcopenia in 562 patients waiting for liver transplantation. The results showed that TPMT/height might be a prognostic factor for waiting list mortality independently of MELD score.

MRI

In the study by Praktiknjo *et al.* (15), fat-free muscle area (FFMA) was measured by MRI and TPMT was measured by CT in 116 patients who had undergone transjugular intrahepatic portosystemic shunt (TIPS) placement. The results showed that patients with sarcopenia diagnosed by FFMA had a significantly worse 3-year survival. FFMA was significantly increased after TIPS procedure.

DEXA

In a study by Belarmino *et al.* (16), appendicular skeletal muscle mass (ASM) was measured by using DEXA in 144 male cirrhotic patients. Appendicular skeletal muscle index (ASMI) was calculated using the formula: ASMI = ASM/height^2. Nondominant handgrip strength (ND-HGS) was measured by using a digital dynamometer. The diagnostic criteria for sarcopenia were defined as follows: ASMI ≤7 kg/m^2 and ND-HGS ≤25 kg. Kaplan-Meier survival curve showed that sarcopenia was significantly associated with worse prognosis (P<0.001).

US

In a study by Tandon *et al.* (17), a total of 152 cirrhotic patients were included. The diagnostic criteria for sarcopenia were the same as the Montano-Loza's study. SMI was measured by using CT or MRI and right thigh muscle thickness was measured by using bedside US. The results showed that thigh muscle measured by US positively correlated with SMI.

Conclusions

Sarcopenia is an accurate and sensitive marker for evaluating malnutrition. Regardless of diagnostic methods and criteria, it is an independent prognostic factor in patients waiting for or undergoing liver transplantation. However, it remains uncertain about which imaging tool and method for diagnosing sarcopenia is the most optimal. First, no study compares the prognostic accuracy among CT, MRI, DEXA, and US. Second, MRI and US may avoid the risk of high radiation exposure, but specific methods for measuring sarcopenia based on MRI and US are insufficient. Third, it is not clear which plane and skeletal muscle is more reliable and accurate for reflecting the severity of sarcopenia and therefore for predicting outcomes. Fourth, the software for analyzing the images, such as SlimOmatic, MATLAB, ImageJ, and MITK, are expensive and complicated. A more simple and easy-to-perform method is needed.

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