Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Preoperative CT-Based Segmentation of Psoas Muscle Area and Subcutaneous Fat Tissue: Associations With Perforation and Length of Hospital Stay in Pediatric Appendicitis

Celal Tacyildiz

drcelaltacyildiz@gmail.com

Elazig Fethi Sekin City Hospital

Suna Yergin Tacyildiz

Elazig Fethi Sekin City Hospital

Research Article

Keywords: Psoas muscle area (PMA), Psoas muscle attenuation (HU), Subcutaneous fat tissue, Pediatric Appendicitis, CT-Based Segmentation

Posted Date: February 27th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-8941099/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

Background

Acute appendicitis is a leading cause of emergency abdominal surgery in children, and predicting postoperative length of hospital stay (LOS) is important for prognosis and resource planning. This study aims to assess the associations of LOS and appendiceal perforation with preoperative CT-derived measurements of psoas muscle area, attenuation, and subcutaneous fat tissue in children with appendicitis.

Methods

This retrospective study comprised 170 pediatric patients (< 18 years) surgically diagnosed with appendicitis between January 2022 and October 2025. At the L3-L4 intervertebral disc level, bilateral psoas muscles and subcutaneous adipose tissue were segmented using 3D Slicer. Right, left, and total psoas muscle area (tPMA), psoas muscle mean attenuation, tPMA Z-scores, subcutaneous fat tissue, inflammatory markers (WBC, neutrophils, and CRP), maximum appendiceal diameter, the presence of an appendicolith, appendiceal perforation status, surgical approach, and LOS were recorded.

Results

Of 170 patients, 51 had perforated appendicitis. Perforation correlated with elevated WBC/neutrophil/CRP levels, increased appendiceal max diameter, a higher incidence of appendicolith, reduced psoas muscle mean attenuation, and extended LOS (median 6.0 vs. 3.0 days; $p < 0.001$). CRP showed a moderate correlation with LOS ($\rho = 0.435$), while WBC ($\rho = 0.302$), neutrophils ($\rho = 0.356$), appendiceal max diameter ($\rho = 0.233$), and psoas muscle mean attenuation ($\rho = -0.208$) showed weak correlations. In multivariable negative binomial regression, perforation (IRR 2.287, $p < 0.001$) and neutrophil count (IRR 1.018 per 1×10^9/L, $p = 0.039$) independently predicted extended LOS.

Conclusions

There is an association between post-appendectomy LOS and CT-derived psoas muscle attenuation, supporting segmentation-based prognostication and promising future studies.

Introduction

Acute appendicitis is one of the most common causes of emergency abdominal surgery in children. Obstruction associated with lymphoid hyperplasia is the most common cause of acute appendicitis in children. Clinical history, physical examination, laboratory values, and imaging play a crucial role in diagnosis. Ultrasound is primarily used for diagnosis; CT may be used when ultrasound is inadequate

(e.g., obesity, atypical location, user- or patient-related factors, etc.). MRI is another imaging method used in pregnant women and children. Uncomplicated acute appendicitis can be treated with antibiotics. Laparoscopic and open surgical procedures can treat acute appendicitis with complications or cases that do not respond to antibiotic treatment. Laparoscopic appendectomy is currently preferred because it is less invasive and is generally associated with faster recovery and shorter hospitalization [1, 2].

The length of hospital stay (LOS) following appendectomy surgery is important in terms of patient health and comfort, reducing costs, and increasing hospital bed utilization. According to studies, high WBC and CRP values (indicating severe inflammation), complicated appendicitis (perforated, gangrenous, etc.), the length of time between the onset of the disease and surgery, the presence of appendicolith, and increased surgery duration are factors that prolong hospital stay [3]. Additionally, studies indicate that the surgical method used to repair the stump (e.g., silk ligation, Endoloop ligation, Hem-o-lok vascular clamp occlusion, and endo-gastrointestinal anastomosis (Endo-GIA) stapling and closure) and the class of antibiotics used also affect the length of hospital stay [3–5].

Sarcopenia is a decrease in muscle mass and function. It is an important indicator of frailty [6]. Sarcopenia is one of the important indicators of morbidity and mortality in the elderly, chronic patients, and cancer patients. There are also studies showing that sarcopenia negatively affects the outcome of surgical procedures [7]. In children, body composition (adipose tissue, skeletal muscle, etc.) may be an important predictor of various health problems [8]. Skeletal muscle growth during childhood is influenced by factors such as maternal nutrition during pregnancy, genetic factors, nutritional intake, physical activity, cardiovascular and metabolic diseases, chronic diseases, and hormones [9]. It is difficult to assess skeletal muscle mass and function in children. This is because normative data for evaluating the results of methods measuring body muscle mass and function in children of different age groups are limited to a few studies. In our study, we used the normative data obtained by Aydın T. and colleagues in their research [10]. Muscle mass can be measured using dual-energy X-ray absorptiometry (DEXA), bioelectrical impedance analysis (BIA), and body composition analysis [7]. Currently, cross-sectional imaging (CT and MRI) has demonstrated that measurements of abdominal muscle and fat areas in axial planes reliably reflect total body muscle and fat mass [8, 11]. The skeletal muscle area measured by CT scan at the L3-L4 vertebra level is generally accepted as a reliable indicator of total muscle volume [12]. These measurements can be obtained manually, using semi-automatic and fully automatic deep learning slice-based muscle segmentation.

The aim of this study is to investigate the association between postoperative LOS and preoperative CT-derived measurements—obtained at the L3-L4 intervertebral disc level, using semi-automatic and manual segmentation—including psoas muscle area, psoas muscle density, and subcutaneous adipose tissue area, as well as laboratory parameters and surgical approach, in pediatric patients diagnosed with appendicitis who underwent appendectomy.

Materials and methods

Study Design

Our study was conducted retrospectively between January 2022 and October 2025 and included patients under the age of 18 who underwent appendectomy surgery. The study was conducted in accordance with the Helsinki Declaration (as revised in 2013) and was approved by the Clinical Research Ethics Committee of our hospital with a waiver of consent (E-95531838-050.99-156362).

Study Population

Between January 2022 and October 2025, 784 children with appendicitis underwent appendectomy at our hospital. Our inclusion criteria were surgical confirmation of appendicitis and age < 18 years, with an available contrast-enhanced abdominal CT scan obtained within 48 hours before surgery when ultrasonography was non-diagnostic or when clinical suspicion persisted. Our exclusion criteria were contrast-enhanced abdominal CT scans with non-diagnostic motion artifacts, patients who underwent an additional surgical procedure concomitantly with appendectomy, children with malignancy or chronic disease, and cases with missing inflammatory marker data. Thus, 170 patients were included in this retrospective study.

CT acquisition protocols

CT images were obtained using a Toshiba Alexion 16-slice CT scanner. Intravenous contrast material was administered at a dose of 1 mL/kg at an injection rate of 0.5–1.5 mL/s. CT images were obtained in the portal venous phase with a slice thickness of 3 mm approximately 60 seconds after intravenous contrast administration. For children weighing less than 15 kg, the CT settings were 80 kV and 30 mA; for 16–30 kg, 100 kV and 30 mA; for 31–45 kg, 100 kV and 30 mA; and for more than 45 kg, 120 kV and 50 mA.

CT-Derived Body Composition Measurements

The patients' CT images were obtained in the picture archiving and communication system (PACS). CT images in the digital imaging and communications in medicine (DICOM) format were opened in 3D Slicer version 5.8.1 (https://www.slicer.org/). The “Segment Editor,” “Segment Statistics,” and “Segment Cross-Section Area” modules in the 3D Slicer application were used. At the axial slice corresponding to the L3-L4 intervertebral disc level, the right and left psoas muscles were manually segmented from a single CT slice using the “Segment Editor” module. On the same CT slice, automatic segmentation was performed in the “Segment Editor” module for subcutaneous fat tissue segmentation using threshold values of -190 and − 30 HU. Visceral/intramuscular adipose tissue and regions erroneously segmented by 3D Slicer were manually removed, thereby completing the semi-automated segmentation process. After segmenting the psoas muscle and subcutaneous fat tissue axial slice at the L3-L4 intervertebral disc level, the average psoas muscle HU value, right and left psoas muscle areas, total psoas muscle area

(tPMA), and subcutaneous fat tissue areas were measured using the “Segment Statistics” and “Segment Cross-Section Area” modules.

Maximum appendiceal diameter was measured on axial images (outer wall to outer wall) at the most distended segment; appendicolith was defined as an intraluminal calcified focus with attenuation higher than adjacent soft tissue. Perforation status was determined based on operative findings, defined as a visible appendiceal wall defect with fecalith/spillage and/or purulent peritonitis, as documented in the surgical report. Whether the surgery was laparoscopic or laparotomy was recorded by checking the surgical notes.

The LOS, intensive care unit requirement, postoperative oral intake day, presence of postoperative complications, and inflammatory markers were recorded for all patients.

tPMA Z-scores were calculated based on the reference values reported by Aydın T et al. in their study establishing normative data for abdominal skeletal muscle compartments in Turkish children [10]. Segmentation and imaging measurements were performed by two radiologists (C.T. and S.Y.T., with 5 and 6 years of experience in abdominal imaging), blinded to clinical outcomes (LOS and perforation status). For interobserver analysis, 35 cases were randomly selected and re-segmented independently by the second reader. Intraclass correlation coefficients were calculated using a two-way random-effects model with absolute agreement (ICC[2, 1]).

Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics, Version 28 (IBM Corp., Armonk, NY, USA). Normality of continuous variables was assessed using the Shapiro–Wilk test. As the majority of continuous variables were not normally distributed, continuous data are presented as median (IQR [25th–75th percentiles]) and were compared between groups using the two-sided Mann–Whitney U test. Categorical variables are summarized as counts and percentages and were compared using the Pearson chi-square test or Fisher’s exact test, as appropriate.

Associations between length of hospital stay (LOS) and individual continuous predictors were evaluated using two-sided Spearman’s rank correlation (ρ). Where multiple simultaneous hypothesis tests were performed, multiplicity was controlled using the Benjamini–Hochberg false discovery rate (FDR) procedure, and FDR-adjusted q-values are reported; statistical significance for these analyses was defined as $q < 0.05$.

LOS was analyzed as count data. Overdispersion was assessed by fitting a Poisson model and examining dispersion indices, including the variance-to-mean ratio and the Pearson chi-square statistic divided by degrees of freedom (χ^2/df). Because overdispersion was present (variance-to-mean ratio = 2.26; Pearson $\chi^2/df = 2.26$), negative binomial regression models were used instead of Poisson regression. Univariable negative binomial models were first fitted for each candidate predictor, followed

by a multivariable negative binomial model including clinically relevant covariates. Effect estimates are reported as incidence rate ratios (IRR) with 95% confidence intervals (CI) and two-sided p-values.

Results

Our study included a total of 170 patients under the age of 18 who underwent appendectomy surgery, comprising 119 cases of non-perforated appendicitis and 51 cases of perforated appendicitis. Of the patients included in our study, 58 (34.1%) were female and 112 (65.9%) were male. The median age of the female patients was 13.96 [10.46–15.90] years, and the median age of the male patients was 13.21 [11.08–15.77] years. The distribution of patients in our study according to age groups is as follows: 0–5 years: 2 individuals (1.2%); 5–10 years: 29 individuals (17.1%); 10–15 years: 85 individuals (50.0%); 15–18 years: 54 individuals (31.8%).

In female patients, subcutaneous fat tissue and subcutaneous fat tissue/total psoas muscle area were significantly higher than in male patients, while total psoas muscle area was significantly higher in male patients. There was no significant difference in psoas muscle attenuation based on gender (Table 1).

Table 1
Median CT segmentation values for female and male and their statistical comparison

Variable	Female (median [IQR])	Male (median [IQR])	p-value (MWU)	q-value (FDR)
Right psoas muscle area (mm²)	626.5 [508.3–721.0]	740.0 [547.3–1029.0]	< 0.001	0.001
Left psoas muscle area (mm²)	616.5 [482.8–720.8]	719.0 [547.5–1047.8]	< 0.001	< 0.001
Total psoas muscle area (mm²)	1244.0 [996.8–1421.3]	1440.0 [1116.3–2137.8]	< 0.001	< 0.001
Subcutaneous fat tissue (mm²)	7281.8 [4430.5-15789.7]	3070.3 [1726.6–5971.8]	< 0.001	< 0.001
Subcutaneous fat tissue / Total psoas muscle area	6.35 [4.03–12.10]	2.20 [1.40–4.30]	< 0.001	< 0.001
tPMA Z-score	-0.38 [-0.96–0.14]	-0.30 [-0.78–0.24]	0.442	0.442
Psoas muscle mean attenuation (HU)	59.1 [54.6–62.0]	60.3 [56.2–63.9]	0.096	0.112
Data are presented as median (interquartile range). The Mann-Whitney U test was used to compare continuous variables between the two independent groups. To correct for multiple testing, q-values were adjusted using the Benjamini-Hochberg False Discovery Rate (FDR) method for 7 comparisons.				
tPMA Z-score, total muscle area Z-score				

In the comparison of non-perforated and perforated appendicitis groups, significant differences were observed in the variables WBC, neutrophils, CRP, appendix max diameter, appendicolith present, psoas muscle mean attenuation (HU), and LOS (Table 2). Age (years) was 13.25 [11.02–15.83] overall, 13.25 [11.04–15.88] in the non-perforated group, and 13.25 [11.00–15.33] in the perforated group (Table 2).

Table 2
Clinical and CT segmentation values according to non-perforated and perforated appendicitis groups in the study population

Variable	Non-perforated (n = 119) (median [IQR])	Perforated (n = 51) (median [IQR])	p-value	q-value (FDR)
Age (years)	13.25 [11.04–15.88]	13.25 [11.00–15.33]	0.662	0.662
WBC (×10⁹/L)	14.5 [12.0–17.0]	17.0 [13.4–20.4]	0.001	0.004
Neutrophils (×10⁹/L)	11.3 [8.8–14.2]	14.2 [11.5–18.0]	< 0.001	0.002
CRP (mg/L)	11.0 [2.3–35.5]	94.8 [25.3–144.2]	< 0.001	< 0.001
Appendix max diameter (mm)	8.7 [7.1–10.0]	11.0 [9.2–12.4]	< 0.001	< 0.001
Male sex	73 (61.3%)	39 (76.5%)	0.077	0.144
Appendicolith present	38 (31.9%)	29 (56.9%)	0.003	0.007
Right psoas muscle area (mm²)	686.0 [545.0–934.0]	683.0 [504.0–852.0]	0.621	0.662
Left psoas muscle area (mm²)	683.0 [549.5–938.5]	679.0 [512.0–838.0]	0.377	0.471
Total psoas muscle area (mm²)	1370.0 [1099.5–1857.0]	1348.0 [1008.5–1719.5]	0.540	0.624
Subcutaneous fat tissue (mm²)	4319.1 [2518.2–11774.7]	3435.4 [1650.9–10594.8]	0.170	0.254
Subcutaneous fat tissue / Total psoas muscle area	3.40 [2.05–8.00]	2.70 [1.40–8.45]	0.273	0.373
tPMA Z-score	-0.11 [-0.82–0.57]	-0.41 [-1.04–0.05]	0.156	0.255
Psoas muscle mean attenuation (HU)	60.4 [56.4–64.2]	58.0 [53.0–61.0]	0.018	0.038
LOS (days)	3.0 [2.0–3.0]	6.0 [5.5–8.0]	< 0.001	< 0.001

Data are presented as median (interquartile range) or number (percentage). Continuous variables were compared using the Mann-Whitney U test, and categorical variables using the chi-square or Fisher's exact test. To correct for multiple testing, q-values were adjusted using the Benjamini-Hochberg False Discovery Rate (FDR) method for 15 comparisons.

WBC, white blood cell; CRP, C-reactive protein; tPMA Z-score, total muscle area Z-score; LOS, length of hospital stay

Spearman correlation analysis between each continuous variable and LOS demonstrated a moderate correlation with CRP and weak correlations with WBC, neutrophil count, maximum appendiceal diameter, and psoas muscle mean attenuation (Table 3). After FDR adjustment, WBC, neutrophil count, CRP,

appendix maximum diameter, and psoas muscle mean attenuation remained statistically significant ($q < 0.05$).

Table 3
The relationship between single continuous variables and length of hospital stay (LOS)

Variable	Spearman ρ	p-value	q-value (FDR)
Age (years)	-0.073	0.346	0.377
WBC (×10⁹/L)	0.302	< 0.001	< 0.001
Neutrophils (×10⁹/L)	0.356	< 0.001	< 0.001
CRP (mg/L)	0.435	< 0.001	< 0.001
Appendix max diameter (mm)	0.233	0.002	0.007
Right psoas muscle area (mm²)	-0.101	0.190	0.254
Left psoas muscle area (mm²)	-0.126	0.102	0.205
Total psoas muscle area (mm²)	-0.113	0.141	0.242
tPMA Z-score	-0.107	0.164	0.246
Psoas muscle mean attenuation (HU)	-0.208	0.006	0.016
Subcutaneous fat tissue (mm²)	-0.075	0.331	0.377
Subcutaneous fat tissue / Total psoas muscle area	-0.013	0.867	0.867
Associations between LOS and each continuous variable were assessed using two-sided Spearman's rank correlation (ρ). P-values were adjusted for multiple testing using the Benjamini–Hochberg false discovery rate (FDR) procedure (m = 12), and FDR-adjusted q-values are reported.			
WBC, white blood cell; CRP, C-reactive protein; tPMA Z-score, total muscle area Z-score			

In the univariable negative binomial regression analysis performed to predict LOS, the variables WBC, neutrophil count, CRP, appendix maximum diameter, psoas muscle mean attenuation, presence of perforation, and surgical approach (laparoscopy vs laparotomy) were significant (Table 4).

Table 4
Univariable negative binomial regression analysis in predicting length of hospital stay (LOS)

Predictor	IRR	95% CI	p-value
Age (per 1 year)	1.006	0.974–1.039	0.700
WBC (×10⁹/L) (per 1)	1.036	1.016–1.056	< 0.001
Neutrophil (per 1×10⁹/L)	1.047	1.026–1.068	< 0.001
CRP (mg/L) (per 10)	1.039	1.025–1.053	< 0.001
Appendix max diameter (mm) (per 1)	1.061	1.022–1.102	0.002
Male sex (vs Female)	1.095	0.883–1.358	0.408
Appendicolith present (vs absent)	1.160	0.945–1.424	0.156
Total psoas muscle area (per 100 mm²)	0.996	0.978–1.013	0.617
Subcutaneous fat tissue (mm²) (per 1000 mm²)	0.998	0.984–1.012	0.747
Subcutaneous fat tissue / Total psoas muscle area (per 1)	0.999	0.980–1.018	0.894
tPMA Z-score (per 1)	0.973	0.852–1.110	0.680
Psoas muscle mean attenuation (HU) (per 10)	0.836	0.700–0.998	0.048
Perforation present (vs absent)	2.557	2.175–3.005	< 0.001
Laparoscopy (vs Laparotomy)	0.756	0.618–0.925	0.007

Univariable associations with length of hospital stay (LOS) were evaluated using negative binomial regression models. Results are reported as incidence rate ratios (IRR) with 95% confidence intervals (CI) and two-sided p-values; continuous predictors were scaled as indicated in the table.

WBC, white blood cell; CRP, C-reactive protein; tPMA Z-score, total muscle area Z-score

In the multivariable negative binomial regression analysis performed to predict LOS, neutrophil count and the presence of perforation were significant (Table 5).

Table 5
Multivariable negative binomial regression analysis in predicting length of hospital stay (LOS)

Predictor	IRR	95% CI	p-value
Neutrophil (per 1×10⁹/L)	1.018	1.001–1.036	0.039
CRP (mg/L) (per 10)	1.008	0.996–1.021	0.186
Appendix max diameter (mm) (per 1)	0.990	0.960–1.022	0.539
Psoas muscle mean attenuation (HU) (per 10)	1.014	0.875–1.175	0.857
Perforation present (vs absent)	2.287	1.880–2.783	< 0.001
Laparoscopy (vs Laparotomy)	0.865	0.732–1.022	0.089

Length of hospital stay (LOS) was modeled using multivariable negative binomial regression (log-link). Results are presented as incidence rate ratios (IRR) with 95% confidence intervals (CI) and two-sided p-values. Continuous predictors were scaled as shown in the table (CRP per 10 mg/L and psoas attenuation per 10 HU)

Interobserver agreement

Using ICC(2,1), interobserver agreement was good for the right psoas area (ICC = 0.82; 95% CI, 0.65–0.89), left psoas area (ICC = 0.83; 95% CI, 0.72–0.90), total psoas area (ICC = 0.83; 95% CI, 0.69–0.90), tPMA Z-score (ICC = 0.83; 95% CI, 0.70–0.90), and psoas muscle mean attenuation HU (ICC = 0.80; 95% CI, 0.69–0.85). Agreement was excellent for subcutaneous fat tissue (ICC = 0.999; 95% CI 0.998–0.999) and for the subcutaneous fat tissue-to-total psoas area ratio (ICC = 0.934; 95% CI 0.907–0.957). All ICC values were statistically significant ($p < 0.001$).

Discussion

Recently, numerous studies have been conducted measuring the psoas muscle area and average psoas muscle density at the L3-L4 intervertebral disc level in CT scans and investigating whether these have prognostic value. In children, there are no single standardized reference values for psoas muscle areas for girls and boys comparable to those used in adults. This fact has led to the establishment of age- and sex-specific reference values for psoas muscle areas in the pediatric population and to the calculation of tPMA Z-scores. Numerous studies have been conducted to calculate the tPMA Z-score [13–17].

Being able to predict the LOS for pediatric patients diagnosed with appendicitis preoperatively plays a critical role both in terms of the patient's prognosis and in terms of predicting and managing healthcare expenditures.

In our study, subcutaneous fat area and the subcutaneous fat area-to-total psoas muscle area ratio were significantly higher in female patients than in male patients, whereas total psoas muscle area was

significantly higher in male patients, consistent with the study by Samim et al. (Table 1) [18].

There were no significant differences in age, gender, tPMA, tPMA Z-score, subcutaneous fat tissue/total psoas muscle area ratio, and subcutaneous fat tissue area values between patient groups with perforated and non-perforated appendicitis (Table 2). tPMA, tPMA Z-score, and subcutaneous fat tissue were not significant predictors of LOS in the Spearman's correlation analysis, and univariable regression analysis likewise showed no significant correlations between LOS and these variables (Table 3 and Table 4). The absence of a significant association between tPMA and tPMA Z-score and LOS may be explained by the characteristics of our cohort, which consisted of previously healthy children presenting to the emergency department with abdominal pain and without any known chronic disease or malignancy prior to symptom onset. In many pediatric studies in which tPMA was measured, a tPMA Z-score below − 2 has been defined as sarcopenia [19–21]. In our study cohort, only 1 of 170 patients had a tPMA Z-score below − 2. Due to the significantly low number of sarcopenic patients, we believe that we could not find a meaningful relationship between LOS and tPMA Z-score in our study.

The mean HU values of the psoas muscle were significantly lower in patients with perforated appendicitis compared to those without perforation, suggesting lower muscle quality and a possible association with a tendency toward complicated disease (Table 2). The mean HU values of the psoas muscle showed a weak correlation with LOS (Table 3). Additionally, although the psoas muscle HU mean had a significant relationship with LOS in the univariate negative binomial regression analysis, this significant relationship was lost in the multivariate negative binomial regression analysis (Table 4 and Table 5). These results are important in that, among previously healthy pediatric patients without chronic disease, psoas muscle mean density—rather than tPMA, tPMA Z-score, or subcutaneous fat tissue area—appears to be associated with LOS and to discriminate appendiceal perforation. This situation showed that, apart from psoas muscle volume, the average density of the muscle, i.e., muscle quality, plays an important role in children. In addition, several studies supporting our findings have emphasized that muscle density may be more important than muscle index in predicting prognosis [22, 23].

There are numerous studies in the literature in which mean muscle density has been assessed in addition to muscle area measurements. In the study by Yuan et al., muscle size and density measured at the T4 and T10 levels were shown to be reduced in children with osteogenesis imperfecta compared with the control group [24]. Hou et al. demonstrated that the psoas muscle index and muscle attenuation were positively correlated with functional status in patients with degenerative lumbar spinal stenosis [25]. Di Cola et al. conducted a multicenter study in patients with cirrhosis and reported that the 1-year cumulative mortality rate in patients with sarcopenia plus myosteatosis or isolated myosteatosis was more than twice that observed in patients with isolated sarcopenia. According to this study, myosteatosis—whether accompanied by sarcopenia or not—was significantly associated with worse outcomes in patients with cirrhosis [22]. According to the study by Yamashita et al., in patients undergoing cardiac surgery, psoas muscle attenuation was a significant indicator of poor muscle function and mortality, whereas the skeletal muscle index—calculated by dividing psoas muscle area by height squared—was not significantly associated with these outcomes [23].

In multivariate negative binomial regression analysis, neutrophil count and the presence of appendiceal perforation were significantly associated with LOS (Table 5). This finding is important because it highlights the critical role of perforation in determining patient prognosis.

This study has several limitations, including the absence of data on height, weight, and BMI, precluding calculation of the psoas muscle index (tPMA/height²), as well as its single-center design. Finally, mean psoas muscle HU values on contrast-enhanced CT may be influenced by acquisition parameters and contrast timing. Therefore, our findings should be interpreted as an association rather than definitive evidence of myosteatosis, and protocol-standardized prospective studies are warranted.

Conclusion

Psoas muscle attenuation was lower in perforated cases and weakly correlated with LOS; however, in multivariable regression modeling, perforation and neutrophil count were the independent predictors. However, given the potential impact of numerous confounding factors on LOS, further comprehensive studies are warranted.

Abbreviations

CRP
C-reactive protein
FDR
False discovery rate
ICC
Intraclass correlation coefficient
IQR
Interquartile range
IRR
Incidence rate ratio
LOS
Length of hospital stay
MWU
Mann–Whitney U test
NB
Negative binomial
tPMA
Total psoas muscle area
WBC
White blood cell

Declarations

Author Contribution

Concept and study design: C.T. Data collection: C.T. and S.Y.T. Data analysis and interpretation: C.T. and S.Y.T. Manuscript writing: C.T.All authors reviewed the manuscript and approved the final version for publication.

Data Availability

The authors of this manuscript confirm that the data supporting the results of this study are available within this manuscript. Additional details are available on reasonable request.

References

1. Borruel Nacenta S, Ibáñez Sanz L, Sanz Lucas R et al. Update on acute appendicitis: Typical and untypical findings. Radiologia (Engl Ed) 2023; 65 Suppl 1: S81-s91. doi:10.1016/j.rxeng.2022.09.010
2. Gil LA, Deans KJ, Minneci PC. Appendicitis in Children. Adv Pediatr 2023; 70: 105–122. doi:10.1016/j.yapd.2023.03.003
3. Zhang P, Zhang Q, Zhao H et al. Factors affecting the length of hospital stay after laparoscopic appendectomy: A single center study. PLoS One 2020; 15: e0243575. doi:10.1371/journal.pone.0243575
4. Sadat-Safavi SA, Nasiri S, Shojaiefard A et al. Comparison the effect of stump closure by endoclips versus endoloop on the duration of surgery and complications in patients under laparoscopic appendectomy: A randomized clinical trial. J Res Med Sci 2016; 21: 87. doi:10.4103/1735-1995.192503
5. Talan DA, Saltzman DJ, DeUgarte DA et al. Methods of conservative antibiotic treatment of acute uncomplicated appendicitis: A systematic review. J Trauma Acute Care Surg 2019; 86: 722–736. doi:10.1097/ta.0000000000002137
6. Namm JP, Thakrar KH, Wang CH et al. A semi-automated assessment of sarcopenia using psoas area and density predicts outcomes after pancreaticoduodenectomy for pancreatic malignancy. J Gastrointest Oncol 2017; 8: 936–944. doi:10.21037/jgo.2017.08.09
7. Islam S, Kanavati F, Arain Z et al. Fully automated deep-learning section-based muscle segmentation from CT images for sarcopenia assessment. Clin Radiol 2022; 77: e363-e371. doi:10.1016/j.crad.2022.01.036
8. Samim A, Spijkers S, Moeskops P et al. Pediatric body composition based on automatic segmentation of computed tomography scans: a pilot study. Pediatr Radiol 2023; 53: 2492–2501. doi:10.1007/s00247-023-05739-x
9. Inoue T, Wakabayashi H, Kawase F et al. Diagnostic criteria, prevalence, and clinical outcomes of pediatric sarcopenia: A scoping review. Clin Nutr 2024; 43: 1825–1843. doi:10.1016/j.clnu.2024.06.024

10. Aydın T, Cingöz E, Durmuş A et al. Determination of reference values for abdominal skeletal muscle compartments in Turkish children. Journal of Back and Musculoskeletal Rehabilitation 2025. 10538127251407660
11. Shen W, Punyanitya M, Wang Z et al. Total body skeletal muscle and adipose tissue volumes: estimation from a single abdominal cross-sectional image. J Appl Physiol (1985) 2004; 97: 2333–2338. doi:10.1152/japplphysiol.00744.2004
12. Smit KC, Derksen JWG, Kurk SA et al. Use of automated assessment for determining associations of low muscle mass and muscle loss with overall survival in patients with colorectal cancer - A validation study. Clin Nutr ESPEN 2024; 63: 572–584. doi:10.1016/j.clnesp.2024.07.001
13. Metzger GA, Sebastião YV, Carsel AC et al. Establishing reference values for lean muscle mass in the pediatric patient. Journal of Pediatric Gastroenterology and Nutrition 2021; 72: 316–323
14. Lurz E, Patel H, Lebovic G et al. Paediatric reference values for total psoas muscle area. Journal of cachexia, sarcopenia and muscle 2020; 11: 405–414
15. Kim J, Lee M-J, Lim HJ et al. Pediatric reference values for total psoas muscle area in Korean children and adolescents. Frontiers in Pediatrics 2025; 12: 1443523
16. Marunowski K, Świętoń D, Bzyl W et al. Reference values for MRI-derived psoas and paraspinal muscles and macroscopic fat infiltrations in paraspinal muscles in children. Journal of Cachexia, Sarcopenia and Muscle 2022; 13: 2515–2524
17. Kudo W, Terui K, Hattori S et al. Establishment and validation of reference values for abdominal skeletal muscle compartments in children. Clinical Nutrition 2023; 42: 653–660
18. Samim A, Spijkers S, Moeskops P et al. Pediatric body composition based on automatic segmentation of computed tomography scans: a pilot study. Pediatric radiology 2023; 53: 2492–2501
19. Ritz A, Kolorz J, Hubertus J et al. Sarcopenia is a prognostic outcome marker in children with high-risk hepatoblastoma. Pediatric Blood & Cancer 2021; 68: e28862
20. Ritz A, Froeba-Pohl A, Kolorz J et al. Total psoas muscle area as a marker for sarcopenia is related to outcome in children with neuroblastoma. Frontiers in surgery 2021; 8: 718184
21. Wang Z, Zeng S, Liu L et al. Weak correlation between total psoas muscle area and sarcopenia index for children with brain tumor. Nutrition in Clinical Practice 2023; 38: 838–849
22. Di Cola S, D'Amico G, Caraceni P et al. Myosteatosis is closely associated with sarcopenia and significantly worse outcomes in patients with cirrhosis. Journal of Hepatology 2024; 81: 641–650
23. Yamashita M, Kamiya K, Matsunaga A et al. Prognostic value of psoas muscle area and density in patients who undergo cardiovascular surgery. Canadian Journal of Cardiology 2017; 33: 1652–1659
24. Yuan Y, Xu Y-f, Feng C et al. Low muscle density in children with osteogenesis imperfecta using opportunistic low-dose chest CT: a case-control study. BMC Musculoskeletal Disorders 2024; 25: 478

25. Hou X, Hu H, Kong C et al. Psoas muscle index and psoas muscle density are associated with functional status in patients with degenerative lumbar spinal stenosis. Journal of Back and Musculoskeletal Rehabilitation 2024; 37: 921–928

Figures

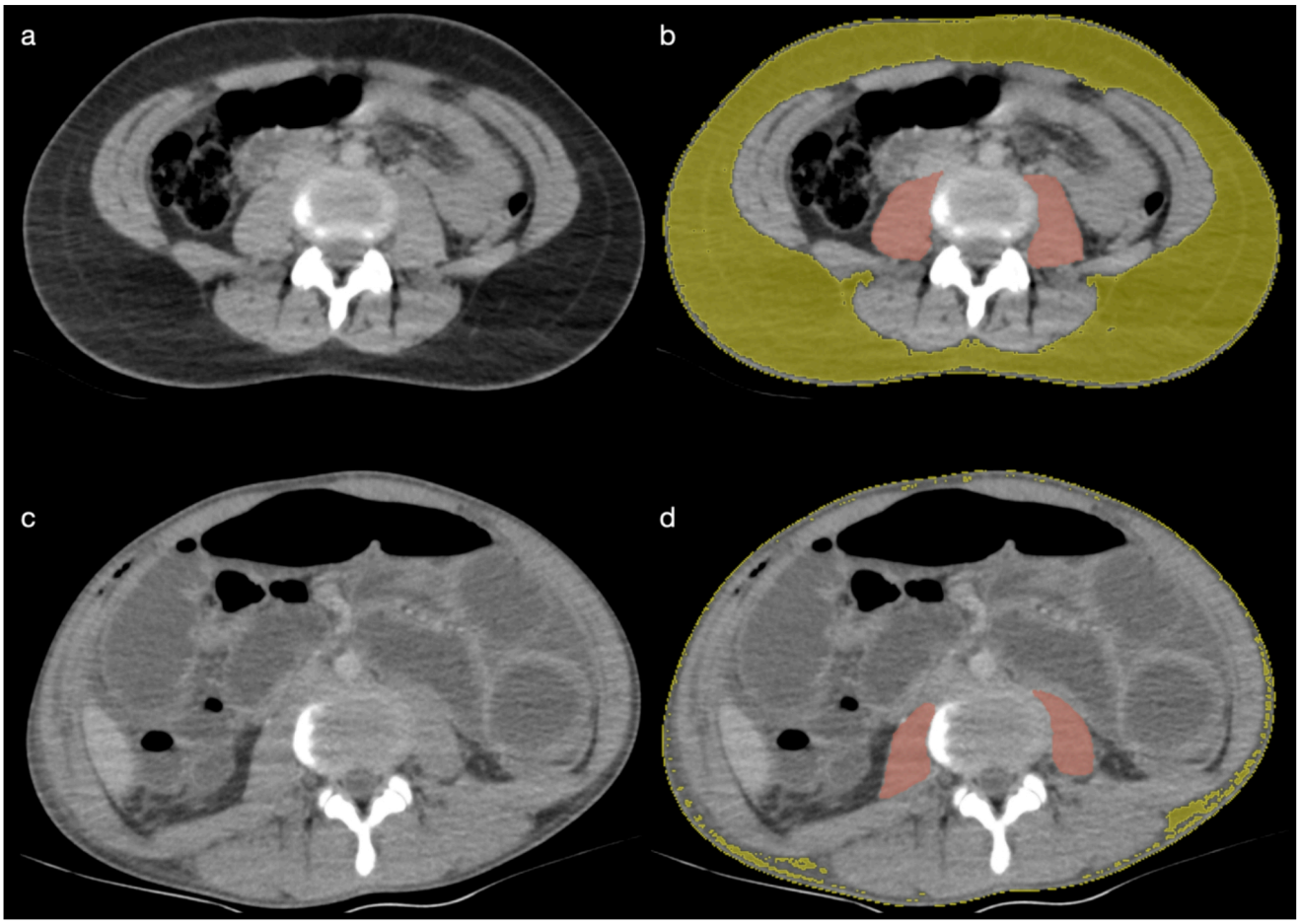


Figure 1

Axial contrast-enhanced CT images and the corresponding post-segmentation CT images at the L3-L4 intervertebral disc level are shown for a 14-year-old female patient diagnosed with non-perforated appendicitis (a-b). Axial contrast-enhanced CT images and the corresponding post-segmentation CT images at the L3-L4 intervertebral disc level are shown for a 14-year-old male patient diagnosed with perforated appendicitis (c-d). *Red psoas muscles, yellow subcutaneous fat tissue*