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BRIEF REPORT

Moving computed tomography–based quantification of muscle mass to the mainstream: Validation of a web-based platform to calculate skeletal muscle index in cirrhosis

To the editor,

Muscle wasting carries important prognostic value in patients with chronic liver disease.[1] Abdominal computed tomography (CT) or magnetic resonance imaging taken at the third lumbar vertebrae (L3) is generally considered the gold standard modality to estimate muscle mass in cirrhosis.[2] It has advantages over other methods used to measure muscle in cirrhosis such as dual energy x-ray absorptiometry as it is not influenced by peripheral fluid retention.[3] However, barriers including cost and access to dedicated software for tissue segmentation and personnel training and the time required for analysis limit broader uptake in clinical practice. In decompensated cirrhosis, the inability to differentiate ascites from muscle based on Hounsfield units (HUs) can also reduce the reliability of automated segmentation of tissue by some software programs. To our knowledge, the between-program agreement of different software programs and the impact of ascites on muscle assessment have not been validated in cirrhotic cohorts. This comparative study aimed to assess clinician use of CT analytic morphomic programs in cirrhosis.

A total of 50 consecutive, single-slice, transverse CT scans taken at the L3 level in patients with cirrhosis enrolled in a clinical trial examining a novel sarcopenia therapy (ACTRN12618000802202) were analyzed by two nontechnically skilled clinicians (P.H. and M.C.) on validated software programs. The open-source, free, Web-based interface CoreSlicer[4] was compared with Tomovision sliceOmatic (Version 5.0; Toronto, Canada), one of the most widely used morphomic programs in recent hepatology literature.[5] The clinicians watched a 15-min tutorial on segmentation available at tomovision.com and were instructed to measure the total muscle area (TMA), subcutaneous fat area (SFA), and visceral fat area (VFA) on each program (Figure 1). No additional training was required to use CoreSlicer. Clinician 1 performed analysis on all studies on sliceOmatic followed by CoreSlicer, and Clinician 2 performed analysis on CoreSlicer followed by sliceOmatic. The clinicians were blinded to the data set.

Demarcation of tissue was semiautomatic with manual correction and based on established HU thresholds: TMA, −29 to 150; adipose tissue (VFA and SFA), −190 to −30. Patient height, sex, age, and the presence of ascites on lumbar CT imaging were recorded. Intraclass correlation coefficients (ICCs) and the Bland–Altman method were used to assess for interrater and between-software agreement. A κ statistic was used to determine the interrater reliability of the diagnosis of sarcopenia based on previously reported sex-specific cutoff values for TMA corrected for height.[1] Clinicians were asked to complete a system usability scale for each program at the conclusion of the study, with each system rated out of 100 for usability.[6] Approval for the clinical trial was obtained through the Austin Health Human Research ethics committee.

A total of 37 patients (74%) were male with a median age of 57 years (interquartile range, 52–63). Of the patients, 19 (38%) had ascites present on CT imaging. Interrater agreements for CoreSlicer and sliceOmatic are presented in Table 1. Between-program agreements showed excellent correlations for TMA (ICC, 0.97; 95% confidence interval [CI], 0.96–0.98), SFA (ICC, 1.00; 95% CI, 0.99–1.00), and VFA (ICC, 0.97; 95% CI, 0.96–0.98). Using the Bland–Altman method, there was minimal bias for between-program assessment of TMA (mean difference, 0.17cm^2; 95% limits of agreement, −12.90 to 12.55) and SFA (mean difference, 0.78; 95% limits of agreement, −13.06 to 14.62). However, bias was observed in VFA measurements (mean difference, 23.36; 95% limits of agreement, −15.41 to 66.13), with CoreSlicer recording on average higher VFA measurements than sliceOmatic (Figure 2). The diagnosis of sarcopenia based on skeletal muscle

Abbreviations: CI, confidence interval; CT, computed tomography; HU, Hounsfield unit; ICC, intraclass correlation coefficient; L3, third lumbar vertebrae; SFA, subcutaneous fat area; TMA, total muscle area; VFA, visceral fat area.

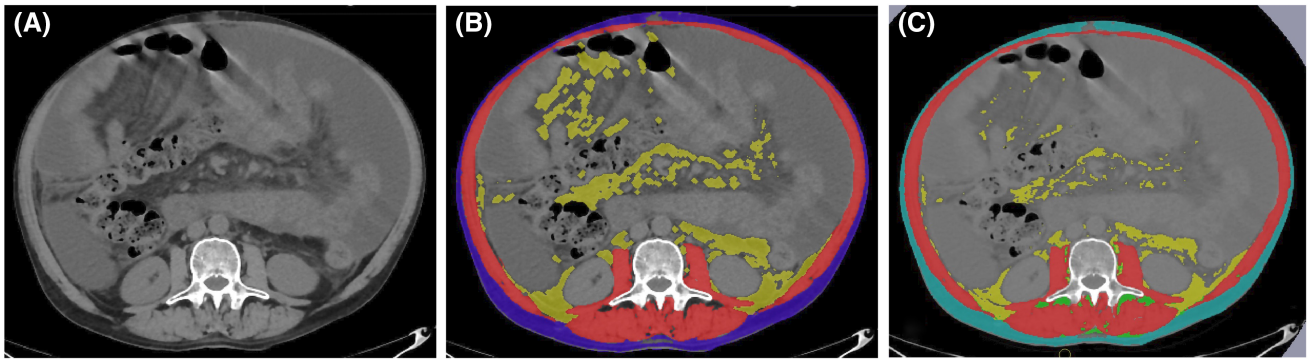

FIGURE 1 Segmentation of tissue on lumbar CT imaging in a patient with ascites (A) without tissue segmentation, (B) with tissue segmentation using CoreSlicer, and (C) with tissue segmentation using sliceOmatic software.

TABLE 1 Interrater agreement on CoreSlicer and sliceOmatic

	CoreSlicer		SliceOmatic	
	ICC	95% CI	ICC	95% CI
TMA	0.97	0.95–0.98	0.94	0.90–0.97
SFA	0.99	0.99–1.00	0.98	0.97–0.99
VFA	0.99	0.99–1.00	0.99	0.99–1.00

Abbreviations: CI, confidence interval; ICC, intraclass correlation coefficient; SFA, subcutaneous fat area; TMA, total muscle area; VFA, visceral fat area.

index (TMA/height^2) was consistent between raters using CoreSlicer (sarcopenia diagnosed in 27 vs. 29 patients; $\kappa = 0.84$, $p < 0.001$) and sliceOmatic (26 vs. 29 patients; $\kappa = 0.88$, $p < 0.001$) and between programs for each rater ($\kappa = 0.88$–1.00, $p < 0.001$). The presence of ascites on CT imaging did not reduce the interrater agreement for TMA (ICC, 0.96; 95% CI, 0.91–0.99) compared with those without ascites (ICC, 0.97; 95% CI, 0.94–0.99). Using the system usability scale, both programs were rated as Grade A (excellent) by both clinicians, with mean ratings of 87.5 for sliceOmatic and 95 for CoreSlicer.

CoreSlicer and sliceOmatic had excellent interrater and between-program agreement in measuring skeletal muscle area in a cirrhotic cohort when performed by clinicians. The presence of ascites does not reduce the interrater agreement in measuring TMA in decompensated liver disease. The discrepancy in VFA measurements may relate to differences in the segmentation process between the software, with CoreSlicer automating VFA measurement followed by manual correction and sliceOmatic relying on user selection of regions containing specific densities of tissue. For example, sliceOmatic may underestimate VFA between bowel loops compared with CoreSlicer as it relies on the user identifying these regions.

In conclusion, the accuracy and accessibility of the free, Web-based program CoreSlicer should improve the use of CT imaging to identify low muscle mass in patients with cirrhosis, although it remains a research tool that is not yet approved for clinical use. We also acknowledge that the routine use of abdominal CT solely for the diagnosis of sarcopenia is not recommended.[2] However, we foresee that improved access and usability of these programs may enable mainstream

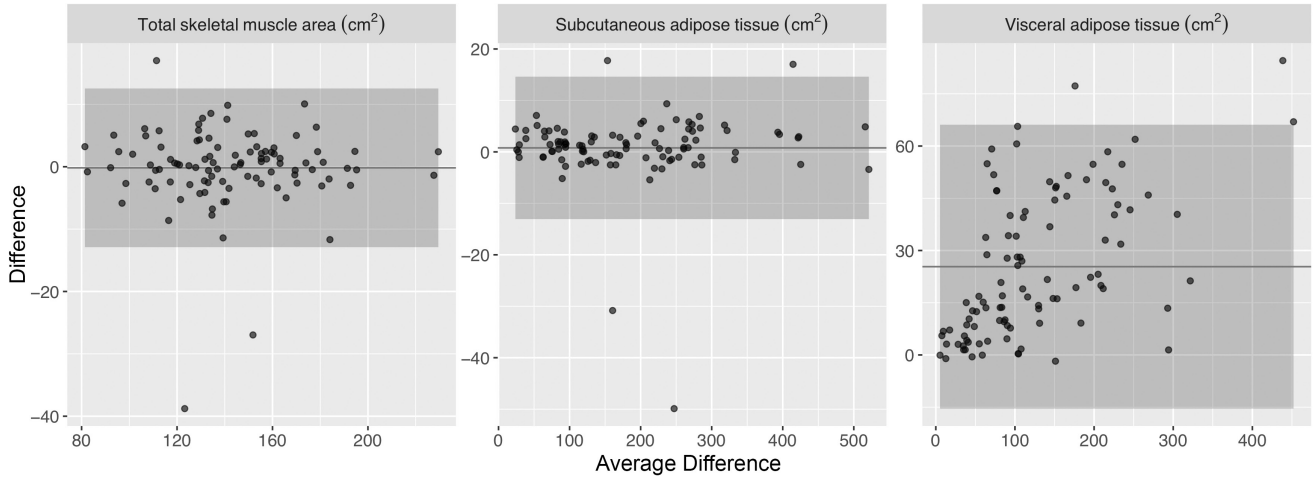

FIGURE 2 Bland–Altman plots demonstrating intersoftware agreement between CoreSlicer and sliceOmatic. Values of mean difference and 95% limit of agreement are reported in the text.

assessment of muscle mass in patients undergoing abdominal CT for clinical indications, such as during liver transplant assessment. The early identification of low muscle mass in this vulnerable group is critical to predict patients at risk of adverse outcomes and help guide therapies such as intensive nutritional support and may assist in prioritization for liver transplantation.[7]

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CONFLICT OF INTEREST

Nothing to report.

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