




Comparison of the Risk of Early Postoperative Infection and Length of Hospital Stay between Sarcopenic and Nonsarcopenic Adults Undergoing Live Donor Liver Transplantation Using Computed Tomography

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Abstract

Objectives Computed tomography (CT)-based sarcopenia assessment and the risk of early postoperative infection among adults undergoing live donor liver transplantation. This article also compares the postoperative length of hospital stay in sarcopenic and nonsarcopenic patients after live donor liver transplantation.

Materials and Methods Sixty live donor liver transplantation recipients undergoing abdominal CT scans were included during the period from April 2022 to February 2024. CT data was obtained via 128-slice Revolution Frontier CT by GE Healthcare. Individual vertebral levels were identified on CT scan and skeletal muscle cross-sectional areas were computed using MATLAB algorithms. SliceOmatic software aided in muscle area determination and L3 vertebra served as the reference for assessing abdominal muscles. Skeletal muscle index was derived by normalizing muscle area to height. Sex-specific sarcopenia cutoffs were applied based on CT findings. Postoperative care included surveillance for infections using blood culture positivity.

Results Note that 76.47% of the infected patients were sarcopenic while 23.53% were nonsarcopenic. Also, 32.56% of the noninfected patients were sarcopenic whereas 67.44% were nonsarcopenic (p -value = 0.003). Postop length of hospital stay in days showed a significant difference between the two groups ($p \leq 0.001$), with the sarcopenic group having the greatest median postop length of hospital stay.

Conclusion Pretransplant sarcopenia as determined by skeletal muscle index is associated with an increased risk of posttransplant infections in a group of patients undergoing liver transplantation as well as longer stay in hospital.

Keywords

- ▶ computed tomography
- ▶ infection
- ▶ live donor liver transplantation
- ▶ liver transplantation
- ▶ skeletal muscle area
- ▶ skeletal muscle index

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Introduction

Sarcopenia, characterized by low muscle function and mass, is a common yet underestimated complication of end-stage liver disease, affecting up to 70% of cirrhosis patients.¹ It results from an imbalance in muscle growth and breakdown, influenced by factors like proinflammatory cytokines and portal hypertension.² Sarcopenia significantly impacts clinical outcomes, including survival and quality of life, particularly in liver transplant candidates, where it is a major risk factor for posttransplant mortality and complications.³ Despite being linked to higher mortality, evidence suggests that reversing sarcopenia can improve survival rates. There is a pressing need for evidence-based strategies to mitigate perioperative risks in these vulnerable populations.⁴

Despite advances in surgical techniques and critical care, infection remains a significant cause of morbidity and mortality in liver transplantation (LT) patients, with over 50% developing posttransplant infections, primarily bacterial.⁵ The risk of infection is influenced by surgical complications and the level of immunosuppression. Infections typically occur in three phases: within the first month, from 1 to 6 months, and after 6 months posttransplant.⁶ Pre-LT sarcopenic assessment may enhance transplant outcomes by allocating resources to those with a higher chance of survival. Assessing candidates for LT poses challenges, particularly in determining those who would benefit most. Cross-sectional imaging, especially computed tomography (CT) scans at the L3 vertebra, is effective for diagnosing sarcopenia, a predictor of posttransplant outcomes, helping prioritize recipients with better survival potential.⁷

Materials and Methods

The study was conducted between April 2022 and February 2024, after getting ethical clearance from the institutional ethical committee. It included 60 adult live donor LT (LDLT) recipient patients referred to the department of radiology and imaging for abdominal CT. Patients received detailed procedure explanations after consent. The data and images were acquired by 128 slice Revolution Frontier CT, GE Healthcare.

LDLT recipients between the age group of 18 and 65 years were included in the study.

Exclusion criteria were patients showing overt signs of infection within 1 month before surgery, acute liver failure, and second liver transplant.

This study analyzed the cross-sectional area of the skeletal muscles at the third lumbar vertebral level (including psoas, erector spinae, quadratus lumborum, external oblique, internal oblique, and rectus abdominis) using CT scans of patients. As such, it provides a very good approximation of the skeletal muscle area of the whole body. The superior aspect of the L3 vertebral body was selected, and skeletal muscle borders were outlined using semiautomated MATLAB algorithms. SliceOmatic software was employed to quantify muscle areas, applying a specific attenuation filter by a trained radiologist. The study focused on calculating

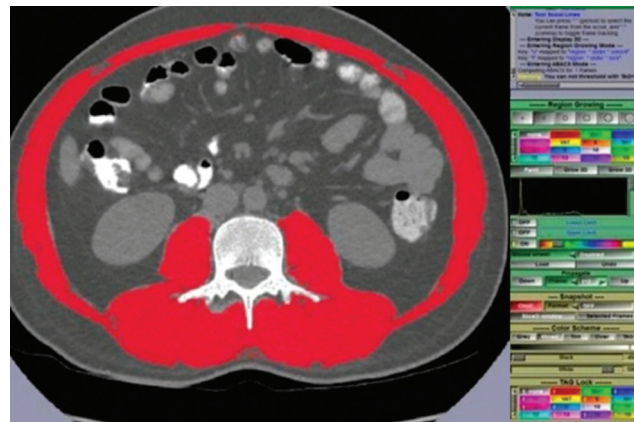


Fig. 1 All the abdominal muscles at the L3 level depicted using SliceOmatic.

normative indices for abdominal muscles at the L3 vertebra level, with the skeletal muscle index (SMI) determined by normalizing muscle area to height. Cutoffs for sarcopenia were established as $< 50 \text{ cm}^2/\text{m}^2$ for men and $< 39 \text{ cm}^2/\text{m}^2$ for women.⁸ Infection surveillance was done based on paired blood culture results on posttransplant patients who were febrile during hospital stays. Note that 8 mL blood was taken from suitable sites in BACTEC culture bottles while antibiotic sensitivity testing was done by automated method and Kirby–Bauer method. Aerobic incubation was done at 37°C for 5 days. We considered isolation of bacteria other than common skin contaminants within 15 days of LT to be blood culture positive (**Fig. 1**).

Statistical Analysis

Categorical variables were presented as number and percentages, while quantitative data were depicted as means \pm standard deviations (SDs) or medians with interquartile ranges (IQRs). The Shapiro–Wilk test assessed data normality. Statistical analysis involved independent *t*-tests for non-normally distributed quantitative variables. Fisher's exact test (in low expected counts) and chi-square test were used for qualitative variables. Analysis was conducted using SPSS software, version 25.0, by IBM, with a significance level set at $p < 0.05$ to identify meaningful differences.

Results

The mean (SD) of SMI in the sarcopenic group was 43.01 (4.99). The mean (SD) of SMI in the nonsarcopenic group was 51.40 (5.99). The median (IQR) of SMI in the sarcopenic group was 45.3 (37.4–47.05). The median (IQR) of SMI in the nonsarcopenic group was 53.9 (44.7–55.8). The SMI in the sarcopenic group ranged from 35.7 to 49.2. The SMI in the nonsarcopenic group ranged from 40.1 to 59.1 (**Tables 1 and 2**).

There was a significant difference between the two groups in terms of SMI ($p < 0.001$), with the median SMI being highest in the nonsarcopenic group (**Table 3 and Fig. 2**).

Strength of association (point biserial correlation) = 0.61 (large effect size)

Table 1 Summary table for association between sarcopenia and parameters

Parameters	Sarcopenia		p-Value
	Present(n = 27)	Absent(n = 33)	
Age (y)	40.00 ± 10.06	42.06 ± 10.09	0.243
Gender			0.419
Male	17 (63.0%)	24 (72.7%)	
Female	10 (37.0%)	9 (27.3%)	
Height (m)	1.70 ± 0.10	1.71 ± 0.08	0.599
SMA at L3 ^a	125.50 ± 25.65	151.31 ± 25.88	< 0.001
SMI ^a	43.01 ± 4.99	51.40 ± 5.99	< 0.001
Blood culture (positive) ^a	6 (22.2%)	3 (9.1%)	0.003
Day of culture positivity	8.33 ± 2.80	8.33 ± 5.86	1.000
Postop length of hospital stay (d) ^a	25.33 ± 3.56	19.52 ± 3.02	< 0.001

Abbreviations: SMA, skeletal muscle area; SMI, skeletal muscle index.

^aSignificant at $p < 0.05$.

Table 2 Comparison of SMI (cm^2/m^2) between nonsarcopenic and sarcopenic

SMI (cm^2/m^2)	Nonsarcopenic (n = 33)	Sarcopenic (n = 27)	Total	p-Value
Mean ± SD	51.4 ± 5.99	43.01 ± 4.99	47.63 ± 6.94	< 0.0001 ^a
Median (25th–75th percentile)	53.9 (44.7–55.8)	45.3 (37.4–47.05)	47.25 (42.775–54.275)	
Range	40.1–59.1	35.7–49.2	35.7–59.1	

Abbreviations: SD, standard deviation; SMI, skeletal muscle index.

^aIndependent *t*-test.

Table 3 Comparison of infection between nonsarcopenic and sarcopenic

Infection	Nonsarcopenic (n = 33)	Sarcopenic (n = 27)	Total	p-Value
Negative	29 (67.44%)	14 (32.56%)	43 (100%)	0.003 ^a
Positive	4 (23.53%)	13 (76.47%)	17 (100%)	
Total	33 (55%)	27 (45%)	60 (100%)	

^aFisher's exact test.

Fisher's exact test was used to explore the association between "sarcopenia" and "blood culture" as more than 20% of the total number of cells had an expected count of less than 5.

There was significant difference between the various groups in terms of distribution of blood culture ($p = 0.003$).

Note that 76.47% of the infected patients were sarcopenic while 23.53% were nonsarcopenic.

Note that 32.56% of the noninfected patients were found to be sarcopenic whereas 67.44% were nonsarcopenic (–Table 4 and –Fig. 3).

The mean (SD) of postop length of hospital stay (in days) in the sarcopenic group was 25.33 (3.56). The mean (SD) of postop length of hospital stay in the nonsarcopenic group was 19.52 (3.02). The median (IQR) of postop length of hospital stay in the sarcopenic group was 25 (23.5–28). The median (IQR) of postop length of hospital stay in the nonsarcopenic group was 19 (18–21). The postop length of hospital stay in the sarcopenic group ranged from 18 to 31.

The postop length of hospital stay in the nonsarcopenic group ranged from 15 to 27.

There was a significant difference between the two groups in terms of postop length of hospital stay ($p \leq 0.001$), with the median postop length of hospital stay being highest in the sarcopenic group.

Strength of association (point biserial correlation) = 0.67 (large effect size)

Discussion

Our research establishes a link between sarcopenia and a higher risk of infectious problems following LT. Similarly to previous studies, we found that in a group of patients receiving LT, pretransplant sarcopenia as assessed by SMI was linked to a higher risk of posttransplant infections. Furthermore, we saw that sarcopenic individuals spent longer days in the hospital following surgery.

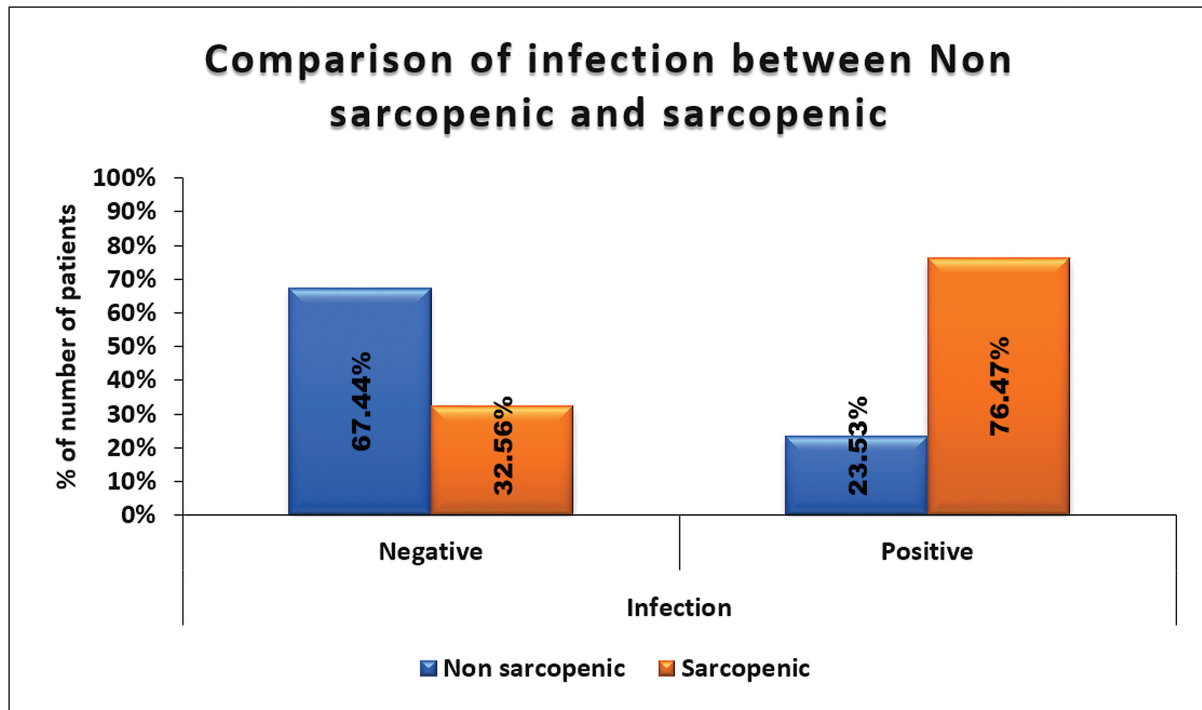


Fig. 2 Comparison of infection between nonsarcopenic and sarcopenic.

Table 4 Comparison of postop length of hospital stay (days) between nonsarcopenic and sarcopenic

Postop length of hospital stay (d)	Nonsarcopenic (n = 33)	Sarcopenic (n = 27)	Total	p-Value
Mean ± SD	19.52 ± 3.02	25.33 ± 3.56	22.13 ± 4.37	< 0.0001 ^a
Median (25th–75th percentile)	19 (18–21)	25 (23.5–28)	21 (18–25)	
Range	15–27	18–31	15–31	

Abbreviation: SD, standard deviation.

^aIndependent t-test.

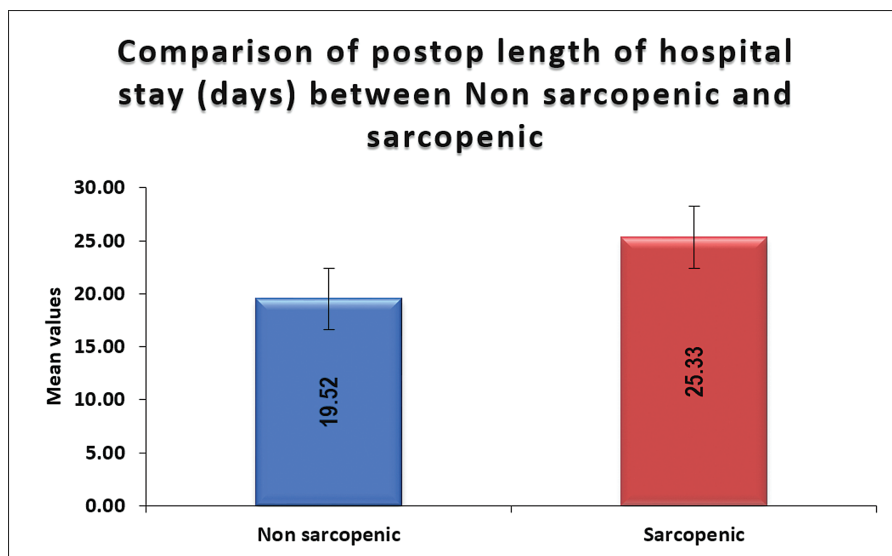


Fig. 3 Comparison of postop length of hospital stay (days) between nonsarcopenic and sarcopenic.

Note that 76.47% of the infected patients were sarcopenic while 23.53% were nonsarcopenic.

Also, 32.56% of the noninfected patients were sarcopenic whereas 67.44% were nonsarcopenic. Regarding infection, there was a significant difference ($p=0.003$) between the two groups.

In the sarcopenic group, the mean (SD) of postop length of hospital stay was 25.33 (3.56) whereas in the nonsarcopenic group, the mean (SD) of postop length of hospital stay was 19.52 (3.02).

Postop length of hospital stay showed a significant difference between the two groups ($p \leq 0.001$), with the sarcopenic group having the greatest median postop length of hospital stay.

The sarcopenic patients' SMI mean (SD) was 43.01 (4.99). In the nonsarcopenic group, the SMI mean (SD) was 51.40 (5.99). The nonsarcopenic patients' SMIs varied from 40.1 to 59.1. The SMIs of the two groups differed significantly ($p \leq 0.001$), with the nonsarcopenic group having the highest median SMI.

Similar to our study, sarcopenia was observed by Montano-Loza et al⁵ to be associated with longer hospital stays and a higher risk of bacterial infection following LT in comparison to LT recipients who did not have sarcopenia. In this study, the hospital stay after LT (40 ± 4 vs. 25 ± 3 days, $p=0.005$) and the intensive care unit stay (12 ± 2 vs. 6 ± 1 days, $p=0.001$) were longer for sarcopenic patients versus nonsarcopenic patients. Also, they found that sarcopenia was associated with higher rates of bacterial infections, which were related to links between malnutrition and/or sarcopenia and impaired immunity. Bacterial infections within the first 90 days after LT were more frequent for sarcopenic patients versus nonsarcopenic patients (26% vs. 15%, $p=0.04$), and there were no significant differences in the frequencies of viral (3% vs. 4%, $p=0.5$) infections.

Compared with other techniques like bioelectrical impedance or anthropometric measurements, the CT-based assessment of sarcopenia in this study offered a more accurate and objective determination of muscle mass. Prior research has shown that CT-derived metrics, including total skeletal muscle mass, rectus femoris cross-sectional area, and psoas muscle area, are accurate predictors of poor surgical outcomes and sarcopenia.

Evidence-based strategies are still desperately needed to lower perioperative risk in populations that are already at risk. Leaders in medicine and policymaking continue to pay close attention to these challenges. Finding patients on the LT list who are more likely to have postoperative morbidity and death is essential to achieving the best results in terms of organ allocation, recipient-to-graft matching, and candidate selection. Sarcopenia is a reliable indicator of susceptibility that is strongly associated with a higher risk of death and morbidity in a variety of patient and procedure populations.

Clinicians can identify individuals at higher risk for posttransplant infections by using CT imaging in the preoperative evaluation of LDLT candidates. This enables more focused therapies, such as physical rehabilitation, nutritional optimization, or more extensive posttransplant care. By detect-

ing sarcopenia before surgery, clinicians can foresee the increased risk of infection and take precautions, including closer observation, early antibiotic prophylaxis, or better postoperative care, to reduce the risk of infection.

The risk of posttransplant infections may be reduced with early detection of sarcopenia, which could result in tailored management plans targeted at enhancing physical strength and nutritional status before surgery.

Our study further supports the growing evidence linking sarcopenia to increased infection risk in LT, especially in the early posttransplant period. For LT recipients, infectious complications are important causes of morbidity and death; more research is needed to determine whether sarcopenia may have an impact on infection-related outcomes. Developing effective countermeasures for risk reduction and management will require improving our understanding of how sarcopenia affects a patient's risk and subsequent consequences.

Our study has some limitations—being a single-center study, it needs to be validated in larger populations to ascertain the true prevalence of sarcopenia. We did not attempt to investigate differences in microbiology or the potential effects of antimicrobial treatment. The study did not include data on key factors such as donor and graft characteristics, surgical factors, and nutritional interventions, which could influence outcomes or serve as confounding factors—for example, prolonged cold ischemia time, postoperative complications, and recipient comorbidities like malnutrition, diabetes, and obesity may increase the risk of posttransplant infections. Various indications of liver transplant—acute liver failure, chronic liver disease, malignancy, and metabolic and vascular disorders—may influence posttransplant infection rates. However, this study focused solely on recipients with chronic liver disease.

Potential confounding variables and further explanations for the increased mortality rate in sarcopenic patients should be investigated in future research.

Conclusion

This study demonstrated a significant association between pretransplant sarcopenia, as measured by SMI, and a higher risk of early posttransplant infections in LDLT recipients. The findings suggest that patients with reduced muscle mass prior to surgery face greater susceptibility to complications after the procedure. Additionally, our observations indicated that those identified as sarcopenic not only experienced a higher incidence of infections but also required extended hospitalization periods postsurgery. This prolonged stay could be attributed to the challenges in recovery faced by sarcopenic individuals, underscoring the potential importance of assessing and addressing muscle health in patients awaiting LT.

Ethical Approval

The study was performed conforming to the Helsinki Declaration of 1975, as revised in 2000 and 2008 concerning human and animal rights, and the authors

followed the policy concerning informed consent as shown on Springer.com.

Patients' Consent

Informed patient consent was taken from the study subjects to enroll them in the study.

Conflict of Interest

None declared.

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