American College of Radiology
ACR Appropriateness Criteria®

Diagnosis and Monitoring of Sarcopenia

Variant: 1 Adult 60 years of age and older with suspected sarcopenia. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
DXA total body composition	Usually Appropriate	☢
US thigh	May Be Appropriate	O
CT abdomen with IV contrast	May Be Appropriate	☢☢☢
CT abdomen without IV contrast	May Be Appropriate	☢☢☢
CT chest with IV contrast	May Be Appropriate	☢☢☢
CT chest without and with IV contrast	May Be Appropriate	☢☢☢
CT chest without IV contrast	May Be Appropriate (Disagreement)	☢☢☢
CT abdomen without and with IV contrast	May Be Appropriate	☢☢☢☢
Radiography chest	Usually Not Appropriate	☢
MRI abdomen without and with IV contrast	Usually Not Appropriate	O
MRI abdomen without IV contrast	Usually Not Appropriate	O
MRI chest without and with IV contrast	Usually Not Appropriate	O
MRI chest without IV contrast	Usually Not Appropriate	O
Bone scan whole body	Usually Not Appropriate	☢☢☢
FDG-PET/MRI whole body	Usually Not Appropriate	☢☢☢
FDG-PET/CT whole body	Usually Not Appropriate	☢☢☢☢

Variant: 2 Adult with cancer and suspected sarcopenia. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
DXA total body composition	Usually Appropriate	☢
US thigh	May Be Appropriate	O
CT abdomen with IV contrast	May Be Appropriate	☢☢☢
CT abdomen without IV contrast	May Be Appropriate	☢☢☢
CT chest with IV contrast	May Be Appropriate	☢☢☢
CT chest without and with IV contrast	May Be Appropriate	☢☢☢
CT chest without IV contrast	May Be Appropriate (Disagreement)	☢☢☢
CT abdomen without and with IV contrast	May Be Appropriate	☢☢☢☢
Radiography chest	Usually Not Appropriate	☢
MRI abdomen without and with IV contrast	Usually Not Appropriate	O
MRI abdomen without IV contrast	Usually Not Appropriate	O
MRI chest without and with IV contrast	Usually Not Appropriate	O
MRI chest without IV contrast	Usually Not Appropriate	O
Bone scan whole body	Usually Not Appropriate	☢☢☢
FDG-PET/MRI whole body	Usually Not Appropriate	☢☢☢
FDG-PET/CT whole body	Usually Not Appropriate	☢☢☢☢

Variant: 3 Adult with cachexia or malnutrition and suspected sarcopenia. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
DXA total body composition	Usually Appropriate	☢
US thigh	May Be Appropriate	O
CT abdomen with IV contrast	May Be Appropriate	☢☢☢
CT abdomen without IV contrast	May Be Appropriate	☢☢☢
CT chest with IV contrast	May Be Appropriate	☢☢☢
CT chest without and with IV contrast	May Be Appropriate	☢☢☢
CT chest without IV contrast	May Be Appropriate (Disagreement)	☢☢☢
CT abdomen without and with IV contrast	May Be Appropriate	☢☢☢☢
Radiography chest	Usually Not Appropriate	☢
MRI abdomen without and with IV contrast	Usually Not Appropriate	O
MRI abdomen without IV contrast	Usually Not Appropriate	O
MRI chest without and with IV contrast	Usually Not Appropriate	O
MRI chest without IV contrast	Usually Not Appropriate	O
Bone scan whole body	Usually Not Appropriate	☢☢☢
FDG-PET/MRI whole body	Usually Not Appropriate	☢☢☢
FDG-PET/CT whole body	Usually Not Appropriate	☢☢☢☢

Variant: 4 Adult with frailty or multiple comorbidities and suspected sarcopenia. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
DXA total body composition	Usually Appropriate	☢
US thigh	May Be Appropriate	O
CT abdomen with IV contrast	May Be Appropriate	☢☢☢
CT abdomen without IV contrast	May Be Appropriate	☢☢☢
CT chest with IV contrast	May Be Appropriate	☢☢☢
CT chest without and with IV contrast	May Be Appropriate	☢☢☢
CT chest without IV contrast	May Be Appropriate (Disagreement)	☢☢☢
CT abdomen without and with IV contrast	May Be Appropriate	☢☢☢☢
Radiography chest	Usually Not Appropriate	☢
MRI abdomen without and with IV contrast	Usually Not Appropriate	O
MRI abdomen without IV contrast	Usually Not Appropriate	O
MRI chest without and with IV contrast	Usually Not Appropriate	O
MRI chest without IV contrast	Usually Not Appropriate	O
Bone scan whole body	Usually Not Appropriate	☢☢☢
FDG-PET/MRI whole body	Usually Not Appropriate	☢☢☢
FDG-PET/CT whole body	Usually Not Appropriate	☢☢☢☢

Variant: 5 Adult with known sarcopenia. Surveillance.

Procedure	Appropriateness Category	Relative Radiation Level
DXA total body composition	Usually Appropriate	☢
US thigh	May Be Appropriate	O
CT abdomen with IV contrast	May Be Appropriate	☢☢☢
CT abdomen without IV contrast	May Be Appropriate	☢☢☢

CT chest with IV contrast	May Be Appropriate	☢☢☢
CT chest without and with IV contrast	May Be Appropriate	☢☢☢
CT chest without IV contrast	May Be Appropriate (Disagreement)	☢☢☢
CT abdomen without and with IV contrast	May Be Appropriate	☢☢☢☢
Radiography chest	Usually Not Appropriate	☢
MRI abdomen without and with IV contrast	Usually Not Appropriate	O
MRI abdomen without IV contrast	Usually Not Appropriate	O
MRI chest without and with IV contrast	Usually Not Appropriate	O
MRI chest without IV contrast	Usually Not Appropriate	O
Bone scan whole body	Usually Not Appropriate	☢☢☢
FDG-PET/MRI whole body	Usually Not Appropriate	☢☢☢
FDG-PET/CT whole body	Usually Not Appropriate	☢☢☢☢

Panel Members

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Summary of Literature Review

Introduction/Background

Sarcopenia is a generalized disease of skeletal muscle characterized by reduced muscle mass and weakness [1]. Weakness may be "muscle specific", defined as the ratio of muscle strength to muscle quantity (eg, muscle cross-sectional area measured in cm^2) [2]. In clinical practice and clinical research, muscle weakness is most commonly evaluated by measuring grip strength or with the chair stand test.

Sarcopenia is consistently associated with adverse clinical outcomes, including outcomes related to health-related quality of life, activities of daily living, physical performance, falls, fractures, and premature mortality [3]. Similar adverse outcomes have been reported when sarcopenia is diagnosed using clinical and imaging methods.

Sarcopenia is more common with aging, and the prevalence may vary depending on the diagnostic criteria utilized (eg, diagnostic method, cut points) and the study population (eg, age, comorbidities). For example, sarcopenia prevalence is lower among community-dwelling older adults (10%), compared to hospitalized patients (23%-24%) and nursing home residents (31%-51%) [4]. Comorbidities also affect the prevalence of sarcopenia, varying from 18% with diabetes to 66% with unresectable esophageal cancer [5].

Muscle depletion is a hallmark of four related conditions that are common in clinical practice: cancer, malnutrition, cachexia, and physical frailty. All of these clinical conditions have individual ICD codes and are associated with adverse outcomes, including hospitalization and excess mortality [6]. Cancer and other conditions can result in muscle depletion that may not be obvious clinically, especially in obese patients. Malnutrition is diagnosed when two conditions are satisfied: one etiologic condition (inflammation or reduced food intake/assimilation) and one phenotypic

condition (low muscle mass that can be identified with imaging, low body mass index (BMI), or nonvolitional weight loss) [7]. Cachexia is a subtype of malnutrition characterized by involuntary loss of muscle associated with a chronic disease (eg, malignancy, chronic obstructive pulmonary disease (COPD), congestive heart failure, or chronic kidney disease). Patients with cancer may have muscle depletion owing to age-related sarcopenia or secondary to cancer cachexia. Frailty is characterized by low physiologic reserve, low adaptive capacity, and vulnerability to stressors [8, 9].

Despite the high prevalence and burden of adverse outcomes, sarcopenia is underdiagnosed and undertreated [10]. Currently, knowledge of sarcopenia is low among many patients and medical providers, but both groups indicate willingness to start treatment [11-13]. The unmet need for sarcopenia detection and education may be partially addressed by quantitative imaging as a biomarker of muscle depletion. Standardized measurements with AI tools are increasingly enabling automated ("opportunistic") analysis of imaging examinations that are already acquired for other routine indications. For example, if there is suspected sarcopenia, clinical CT or MRI scans can be used secondarily to screen for quantitative imaging findings associated with sarcopenia, namely myopenia (low muscle mass) and myosteatosis (high muscle fat) [14, 15]. Such an opportunistic evaluation is generally performed when a referring provider requests this secondary analysis owing to clinically suspected sarcopenia. Myopenia and myosteatosis identified by imaging are characteristic of sarcopenia, but are not sufficient in isolation to diagnose the clinical disease of sarcopenia.

Sarcopenia may be suspected when predisposing risk factors are present, including low muscle strength (eg, grip strength), physical frailty, recurrent falls, major health conditions, hospitalization, and residency in a long-term care facility [16, 17]. Screening for sarcopenia also has been recommended on an annual basis in older adults at risk, particularly those with low physical activity levels [18-20].

Sarcopenia is a potentially reversible disease [21]. Beyond prevention, exercise and proper nutrition are the mainstays of sarcopenia treatment that can be tailored to individual patients [22-24]. There is no approved pharmacologic treatment for sarcopenia, but numerous drugs are currently under evaluation in clinical trials [25-27]. For malnutrition, management may include nutritional counseling supplemented by oral, enteral, or parenteral nutrition [28]. For cachexia, interventions also include targeted pharmacological and psychosocial therapies, in addition to treatment of the underlying disease process [29].

Special Imaging Considerations

Dual-energy X-ray absorptiometry (DXA) uses two X-ray energies with differential absorption that allows measurement of bone mineral density, fat mass, and lean mass. DXA measurements of lean mass in the upper and lower extremities are summed to yield the appendicular lean soft tissue mass, with reference values generally adjusted or "indexed" using patient height or BMI. Although widely used in research, the value of DXA in the evaluation of muscle mass has been increasingly questioned. There are four main concerns: 1) DXA measures "lean mass" (all tissue that is not fat or bone), and therefore does not directly measure muscle mass; 2) as a projectional technique, DXA also does not measure muscle quality features directly, such as myosteatosis; 3) measurements may be influenced by patient fluid status; and 4) there is limited comparability between different scanner manufacturers and models.

CT, MRI, and ultrasound (US) allow measurement of features associated with muscle quantity and tissue quality. With CT and MRI, proxies for muscle mass include cross-sectional areal measurements of muscle size. CT and MRI tissue quality proxies aim to assess noncontractile components within muscle, such as adipose tissue. With US, muscle quantity parameters measured most commonly are muscle thickness and cross-sectional area (eg, quadriceps musculature in the thigh). The muscle quality parameter measured most commonly is echo intensity (associated with fat content). US potential limitations include intra- and interuser variability. Recent meta-analysis of US studies with 2,143 participants found low-to-moderate accuracy for sarcopenia diagnosis depending on different US parameters, measured muscles, reference standards, and study populations [30]. The Sarcopenia through Ultrasound (SARCUS) Working Group has provided a framework to standardize appendicular muscle measurements [31]. Ongoing work includes further validating of optimal cutoff points to indicate sarcopenia in diverse populations (including adjustments for patient height and weight), understanding the impact of fluid status on US assessment, and documenting the added clinical value of US in predicting patient outcomes are still works in progress [32-34].

Initial Imaging Definition

Initial imaging is defined as imaging at the beginning of the care episode for the medical condition defined by the variant. More than one procedure can be considered usually appropriate in the initial imaging evaluation when:

- There are procedures that are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care)

OR

- There are complementary procedures (ie, more than one procedure is ordered as a set or simultaneously wherein each procedure provides unique clinical information to effectively manage the patient's care).

Discussion of Procedures by Variant

Variant 1:Adult 60 years of age and older with suspected sarcopenia. Initial imaging.

When sarcopenia is suspected clinically, various imaging techniques have been validated to confirm the diagnosis of sarcopenia by showing low muscle quantity or quality, particularly with CT, MRI, DXA, or US [16, 35].

Variant 1:Adult 60 years of age and older with suspected sarcopenia. Initial imaging.
A. Bone scan whole body

There is no relevant literature to support the use of whole body bone scan for initial imaging of suspected sarcopenia because these scans primarily assess bone metabolism rather than muscle mass and quality.

Variant 1:Adult 60 years of age and older with suspected sarcopenia. Initial imaging.
B. CT abdomen with IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of abdominal CT with intravenous (IV) contrast. However, if abdominal CT with IV contrast is already being obtained for a routine clinical indication (eg, abdominal surgery [44, 45]), a

secondary quantitative analysis of muscle is usually appropriate for initial imaging evaluation in a patient with suspected sarcopenia [46]. Based on currently available evidence, muscle quantification is best done using existing images rather than re-scanning. Of note, the presence of IV contrast tends to result in a small increase in measured muscle quantity (≤1.1 cm^2/m^2, 2.6%) at the L3 level [47]. Muscle density measurements increase variably after IV contrast administration [48, 49], but a simplified correction factor of 7.5 Hounsfield units has been recommended at the L3 level for venous and delayed phase contrast scans [50, 51]. Compared to noncontrast abdominal CT, contrast-enhanced CT does not provide added information with regard to sarcopenia.

Variant 1:Adult 60 years of age and older with suspected sarcopenia. Initial imaging. C. CT abdomen without and with IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of abdominal CT without and with IV contrast. However, if abdominal CT without and with IV contrast is obtained for another clinical indication, a secondary quantitative analysis of muscle is usually appropriate for initial imaging evaluation in a patient with suspected sarcopenia. Based on currently available evidence, muscle quantification is best done using existing images rather than re-scanning. Noncontrast images are preferred for measurements due to the variable influence of IV contrast. Compared to noncontrast CT, contrast-enhanced CT does not provide added information with regard to sarcopenia.

Variant 1:Adult 60 years of age and older with suspected sarcopenia. Initial imaging. D. CT abdomen without IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of abdominal CT without IV contrast. However, if abdominal CT without IV contrast is already being obtained for a routine clinical indication [52-54], a secondary quantitative analysis of the muscle is usually appropriate for initial imaging evaluation in a patient with suspected sarcopenia. Based on currently available evidence, muscle quantification is best done using existing images rather than re-scanning.

Variant 1:Adult 60 years of age and older with suspected sarcopenia. Initial imaging. E. CT chest with IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of chest CT with IV contrast. However, if chest CT with IV contrast is already being obtained for a routine clinical indication (eg, COVID-19 [55], transcatheter aortic valve replacement [56, 57], or admission to the intensive care unit [58]), a secondary quantitative analysis of muscle may be appropriate for initial imaging evaluation in a patient with suspected sarcopenia. Based on currently available evidence, muscle quantification is best done using existing images rather than re-scanning. Of note, contrast-enhanced and noncontrast data should not be used interchangeably, although correction modeling can be performed for varying chest CT protocols [59].

Variant 1:Adult 60 years of age and older with suspected sarcopenia. Initial imaging. F. CT chest without and with IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of chest CT without and with IV contrast. However, if chest CT without and with IV contrast is obtained for another clinical indication, a secondary quantitative analysis of muscle may be appropriate for initial imaging evaluation in a patient with suspected sarcopenia. Based on currently available evidence, muscle quantification is best done using existing images rather than

re-scanning. Noncontrast images are preferred for measurements due to the variable influence of IV contrast. Compared to noncontrast CT, contrast-enhanced CT does not provide added information with regard to sarcopenia.

Variant 1:Adult 60 years of age and older with suspected sarcopenia. Initial imaging. G. CT chest without IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of chest CT without IV contrast. However, if chest CT without IV contrast is already being obtained for a routine clinical indication (eg, in older hospitalized patients [60], lung cancer screening [61, 62]), a secondary quantitative analysis of the muscle may be appropriate for initial imaging evaluation in a patient with suspected sarcopenia. Based on currently available evidence, muscle quantification is best done using existing images rather than re-scanning.

Variant 1:Adult 60 years of age and older with suspected sarcopenia. Initial imaging. H. DXA total body composition

DXA is usually appropriate for imaging of suspected sarcopenia. Most expert working groups recommend DXA as a technique to confirm the imaging features of sarcopenia, with specific cutoff thresholds and wide adoption in research settings [16, 17, 36-38].

Given recent studies indicating that DXA associations with sarcopenia-related clinical outcomes are weak or inconsistent [1, 39, 40], combining clinical evaluation with secondary analysis of muscle on an available recent CT scan may be more appropriate than performing a new DXA scan.

Variant 1:Adult 60 years of age and older with suspected sarcopenia. Initial imaging. I. FDG-PET/CT whole body

There is insufficient evidence to support the use of whole body FDG-PET/CT for initial imaging of suspected sarcopenia. There is a paucity of literature to support secondary quantitative analysis of muscle on CT scans routinely performed with PET (eg, cardiac PET/CT in patients with cardiometabolic syndrome [71]).

Variant 1:Adult 60 years of age and older with suspected sarcopenia. Initial imaging. J. FDG-PET/MRI whole body

There is no relevant literature to support the use of whole body fluorine-18-2-fluoro-2-deoxy-D-glucose (FDG)-PET/MRI for initial imaging of suspected sarcopenia.

Variant 1:Adult 60 years of age and older with suspected sarcopenia. Initial imaging. K. MRI abdomen without and with IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of abdominal MRI without and with IV contrast. There is a paucity of literature to support secondary quantitative analysis of muscle if abdominal MRI without and with IV contrast is already being obtained for a routine clinical indication (eg, Crohn disease [64, 65], chronic liver disease [66, 67]).

Variant 1:Adult 60 years of age and older with suspected sarcopenia. Initial imaging. L. MRI abdomen without IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of abdominal MRI without IV contrast. There is a paucity of literature to support secondary quantitative analysis of muscle if abdominal MRI without IV contrast is already being obtained for a routine clinical indication. On abdomen and chest scans covering the L1 level (level of the superior

mesenteric artery), there is a high intraindividual correlation between MRI and CT for biomarkers of muscle quantity and quality [68].

Variant 1:Adult 60 years of age and older with suspected sarcopenia. Initial imaging.
M. MRI chest without and with IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of chest MRI without and with IV contrast. There is a paucity of literature to support secondary quantitative analysis of muscle if chest MRI without and with IV contrast is already being obtained for a routine clinical indication (eg, cardiomyopathy [69], aortic valve replacement [70]).

Variant 1:Adult 60 years of age and older with suspected sarcopenia. Initial imaging.
N. MRI chest without IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of chest MRI without IV contrast. There is a paucity of literature to support secondary quantitative analysis of muscle if chest MRI without IV contrast is already being obtained for a routine clinical indication.

Variant 1:Adult 60 years of age and older with suspected sarcopenia. Initial imaging.
O. Radiography chest

There is insufficient evidence to support the use of chest radiography for initial imaging of suspected sarcopenia [63].

Variant 1:Adult 60 years of age and older with suspected sarcopenia. Initial imaging.
P. US thigh

Thigh US, performed in conjunction with clinical history and physical examination, may be useful for the evaluation of suspected sarcopenia. US is not routinely used for evaluating sarcopenia. Some studies have found sonographic muscle measurements for muscle depletion can help stratify mortality risk (eg, patients hospitalized with COVID-19 [41]), and should be used increasingly in the future [42]. More research in various settings is needed to clarify the value of muscle US in clinical practice [43].

Variant 2:Adult with cancer and suspected sarcopenia. Initial imaging.

Patients with cancer may have muscle depletion owing to age-related sarcopenia or secondary to cancer cachexia. This muscle depletion may be occult clinically, particularly in obese patients.

Variant 2:Adult with cancer and suspected sarcopenia. Initial imaging.
A. Bone scan whole body

There is no relevant literature to support the use of whole body bone scan for initial imaging of suspected sarcopenia in adults with cancer because these scans primarily assess bone metabolism rather than muscle mass and quality.

Variant 2:Adult with cancer and suspected sarcopenia. Initial imaging.
B. CT abdomen with IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of abdominal CT with IV contrast. However, if abdominal CT with IV contrast is already being obtained for a routine clinical indication (eg, malignancy [78-82]), a secondary quantitative analysis of muscle is usually appropriate for initial imaging evaluation in an adult patient with suspected sarcopenia [46]. Based on currently available evidence, muscle quantification is best done using existing images rather than re-scanning. Compared to noncontrast abdominal CT, contrast-

enhanced CT does not provide added information with regard to sarcopenia.

Variant 2:Adult with cancer and suspected sarcopenia. Initial imaging.
C. CT abdomen without and with IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of abdominal CT without and with IV contrast. However, if abdominal CT without and with IV contrast is obtained for another clinical indication, a secondary quantitative analysis of muscle is usually appropriate for initial imaging evaluation in an adult with cancer and suspected sarcopenia. Based on currently available evidence, muscle quantification is best done using existing images rather than re-scanning. Noncontrast images are preferred for measurements due to the variable influence of IV contrast. Compared to noncontrast CT, contrast-enhanced CT does not provide added information with regard to sarcopenia.

Variant 2:Adult with cancer and suspected sarcopenia. Initial imaging.
D. CT abdomen without IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of abdominal CT without IV contrast. However, if abdominal CT without IV contrast is already being obtained for a routine clinical indication, a secondary quantitative analysis of the muscle is usually appropriate for initial imaging evaluation in an adult with cancer and suspected sarcopenia. Based on currently available evidence, muscle quantification is best done using existing images rather than re-scanning.

Variant 2:Adult with cancer and suspected sarcopenia. Initial imaging.
E. CT chest with IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of chest CT with IV contrast. However, if chest CT with IV contrast is already being obtained for a routine clinical indication (eg, prior to thoracic surgery in the setting of lung cancer [83-86]), a secondary quantitative analysis of muscle may be appropriate for initial imaging evaluation in an adult with cancer and suspected sarcopenia. Based on currently available evidence, muscle quantification is best done using existing images rather than re-scanning. Of note, contrast-enhanced and noncontrast data should not be used interchangeably, although correction modeling can be performed for varying chest CT protocols [59].

Variant 2:Adult with cancer and suspected sarcopenia. Initial imaging.
F. CT chest without and with IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of chest CT without and with IV contrast. However, if chest CT without and with IV contrast is obtained for another clinical indication, a secondary quantitative analysis of muscle may be appropriate for initial imaging evaluation in an adult with cancer and suspected sarcopenia. Based on currently available evidence, muscle quantification is best done using existing images rather than re-scanning. Noncontrast images are preferred for measurements due to the variable influence of IV contrast. Compared to noncontrast CT, contrast-enhanced CT does not provide added information with regard to sarcopenia.

Variant 2:Adult with cancer and suspected sarcopenia. Initial imaging.
G. CT chest without IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of chest CT. However, if chest CT without IV contrast is already being obtained for a routine clinical indication (eg, non–small-cell lung cancer [87]), a secondary quantitative analysis of the

muscle may be appropriate for initial imaging evaluation in an adult with cancer and suspected sarcopenia. Based on currently available evidence, muscle quantification is best done using existing images rather than re-scanning.

Variant 2:Adult with cancer and suspected sarcopenia. Initial imaging.
H. DXA total body composition

DXA is usually appropriate for imaging of suspected sarcopenia. Most expert working groups recommend DXA as a technique to confirm the imaging features of sarcopenia, with specific cutoff thresholds and wide adoption in research settings [16, 17, 36-38]. If DXA is being performed for evaluation of bone density, DXA for total body composition could potentially be performed contemporaneously. However, given that DXA associations with some sarcopenia-related clinical outcomes are weak or inconsistent, combining clinical evaluation with secondary analysis of muscle on a recent CT scan may be more appropriate than performing a new DXA scan. Of note, DXA and CT are not interchangeable in the evaluation of sarcopenia; there can be poor agreement between the two modalities for sarcopenia diagnosis in patients with cancer [72].

Variant 2:Adult with cancer and suspected sarcopenia. Initial imaging.
I. FDG-PET/CT whole body

There is insufficient evidence to support the use of FDG-PET/CT as a stand-alone indication for diagnosing sarcopenia. There is a paucity of literature to support secondary quantitative analysis of muscle if FDG-PET/CT is already being obtained for a routine clinical indication (eg, esophageal adenocarcinoma [93, 94], multiple myeloma [95], lymphoma [96], neck cancer [97], non–small-cell lung cancer [98]).

Variant 2:Adult with cancer and suspected sarcopenia. Initial imaging.
J. FDG-PET/MRI whole body

There is no relevant literature to support the use of FDG-PET/MRI for initial imaging of suspected sarcopenia.

Variant 2:Adult with cancer and suspected sarcopenia. Initial imaging.
K. MRI abdomen without and with IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of abdominal MRI without and with IV contrast. There is a paucity of literature to support secondary quantitative analysis of muscle if abdominal MRI without and with IV contrast is already being obtained for a routine clinical indication (eg, hepatocellular carcinoma [88-90], pancreatic cancer [91]).

Variant 2:Adult with cancer and suspected sarcopenia. Initial imaging.
L. MRI abdomen without IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of abdominal MRI without IV contrast. There is a paucity of literature to support secondary quantitative analysis of muscle if abdominal MRI without IV contrast is already being obtained for a routine clinical indication.

Variant 2:Adult with cancer and suspected sarcopenia. Initial imaging.
M. MRI chest without and with IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of chest MRI without and with IV contrast. There is a paucity of literature to support secondary quantitative analysis of muscle if chest MRI without and with IV contrast is already being obtained

for a routine clinical indication (eg, breast cancer [92]).

Variant 2:Adult with cancer and suspected sarcopenia. Initial imaging.
N. MRI chest without IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of chest MRI without IV contrast. There is a paucity of literature to support secondary quantitative analysis of muscle if chest MRI without IV contrast is already being obtained for a routine clinical indication.

Variant 2:Adult with cancer and suspected sarcopenia. Initial imaging.
O. Radiography chest

There is insufficient evidence to support the use of chest radiography for initial imaging of suspected sarcopenia.

Variant 2:Adult with cancer and suspected sarcopenia. Initial imaging.
P. US thigh

Thigh US, in conjunction with patient history and physical examination, is sometimes useful the evaluation of suspected sarcopenia [73, 74]. US is not routinely used for evaluating sarcopenia. Some studies have found sonographic thigh measurements for muscle depletion can help stratify risk of adverse outcomes (eg, neutropenia after chemotherapy) [75, 76]. Combining thigh and arm US measurements may result in improved diagnostic results [77].

Variant 3:Adult with cachexia or malnutrition and suspected sarcopenia. Initial imaging.

Patients with cancer may have muscle depletion owing to age-related sarcopenia or secondary to cancer cachexia. This muscle depletion is often occult clinically, particularly in obese patients. Muscle depletion may be clinically occult in patients with cachexia or malnutrition, particularly in early stages or in the setting of obesity. Not only is malnutrition strongly associated with sarcopenia, the combination of malnutrition and sarcopenia are associated with increased mortality rates [99].

Variant 3:Adult with cachexia or malnutrition and suspected sarcopenia. Initial imaging.
A. Bone scan whole body

There is no relevant literature to support the use of whole body bone scan for initial imaging of suspected sarcopenia in adults with cancer because these scans primarily assess bone metabolism rather than muscle mass and quality.

Variant 3:Adult with cachexia or malnutrition and suspected sarcopenia. Initial imaging.
B. CT abdomen with IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of abdominal CT with IV contrast. However, if abdominal CT with IV contrast is already being obtained for a routine clinical indication [100, 101], a secondary quantitative analysis of muscle may be appropriate for initial imaging evaluation in an adult with cachexia/malnutrition and suspected sarcopenia. Muscle quantification is best done using existing images rather than re-scanning. Compared to noncontrast abdominal CT, contrast-enhanced CT does not provide added information with regard to sarcopenia.

Variant 3:Adult with cachexia or malnutrition and suspected sarcopenia. Initial imaging.
C. CT abdomen without and with IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the

use of abdominal CT without and with IV contrast. However, if abdominal CT without and with IV contrast is obtained for another clinical indication, a secondary quantitative analysis of muscle may be appropriate for initial imaging evaluation in an adult with cachexia/malnutrition and suspected sarcopenia. Muscle quantification is best done using existing images rather than re-scanning. Noncontrast images are preferred for measurements due to the variable influence of IV contrast. Compared to noncontrast CT, contrast-enhanced CT does not provide added information with regard to sarcopenia.

Variant 3:Adult with cachexia or malnutrition and suspected sarcopenia. Initial imaging. D. CT abdomen without IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of abdominal CT without IV contrast. However, if abdominal CT without IV contrast is already being obtained for a routine clinical indication, a secondary quantitative analysis of the muscle may be appropriate for initial imaging evaluation in an adult with cachexia/malnutrition and suspected sarcopenia. Muscle quantification is best done using existing images rather than re-scanning.

Variant 3:Adult with cachexia or malnutrition and suspected sarcopenia. Initial imaging. E. CT chest with IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of chest CT with IV contrast. If chest CT with IV contrast is already being obtained for a routine clinical indication, a secondary quantitative analysis of muscle may occasionally be appropriate for initial imaging evaluation in an adult with cachexia/malnutrition and suspected sarcopenia. Muscle quantification is best done using existing images rather than re-scanning. Of note, contrast-enhanced and noncontrast data should not be used interchangeably, although correction modeling can be performed for varying CT protocols [59].

Variant 3:Adult with cachexia or malnutrition and suspected sarcopenia. Initial imaging. F. CT chest without and with IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of chest CT without and with IV contrast. If chest CT without and with IV contrast is obtained for another clinical indication, a secondary quantitative analysis of muscle may occasionally be appropriate for initial imaging evaluation in an adult with cachexia/malnutrition and suspected sarcopenia. Muscle quantification is best done using existing images rather than re-scanning. Noncontrast images are preferred for measurements due to the variable influence of IV contrast. Compared to noncontrast CT, contrast-enhanced CT does not provide added information with regard to sarcopenia.

Variant 3:Adult with cachexia or malnutrition and suspected sarcopenia. Initial imaging. G. CT chest without IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of chest CT without IV contrast. If chest CT without IV contrast is already being obtained for a routine clinical indication, a secondary quantitative analysis of the muscle may occasionally be appropriate for initial imaging evaluation in an adult with cachexia/malnutrition and suspected sarcopenia. Muscle quantification is best done using existing images rather than re-scanning.

Variant 3:Adult with cachexia or malnutrition and suspected sarcopenia. Initial imaging. H. DXA total body composition

DXA is usually appropriate for imaging of suspected sarcopenia. Most expert working groups recommend DXA as a technique to confirm the imaging features of sarcopenia, with specific cutoff

thresholds and wide adoption in the research settings [16, 17, 36-38]. Given recent studies indicating that DXA associations with some sarcopenia-related clinical outcomes are weak or inconsistent, combining clinical evaluation with secondary analysis of muscle on a recent available abdominal CT scan may be more appropriate than performing a new DXA scan.

Variant 3:Adult with cachexia or malnutrition and suspected sarcopenia. Initial imaging. I. FDG-PET/CT whole body

There is insufficient evidence to support the use of FDG-PET/CT as a stand-alone indication for suspected sarcopenia. If FDG-PET/CT is already being obtained for a routine clinical indication, a secondary quantitative analysis of existing FDG-PET/CT data may occasionally be appropriate for initial imaging evaluation in a patient with cachexia/malnutrition and suspected sarcopenia, but there is not substantial evidence to support this in the literature.

Variant 3:Adult with cachexia or malnutrition and suspected sarcopenia. Initial imaging. J. FDG-PET/MRI whole body

There is no relevant literature to support the use of FDG-PET/MRI for initial imaging of suspected sarcopenia.

Variant 3:Adult with cachexia or malnutrition and suspected sarcopenia. Initial imaging. K. MRI abdomen without and with IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of abdominal MRI without and with IV contrast. There is a paucity of literature to support secondary quantitative analysis of muscle if abdominal MRI without and with IV contrast is already being obtained for a routine clinical indication.

Variant 3:Adult with cachexia or malnutrition and suspected sarcopenia. Initial imaging. L. MRI abdomen without IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of abdominal MRI without IV contrast. There is a paucity of literature to support secondary quantitative analysis of muscle if abdominal MRI without IV contrast is already being obtained for a routine clinical indication.

Variant 3:Adult with cachexia or malnutrition and suspected sarcopenia. Initial imaging. M. MRI chest without and with IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of chest MRI without and with IV contrast. There is a paucity of literature to support secondary quantitative analysis of muscle if chest MRI without and with IV contrast is already being obtained for a routine clinical indication.

Variant 3:Adult with cachexia or malnutrition and suspected sarcopenia. Initial imaging. N. MRI chest without IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of chest MRI without IV contrast. There is a paucity of literature to support secondary quantitative analysis of muscle if chest MRI without IV contrast is already being obtained for a routine clinical indication.

Variant 3:Adult with cachexia or malnutrition and suspected sarcopenia. Initial imaging. O. Radiography chest

There is no relevant literature to support the use of chest radiography for initial imaging of

suspected sarcopenia.

Variant 3:Adult with cachexia or malnutrition and suspected sarcopenia. Initial imaging.
P. US thigh

Thigh US, in conjunction with patient history and physical examination, is sometimes useful the evaluation of suspected sarcopenia [73, 74]. US is not routinely used for evaluating sarcopenia.

Variant 4:Adult with frailty or multiple comorbidities and suspected sarcopenia. Initial imaging.

Adults with frailty or multiple comorbidities are at increased risk for sarcopenia. Comorbidities commonly associated with sarcopenia include chronic diseases such as diabetes, chronic kidney disease, cardiovascular disease, neurological disease, and bone and joint disease [102, 103]. The frequency of sarcopenia increases with the number of chronic diseases. For example, the risk of sarcopenia for older hospitalized patients with >6 chronic diseases is >5 times higher than for 2 to 3 chronic diseases [103]. Patients with a greater comorbidity burden are also more likely to undergo CT and MRI [104], which can be used for secondary analysis for sarcopenia [15].

Specific phenotypes evaluated with imaging of sarcopenia include obesity ("sarcopenic obesity" [105, 106]) and osteoporosis ("osteosarcopenia" [107]). Sarcopenic obesity (compared to patients without sarcopenia and obesity) is associated with functional dependence (3.8×) and mortality (2.8×) [108]. Osteosarcopenia is associated with an increased risk of fall (1.5×), fracture (2.1×), and mortality (1.8×) [109]. Screening and treatment protocols for older adults have been suggested to mitigate adverse health outcomes [108]. Imaging evaluation of body composition may be appropriate in some patients to inform clinical decision-making and identify patients who may benefit from rehabilitation interventions [110].

Variant 4:Adult with frailty or multiple comorbidities and suspected sarcopenia. Initial imaging.
A. Bone scan whole body

There is no relevant literature to support the use of whole body bone scan for initial imaging of suspected sarcopenia in adults with cancer because these scans primarily assess bone metabolism rather than muscle mass and quality.

Variant 4:Adult with frailty or multiple comorbidities and suspected sarcopenia. Initial imaging.
B. CT abdomen with IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of abdominal CT with IV contrast. However, if abdominal CT with IV contrast is already being obtained for a routine clinical indication (eg, in the setting of trauma [117], emergency laparotomy [118], chronic limb-threatening ischemia [119], liver transplantation [120], surgical oncology [121], frail older adults with cancer [122]), then a secondary quantitative analysis of muscle may be complementary for initial imaging evaluation in an adult with clinical frailty and suspected sarcopenia. Muscle quantification is best done using existing images rather than re-scanning. Compared to noncontrast abdominal CT, contrast-enhanced CT does not provide added information with regard to sarcopenia.

Variant 4:Adult with frailty or multiple comorbidities and suspected sarcopenia. Initial imaging.
C. CT abdomen without and with IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of abdominal CT without and with IV contrast. However, if abdominal CT without and with IV contrast is obtained for another clinical indication, then a secondary quantitative analysis of muscle may be appropriate for initial imaging evaluation for suspected sarcopenia in an adult with clinical frailty or multiple comorbidities. Muscle quantification is best done using existing images rather than re-scanning. Noncontrast images are preferred for measurements due to the variable influence of IV contrast. Compared to noncontrast CT, contrast-enhanced CT does not provide added information with regard to sarcopenia.

Variant 4:Adult with frailty or multiple comorbidities and suspected sarcopenia. Initial imaging.
D. CT abdomen without IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of abdominal CT without IV contrast. However, if abdominal CT without IV contrast is already being obtained for a routine clinical indication, then a secondary quantitative analysis of the muscle may be appropriate for initial imaging evaluation for suspected sarcopenia in an adult with clinical frailty or multiple comorbidities. For example, in a study of patients with acute kidney injury (n = 2,200, mostly >65 years of age, with multiple comorbidities), noncontrast abdominal CT evaluation of muscle at the L3 level showed strong protective effects of muscle mass on short-term mortality [123]. Muscle quantification is best done using existing images rather than re-scanning.

Variant 4:Adult with frailty or multiple comorbidities and suspected sarcopenia. Initial imaging.
E. CT chest with IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of chest CT with IV contrast. If chest CT with IV contrast is already being obtained for a routine clinical indication in older patients (eg, burn patients [124], in the setting of transcatheter aortic valve replacement [125], cardiac surgery with cardiopulmonary bypass [126], hip fracture [127]), then a secondary quantitative analysis of muscle may be appropriate for initial imaging evaluation for suspected sarcopenia in an adult with clinical frailty or multiple comorbidities. Muscle quantification is best done using existing images rather than re-scanning. Of note, contrast-enhanced and noncontrast data should not be used interchangeably, although correction modeling can be performed for varying CT protocols [59].

Variant 4:Adult with frailty or multiple comorbidities and suspected sarcopenia. Initial imaging.
F. CT chest without and with IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of chest CT without and with IV contrast. However, if chest CT without and with IV contrast is obtained for another clinical indication, then a secondary quantitative analysis of muscle may be appropriate for initial imaging evaluation for suspected sarcopenia in an adult with clinical frailty or multiple comorbidities. Muscle quantification is best done using existing images rather than re-scanning. Noncontrast images are preferred for measurements due to the variable influence of IV contrast. Compared to noncontrast CT, contrast-enhanced CT does not provide added information with regard to sarcopenia.

Variant 4:Adult with frailty or multiple comorbidities and suspected sarcopenia. Initial imaging.
G. CT chest without IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of chest CT without IV contrast. However, if chest CT without IV contrast is already being obtained for a routine clinical indication in older patients (eg, in the setting of hip fracture [128], idiopathic pulmonary fibrosis [129], hemodialysis [130]), then a secondary quantitative analysis of the muscle may be appropriate for initial imaging evaluation for suspected sarcopenia in an adult with clinical frailty or multiple comorbidities. Muscle quantification is best done using existing images rather than re-scanning.

Variant 4:Adult with frailty or multiple comorbidities and suspected sarcopenia. Initial imaging.
H. DXA total body composition

DXA is usually appropriate for imaging of suspected sarcopenia. Most expert working groups recommend DXA as a technique to confirm the imaging features of sarcopenia, with specific cutoff thresholds and wide adoption in research settings, including for suspected sarcopenia in adults with clinical frailty or comorbidities [111, 112]. Given that DXA associations with some sarcopenia-related clinical outcomes are weak or inconsistent, combining clinical evaluation with secondary analysis of muscle on a recent CT scan may be more appropriate than performing a new DXA scan.

Variant 4:Adult with frailty or multiple comorbidities and suspected sarcopenia. Initial imaging.
I. FDG-PET/CT whole body

There is insufficient evidence to support the use of FDG-PET/CT as a stand-alone indication for suspected sarcopenia. There is a paucity of literature to support secondary quantitative analysis of muscle if FDG-PET/CT is already being obtained for a routine clinical indication.

Variant 4:Adult with frailty or multiple comorbidities and suspected sarcopenia. Initial imaging.
J. FDG-PET/MRI whole body

There is no relevant literature to support the use of FDG-PET/MRI for initial imaging of suspected sarcopenia.

Variant 4:Adult with frailty or multiple comorbidities and suspected sarcopenia. Initial imaging.
K. MRI abdomen without and with IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of abdominal MRI without and with IV contrast. There is a paucity of literature to support secondary quantitative analysis of muscle if abdominal MRI without or with IV contrast is already being obtained for a routine clinical indication.

Variant 4:Adult with frailty or multiple comorbidities and suspected sarcopenia. Initial imaging.
L. MRI abdomen without IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of abdominal MRI without IV contrast. There is a paucity of literature to support secondary quantitative analysis of muscle if abdominal MRI without IV contrast is already being obtained for a routine clinical indication.

Variant 4:Adult with frailty or multiple comorbidities and suspected sarcopenia. Initial imaging.
M. MRI chest without and with IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of chest MRI. There is a paucity of literature to support secondary quantitative analysis of muscle in this setting.

Variant 4:Adult with frailty or multiple comorbidities and suspected sarcopenia. Initial imaging.
N. MRI chest without IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of chest MRI without IV contrast. There is a paucity of literature to support secondary quantitative analysis of muscle if chest MRI without IV contrast is already being obtained for a routine clinical indication.

Variant 4:Adult with frailty or multiple comorbidities and suspected sarcopenia. Initial imaging.
O. Radiography chest

There is no relevant literature to support the use of chest radiography for suspected sarcopenia.

Variant 4:Adult with frailty or multiple comorbidities and suspected sarcopenia. Initial imaging.
P. US thigh

Thigh US, in conjunction with patient history and physical examination, is sometimes useful the evaluation of suspected sarcopenia in an adult with clinical frailty or comorbidities [113-116]. US is not routinely used for evaluating sarcopenia.

Variant 5:Adult with known sarcopenia. Surveillance.

Sarcopenia prevalence increases with age but wide variations in the "normal range" of muscle on imaging have been observed, even in young healthy individuals [131]. In order to better characterize muscle status in an individual patient, it may be helpful to evaluate muscle mass and quality for any longitudinal changes. By analyzing muscle at two or more time points, the rate of change over time may be determined. However, there is no consensus regarding specific intervals for repeated imaging in adult patients with known sarcopenia.

Accurate monitoring of established sarcopenia may aid in optimizing individual patient management plans and assessing efficacy of interventions [132]. Accelerated patient-specific muscle changes may have more profound implications for management and prognosis than using a single time point and a general population-based threshold. When evaluating for meaningful changes in the time interval between comparison examinations for a patient, attention to technical factors is essential because measurement precision (ie, measurement reproducibility) varies with different imaging techniques. The concept of least significant change (LSC) is most developed with DXA and refers to a minimum change that can be considered statistically significant. If a change in muscle is less than the LSC, it may simply reflect measurement variability. As with any imaging evaluation at a single timepoint, the clinical context for longitudinal changes in muscle is important.

Variant 5:Adult with known sarcopenia. Surveillance.
A. Bone scan whole body

There is no relevant literature to support the use of whole body bone scan for surveillance of sarcopenia because these scans primarily assess bone metabolism rather than muscle mass and quality.

Variant 5:Adult with known sarcopenia. Surveillance.
B. CT abdomen with IV contrast

There is insufficient evidence to support sarcopenia surveillance as a stand-alone indication for the use of abdominal CT with IV contrast. However, if abdominal CT with IV contrast is already being obtained for a routine clinical indication, a secondary quantitative analysis of the muscle may be appropriate for imaging follow-up of sarcopenia (rather than additional re-scanning). For example, with immune checkpoint inhibitor therapy for various neoplasms, progressive decreases in both muscle mass and radiodensity metric at L3 on serial CT scans are associated with worse survival [146]. Furthermore, longitudinal muscle loss may predict worse survival with colorectal cancer [147-149] and decreasing muscle density during treatment for endometrial cancer is associated with worse survival [150]. Temporal changes in muscle; however, do not always predict clinical outcomes. For example, overall survival may be predicted by lower baseline muscle mass and density in studies of sepsis [151] and metastatic pancreatic cancer [152], respectively, but longitudinal changes in muscle metrics may not be. Compared to noncontrast abdominal CT, contrast-enhanced CT does not provide added information.

Variant 5:Adult with known sarcopenia. Surveillance.
C. CT abdomen without and with IV contrast

There is insufficient evidence to support sarcopenia surveillance as a stand-alone indication for the use of abdominal CT without and with IV contrast. However, if abdominal CT without and with IV contrast is obtained for another clinical indication, a secondary quantitative analysis of muscle may be appropriate for imaging follow-up in a patient with sarcopenia (rather than additional re-scanning). For example, patients with liver cirrhosis [159], both persistent sarcopenia and new onset sarcopenia defined by a low skeletal muscle index at the L3 level [160] have been associated with higher risk of death. Noncontrast images are preferred for measurements due to the variable influence of IV contrast. Compared to noncontrast CT, contrast-enhanced CT does not provide added information.

Variant 5:Adult with known sarcopenia. Surveillance.
D. CT abdomen without IV contrast

There is insufficient evidence to support sarcopenia surveillance as a stand-alone indication for the use of abdominal CT without IV contrast. However, if abdominal CT without IV contrast is already being obtained for a routine clinical indication, a secondary quantitative analysis of the muscle may be appropriate for imaging follow-up of sarcopenia (rather than additional re-scanning). For example, in a study of 101 patients with colorectal cancer [153], there was not a significant association of baseline muscle mass and attenuation on CT with clinical outcomes, but the interval decrease in these CT metrics within a 1-year period after the diagnosis of colorectal cancer was associated with decreased survival.

Variant 5:Adult with known sarcopenia. Surveillance.
E. CT chest with IV contrast

There is insufficient evidence to support sarcopenia surveillance as a stand-alone indication for the use of chest CT with IV contrast. However, if chest CT with IV contrast are already being obtained for a routine clinical indication, a secondary quantitative analysis of muscle may be appropriate for imaging follow-up of sarcopenia (rather than additional re-scanning) (eg, after lobectomy for lung cancer [154], advanced stage lung cancer [155]). Of note, contrast-enhanced and noncontrast data should not be used interchangeably, although correction modeling can be performed for varying chest CT protocols.

Variant 5:Adult with known sarcopenia. Surveillance.
F. CT chest without and with IV contrast

There is insufficient evidence to support suspected sarcopenia as a stand-alone indication for the use of chest CT without and with IV contrast. However, if serial chest CT without and with IV contrast are obtained for another clinical indication, a secondary quantitative analysis of muscle may be appropriate for imaging follow-up of sarcopenia (rather than additional re-scanning). Noncontrast images are preferred for measurements due to the variable influence of IV contrast. Compared to noncontrast CT, contrast-enhanced CT does not provide added information.

Variant 5:Adult with known sarcopenia. Surveillance.
G. CT chest without IV contrast

There is insufficient evidence to support sarcopenia surveillance as a stand-alone indication for the use of chest CT without IV contrast. However, if serial chest CT without IV contrast are already being obtained for a routine clinical indication (eg, COPD), a secondary quantitative analysis of muscle may be appropriate for imaging follow-up of sarcopenia (rather than additional re-scanning). For example, in patients with COPD already undergoing chest CTs, the longitudinal decrease in the pectoralis muscle area has been associated with mortality risk (independent of baseline muscle status, BMI, and COPD severity) [156]. However, an association between CT muscle metrics and clinical outcomes has not been established in all studies [62, 157], and deserves further study [158].

Variant 5:Adult with known sarcopenia. Surveillance.
H. DXA total body composition

DXA is usually appropriate for imaging surveillance of sarcopenia and is widely used in research settings. DXA has several advantages, including positive correlation with CT and MRI measurements in cross-sectional clinical trials. In longitudinal studies; however, DXA has not been reliable in detecting muscle changes over time when compared with CT or MRI [133-135].

For monitoring changes in lean mass with whole body DXA, consecutive-day analysis of precision error and LSC values is advocated to assess for meaningful measurement changes. Although there is limited literature on these values when surveilling patients with sarcopenia in clinical practice, the consecutive-day precision error for whole body lean mass can average approximately 925 g, with an LSC of 3.2%, in young adult resistance-trained athletes [136]. Worse precision tends to occur with longer-term follow-up [137].

Greater decline in DXA lean mass has been associated with modest increased mortality risk, but may not be associated with recurrent falls or hospital admissions [138]. Furthermore, whole body DXA measurements of lean mass declines more slowly than muscle strength [139, 140]. Currently available data suggests that combining clinical evaluation with secondary analysis of muscle on an available recent CT scan may be more appropriate than performing a new DXA scan.

Variant 5:Adult with known sarcopenia. Surveillance.
I. FDG-PET/CT whole body

There is insufficient evidence to support the use of whole body FDG-PET/CT for surveillance imaging of sarcopenia. However, CT scans are routinely performed with PET, and therefore potentially valuable CT body composition data may be extracted, such as in patients >65 years of age with Hodgkin lymphoma [161], but further research is warranted. In patients with breast cancer, for example, CT-derived metrics for muscle mass at baseline are associated increased

mortality and severe neutropenia, but there is not currently a proven association between follow-up body composition measurements and clinical outcomes [162].

Variant 5:Adult with known sarcopenia. Surveillance.
J. FDG-PET/MRI whole body

There is no relevant literature to support the use of whole body FDG-PET/MRI for surveillance imaging of sarcopenia.

Variant 5:Adult with known sarcopenia. Surveillance.
K. MRI abdomen without and with IV contrast

There is no relevant literature to support the use of abdominal MRI without and with IV contrast for surveillance imaging of sarcopenia.

Variant 5:Adult with known sarcopenia. Surveillance.
L. MRI abdomen without IV contrast

There is no relevant literature to support the use of MRI of the abdomen without IV contrast for surveillance imaging of sarcopenia.

Variant 5:Adult with known sarcopenia. Surveillance.
M. MRI chest without and with IV contrast

There is no relevant literature to support the use of chest MRI without and with IV contrast for surveillance imaging of sarcopenia.

Variant 5:Adult with known sarcopenia. Surveillance.
N. MRI chest without IV contrast

There is no relevant literature to support the use of chest MRI without IV contrast for surveillance imaging of sarcopenia.

Variant 5:Adult with known sarcopenia. Surveillance.
O. Radiography chest

There is no relevant literature to support the use of chest radiography for surveillance imaging of sarcopenia.

Variant 5:Adult with known sarcopenia. Surveillance.
P. US thigh

Thigh US, in conjunction with clinical history and physical examination, may be useful for the surveillance of sarcopenia. US is not routinely used in most practices for evaluating sarcopenia, and further standardization and validation of clinical usefulness is warranted. However, for assessment of malnutrition, US evaluation is supported by the Global Leadership Initiative on Malnutrition, particularly for repeated measurements of muscle thickness and cross-sectional area [141]. Thigh US can show dynamic changes of muscle atrophy and edema acutely during hospitalization that may be associated with poor clinical outcomes [142, 143]. Chronic longitudinal deterioration in muscle thickness and echo intensity can be observed in stroke survivors, and may help guide appropriate prescription of physical therapy [144, 145]. More research in various settings is needed to clarify the value of muscle longitudinal changes in clinical practice.

Summary of Highlights

This is a summary of the key recommendations from the variant tables. Refer to the complete narrative document for more information.

- **Variants 1-5**: DXA is usually appropriate. Thigh US, performed in conjunction with clinical history and physical examination, may be useful. There is insufficient evidence to support a stand-alone indication for the use of CT of the abdomen (with or without IV contrast) or chest (with, without and with, without IV contrast), but a secondary quantitative analysis of muscle may be appropriate using examinations obtained for another clinical indication.

Supporting Documents

The evidence table, literature search, and appendix for this topic are available at https://acsearch.acr.org/list. The appendix includes the strength of evidence assessment and the final rating round tabulations for each recommendation.

For additional information on the Appropriateness Criteria methodology and other supporting documents, please go to the ACR website at https://www.acr.org/Clinical-Resources/Clinical-Tools-and-Reference/Appropriateness-Criteria.

Gender Equality and Inclusivity Clause

The ACR acknowledges the limitations in applying inclusive language when citing research studies that predates the use of the current understanding of language inclusive of diversity in sex, intersex, gender, and gender-diverse people. The data variables regarding sex and gender used in the cited literature will not be changed. However, this guideline will use the terminology and definitions as proposed by the National Institutes of Health.

Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, because of both organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared with those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document.

Relative Radiation Level Designations

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
O	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢☢	0.1-1 mSv	0.03-0.3 mSv
☢☢☢	1-10 mSv	0.3-3 mSv
☢☢☢☢	10-30 mSv	3-10 mSv
☢☢☢☢☢	30-100 mSv	10-30 mSv

*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (e.g., region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as “Varies.”

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Disclaimer

condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.

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