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Authors

Priester, Jacob I

Simister, Samuel K

Sario, Matthew

et al.

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RESEARCH ARTICLE

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Scrutinizing the use of contrasted chest CTs in extremity sarcoma staging and surveillance

Jacob I. Priester MD[1] | Samuel K. Simister MD, MBA[1] | Matthew Sario BS[1] | Justin Choi BS[2] | Dagoberto Pina BS[1] | Raminta Theriault MD[3] | Cyrus Bateni MD[4] | Ahmadreza Ghasemiesfe MD[2] | Janai Carr-Ascher MD[1,5] | Arta M. Monjazeb MD, PhD[1,6] | Robert J. Canter MD[7] | R. L. Randall MD[1] | Steven W. Thorpe MD[1]

[1]Department of Orthopaedic Surgery, University of California, Davis, Sacramento, California, USA

[2]Department of Radiology, Cardiothoracic Imaging, University of California, Davis, Sacramento, California, USA

[3]Department of Orthopaedic Surgery, Ochsner Medical Center, New Orleans, Louisiana, USA

[4]Department of Radiology, Musculoskeletal Radiology, University of California, Davis, Sacramento, California, USA

[5]Department of Internal Medicine, Hematology and Oncology, University of California, Davis, Sacramento, California, USA

[6]Department of Radiation Oncology, University of California, Davis, Sacramento, California, USA

[7]Department of Surgery, Surgical Oncology, University of California, Davis, Sacramento, California, USA

Correspondence
Steven W. Thorpe, MD, 4860 Y St, Suite 3800, Sacramento, CA 95817, USA.
Email: thorpe@ucdavis.edu

Abstract

Background: Since 2015, the American College of Radiology (ACR) has recommended staging for lung metastasis via chest computed tomography (CT) without contrast for extremity sarcoma staging and surveillance. The purpose of this study was to determine our institutional compliance with this recommendation.

Methods: This was a retrospective chart review of patients diagnosed with sarcoma in the extremities who received CT imaging of the chest for pulmonary staging and surveillance at our institution from 2005 to 2023. A total of 1916 CT studies were included for analysis. We scrutinized ordering patterns before and after 2015 based on the ACR-published metastasis staging and screening guidelines. An institutional and patient cost analysis was performed between CT modalities.

Results: The prevalence of CT scans ordered and performed with contrast was greater than those without contrast both prior and post-ACR 2015 guidelines. Furthermore, 79.2% of patient's final surveillance CTs after 2015 were performed with contrast. A cost analysis was performed and demonstrated an additional $297 704 in patient and institutional costs.

Conclusions: At our institution, upon review of CT chest imaging for pulmonary staging and surveillance in patients with extremity sarcoma the use of contrast has been routinely utilized despite a lack of evidence for its necessity and contrary to ACR guidelines.

KEYWORDS

sarcoma, surveillance chest imaging, extremity sarcoma, sarcoma guideline based care

1 | INTRODUCTION

It has been well established that the most common site of distant metastasis for bone and soft tissue sarcoma of the extremity is the lungs.[1] As a result, National Comprehensive Cancer Network (NCCN) guidelines recommend chest imaging (which often is computed tomography [CT]) for surveillance in patients diagnosed with bone and soft tissue sarcomas. Furthermore, these guidelines state that CT without contrast is preferred, but CT with contrast can be used if "clinically indicated."[2-5] In these guidelines, the term "chest imaging" is utilized due to the controversy surrounding the clinical utility of chest CT over chest radiographs for sarcoma surveillance, which is

being scrutinized in The Surveillance After Extremity Tumor Surgery trial.[6] While sarcoma surgeons in the United States are most likely to refer to the NCCN guidelines for chest imaging of staging and screening for bone and soft tissue sarcoma, the guidelines lack the specificity of which modality should be ordered. This can lead to confusion as to whether a CT of the chest with contrast is "indicated" and can lead to improper practice guidelines.[7,8]

On the other hand, the American College of Radiology (ACR) has a much more specific recommendation for surveillance studies. Their published guidelines from 2015 recommended staging for lung metastasis with CT without contrast both at the time of diagnosis and in the 3–6-month period following systemic treatment or surgery.[9] These recommendations are based on the opinion that CT with contrast is unnecessary because bone and soft tissue sarcomas rarely metastasize to nonpulmonary locations in the chest such as the mediastinum, where traditionally the use of contrast may provide benefit in the identification of soft tissue masses including lymphadenopathy or solid organ involvement.[2,10] The use of contrast is also not without risk, including the risk of impaired renal function, allergic reactions, and potential additional costs with its use.[10] Following the recommendations of the NCCN and ACR, other international review boards, such as the Indian College of Radiology, have adopted these same recommendations.[11] We have anecdotally observed that there is relatively high utilization of contrast when ordering CT scans for staging and surveillance studies in patients with extremity sarcomas despite these national and international recommendations against its regular use.

Currently, there is no definitive evidence to demonstrate any clinical or diagnostic benefit for the routine use of contrast-enhanced CT chest imaging in the management of patients with extremity sarcomas. The primary benefit of contrast in CT chest imaging traditionally has been to further characterize vascular and pleural diseases, both of which do not have significant clinical relevance to the management of sarcomas.[12]

In addition to a lack of evidence for its routine use, there may be additional financial costs and logistical scheduling considerations when ordering CT chest examinations with contrast. There is a paucity of research that directly compares the efficacy of CT without contrast to CT with contrast for screening purposes in the sarcoma population.[13,14]

The purpose of this study is to evaluate the frequency of ordering chest CT with and without contrast at our institution for both staging and surveillance studies in patients with extremity sarcomas. A secondary aim of our study was to determine the potential added cost of the use of contrast routinely in CT chest imaging. Our hypothesis is that there would be high utilization of contrast-enhanced CT chest imaging despite the lack of support for this practice in the national guidelines and literature with no additional benefit. Furthermore, we hypothesized that this would increase costs to the healthcare system while decreasing the efficiency in addition to adding burden to the patient.

2 | METHODS

Institutional Review Board approval was obtained before the start of this retrospective chart review of extremity sarcoma patients at our institution from 2005 to June 2023. The initial cohort of patients included 703 patients at our institution diagnosed with extremity bone or soft tissue sarcoma. The inclusion criteria were a diagnosis of extremity bone or soft tissue sarcoma, a history of chest CT for staging and at least once for surveillance performed at our institution, and an age greater than 18 years old at the time of diagnosis. There was no minimum follow-up requirement for inclusion in this study. Exclusion criteria included patients with low-grade sarcoma, patients with a chest CT from an outside institution, CT studies that included the abdomen/pelvis (which automatically receive contrast), and patients with the diagnosis of myxoid liposarcoma or atypical lipomatous tumor/well-differentiated liposarcoma (the management of these differs from the norm). After the application of our inclusion and exclusion criteria, a total of 269 patients (38.3%) were included for further analysis (Figure 1). Diagnosis of sarcoma was confirmed with a prior biopsy in 250 of the 269 patients included.

Descriptive statistics were analyzed for basic patient demographics, and the sarcoma histologic subtype for each patient was determined via chart review. Current Procedural Terminology codes were used for identifying staging and surveillance procedures between the ordering and final provider and comparing with and without contrast. We further stratified the imaging data by the year it was ordered to determine patterns of use with the release of the ACR sarcoma screening guidelines (2015) and after the initiation of the present study (2020). Additionally, to better describe CT interpretations, imaging for all patients was reviewed for pulmonary nodules by the authors of the present study. Pulmonary nodules that were described as "metastasis" were further explored to include plurality, size, common descriptors, and evidence of enhancement.

Our secondary analysis explored costs and adverse events. Referencing our institution's master charge list, we determined that a CT of the chest without contrast costs $3979, whereas a CT of the chest with contrast costs $4178. Using this information, we calculated the total cost incurred to both the individual patient and the institution during the study period based on the total number of CT chest obtained without comparing with contrast for each patient. In addition, we identified any adverse events associated with the use of non-ionic contrast, including rash, renal injury, and anaphylaxis.[15,16]

Primary analysis of all data was completed with descriptive statistics. Evaluation of CT scans by year was completed between three time periods (pre-2015, 2015–2019, and 2020-present) utilizing one-way analysis of variance (ANOVA) and post hoc Tukey tests for significance. Given the low frequency of identification of enhancement or indeterminate nodules, we were unable to use this metric for comparison of the efficacy of the imaging modalities when characterizing pulmonary nodules in our cohort. Additional testing for significance included utilizing χ^2, Fischer-exact tests, or independent *t*-tests depending on the appropriate variable. All analyses were

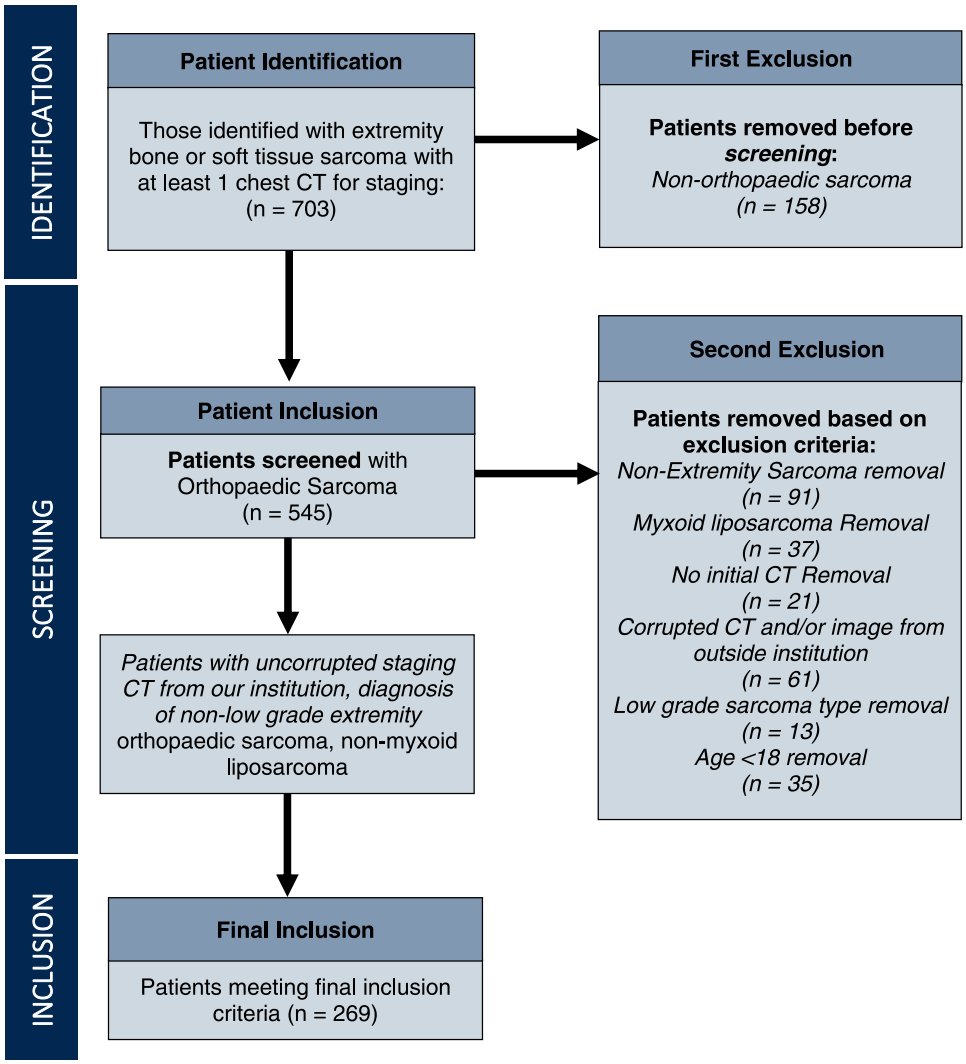

FIGURE 1 Study cohort inclusion and exclusion criteria. CT, computed tomography.

TABLE 1 Overall CT criteria, 2005–2023.

Criteria	Number patients	Relative percentage (%), *N* = 268
Patients staging CT ordered with contrast	213	79.2
Patients staging CT ordered without	56	2.8
Patients receiving contrast, any CT	247	91.8

Note: This table describes the total number of patients receiving CT with contrast at any point during staging or surveillance. It also compares the initial staging CT modality being ordered with or without contrast.

Abbreviation: CT, computed tomography.

completed with SAS® Studio software (SAS Institute Inc.), with significance being calculated at a *p*-value of 0.05.

3 | RESULTS

Within our population, the vast majority (79.2%) of CT imaging for staging/screening was ordered with contrast (Table 1). Over the study period, 2005 to June 2023, there was a continual decrease in the percentage of CT scans ordered with contrast; a year-by-year summary of all CT scans ordered between is shown in Figure 2. Overall, the mean number of total chest CT exams ordered (with and without contrast) was 7.1 per patient. Upon further analysis, the mean number of chest CTs with contrast was 5.6 per patient compared to a mean number of chest CTs without contrast of 1.6 per patient. When the cohort was analyzed, we found that 247 patients (91.8% of the total) had at least one chest CT with contrast during the study period. The most frequent biopsy-proven diagnosis in our

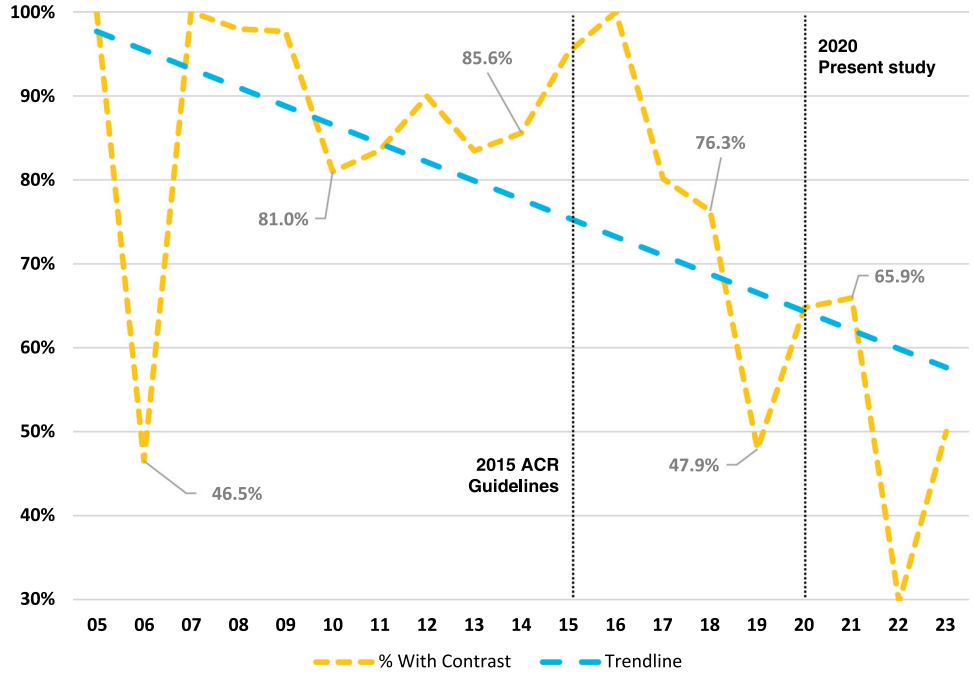

FIGURE 2 A year-by-year summary of CT scans. These figures demonstrate CT ordering tendencies from 2005 to 2023 as a percentage of CTs with contrast and its associated trendline. ACR, American College of Radiology; CT, computed tomography.

TABLE 2 Frequency of tumor diagnoses.

Histological diagnosis	Frequency	Percent of total (%), *N* = 250
Undifferentiated pleomorphic sarcoma	74	29.6
Myxofibrosarcoma	35	14.0
Soft tissue leiomyosarcoma	23	9.2
Extremity synovial sarcoma	23	9.2
Ewing's sarcoma	21	8.4
Osteosarcoma	19	7.6
Dedifferentiated liposarcoma	15	6.0
Malignant peripheral nerve sheath tumor	6	2.4
Myxoid chondrosarcoma	6	2.4
Angiosarcoma	5	2.0
Chondrosarcoma	4	1.6
High-grade soft tissue sarcoma	3	1.2
Epithelioid sarcoma	3	1.2
Undifferentiated spindle cell sarcoma	3	1.2

Note: This table describes the frequency of various biopsy-proven extremity soft tissue sarcoma types within our patient population. Missing 11 characterized cancer types as there were no biopsies affiliated with these patients.

cohort was undifferentiated pleomorphic sarcoma (29.6%), the next most common were myxofibrosarcoma and soft tissue leiomyosarcoma, 14.0% and 9.2%, respectively (Table 2).

Imaging study ordering tendencies were then stratified into three periods: (1) 2005–2014, before the ACR screening guidelines, (2) 2015–2019, after the ACR screening guidelines but before this study, and (3) 2020–2023, after initiation of the present study. According to these, 85.4% ("05–"14), 78.4% ("15–"19), and 58.2% ("20–"23) of all CTs were ordered with contrast, including 7.76, 5.39, and 2.75 average per patient, respectively. The difference between these groups was significantly different by one-way ANOVA, $p = <0.001$. Additionally, the Tukey post hoc tests showed that the average number of CT scans with contrast was significantly higher in the pre-2015 group, when compared to the "14–"19 and "20–"23 groups ($p = 0.022$, <0.001). This analysis also showed that the "14–"19 group was significantly higher than the "20–"23 group ($p = 0.017$). Conversely, the average CT without contrast per patient for these groups was not statistically significant at 1.32, 1.48, and 1.97, respectively. Lastly, when analyzing the ACR guidelines and this study as interventions, both periods ("14–"19 vs. "05–"14 and "20–"23 vs. "05–"19) saw a significant decrease in the number of CTs ordered with contrast (ACR guides, $p = 0.021$; present study, $p = <0.001$; see Table 3) but not without. Lastly, we recorded imaging tendencies for CT screen orders and the final CT provided.

Finally, an analysis of order alteration from noncontrast to contrast studies was completed. We found that 13 initial CT orders were overridden from CT without contrast to CT with contrast by a

provider in the radiology department when protocolling the study. This led to the protocol of subsequent CT studies being altered from without contrast to with contrast by radiology attending or resident 57 times throughout the study period. The findings of these changes as described by our three study periods are shown in Figure 3.

In the present study, 120 patients were noted to have a nodule on CT imaging, and 78.3% of these were imaged with contrast however, this was not significant ($p = 0.437$). Fifty two of the patients had a nodule < 5 mm, with 77.6% of these imaged with contrast ($p = 0.308$). Finally, 85 patients were noted to have multiple metastases, with 77.6% of these imaged with contrast ($p = 0.903$, Table 4). Radiology interpretations were also reviewed to attempt radiologist characterization of nodules on the basis of contrast enhancement, but this did not appear clinically valuable as the data collected contained sparse mention of any characteristics other than size, including density or shape (Table 5). Only 32 patients had subcentimeter nodules on their initial CT, and only 4 of these patients (12.5%) were later diagnosed with sarcoma metastasis. Most patients (87.5%) with indeterminate nodules identified on initial imaging did not develop documented metastatic disease within our observational study period. All the patients who ultimately were identified as having metastatic disease did undergo chest CT with contrast. Importantly, there was no specific mention of indications for needing a contrast-enhanced study as necessary to better characterize any

TABLE 3 Comparison of CT scans within three time periods.

	Mean ± SD	p
With contrast		
2005–2014	7.76 ± 8.53	<0.001
2015–2019	5.39 ± 4.68	
2020–2023	2.75 ± 2.64	
Without		
2005–2014	1.32 ± 3.27	0.336
2015–2019	1.48 ± 3.24	
2020–2023	1.97 ± 2.2	
Intervention comparison		
2015–2019 vs. 2005–2014	With	0.021
	Without	0.736
2020–2023 vs. 2005–2019	With	<0.001
	Without	0.152

Note: Initial comparison completed with one-way analysis of variance. Intervention comparison completed with independent *t* tests.

Abbreviation: CT, computed tomography.

TABLE 4 Description of chest CT nodules.

Description	With contrast	Without	p
Nodule visualized on CT	78.3% (94/120)	21.7% (26/120)	0.437
Nodule size ≤ 5 mm	82.7% (43/52)	17.3% (9/52)	0.308
Multiple metastasis visualized	77.6% (66/85)	22.4% (19/85)	0.903

Note: Analysis includes comparing nodules called metastasis as visualized on review of previous radiology interpretation, both with and without contrast, according to any diagnosis, nodule called, nodule size < 5 mm, or multiple metastases noted. $\alpha = 0.05$.

Abbreviation: CT, computed tomography.

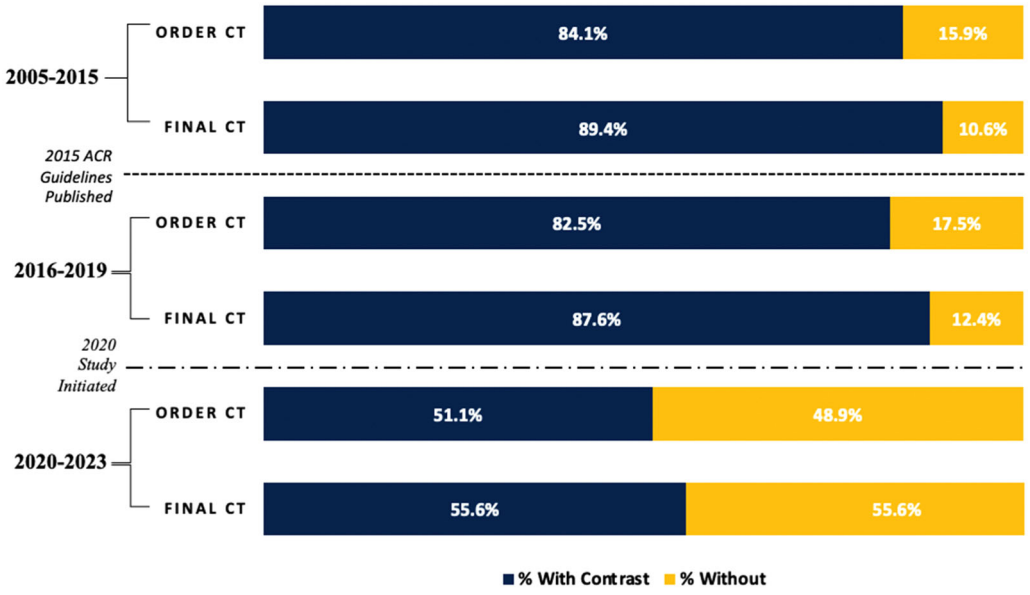

FIGURE 3 Initial versus final CT orders over three different time periods. A comparison of ordering habits over three timelines: (1) 2005–2015: before the ACR guidelines were published. (2) 2016–2019: after guidelines published. (3) 2020–2023: after initiation of this study. ACR, American College of Radiology; CT, computed tomography.

TABLE 5 Common descriptions of nodules as noted by the radiologist interpretation.

Common nodule descriptors	*n* = 120
Ground-glass	7
Round	6
Well-circumscribed	6
Irregular	5
Solid	5
Triangular	5
Calcified	4
Indeterminate	4

TABLE 6 Cost analysis of CT scans.

Modality	Total studies	Facility cost
CT with contrast	1496	$4178
CT without contrast	420	$3979
Total cost to the institution: $297 704		
The average cost to the patient: $1107		

Note: A cost analysis of unnecessary costs incurred to both the individual patient and the institution, at the assumption that CTs with contrast cost on average $199 more than CTs without.

Abbreviation: CT, computed tomography.

lesion. More specifically, in any patient with pleural or mediastinal nodules, it was never specified that CT with contrast was ordered to enhance the characterization of these lesions.

In a subsequent analysis, we found that a total of three contrast-related adverse events were noted in the entire study period, all being rashes. No patient ever experienced anaphylaxis or acute renal injury. The results of this analysis were not determined to be statistically significant due to the lack of overall events included for analysis. Of note, no patient had a documented history of contrast allergy in the EMR before administration of contrast and the subsequent development of a rash. Further, no patient who underwent CT without contrast had an indication listed as any variation of "unable to undergo CT with contrast due to renal insufficiency."

For our secondary analysis, the total cost of imaging with and without contrast was compared (Table 6). Overall, the base cost difference between chest CT without vs with contrast was determined to be $199 based on pricing at our institution. We were able to extrapolate the average potential unnecessary incurred cost per patient ($1107) by combining the cost difference of adding contrast only between protocols and using the frequency of protocol-specific imaging per patient data. Importantly, this does not consider additional laboratory studies or personnel needs that would normally be required for contrasted studies. Furthermore, the calculated total institutional cost incurred by ordering 1496 chest CTs with contrast was around $297 704 (Table 6).

4 | DISCUSSION

This study was conducted to characterize the ordering patterns of the utilization of contrast in chest CT imaging for metastasis staging and screening with chest CT studies for patients diagnosed with extremity bone and soft tissue sarcomas at our institution. We hypothesized that there was an unnecessary frequency of ordering chest CTs with contrast that did not comply with the 2015 ACR recommendations published on extremity sarcoma metastasis screening at our institution. Importantly, we could not find any published studies demonstrating efficacy or even evaluating contrast utilization in chest imaging for patients with extremity sarcomas. The present study found a 79.2% rate of ordering CT scans with contrast at our institution, even after the publication of the 2015 ACR recommendations. Additionally, while our study was not specific to detecting the efficacy of contrast in sarcoma surveillance, we did not detect any notable benefit to the use of contrast in terms of nodule characterization. Instead, the practice of ordering chest CTs with contrast likely only adds unnecessary direct and indirect, unrealized costs to hospital systems and patients.

In the present study, before 2015, most of the patients in our cohort (91.8%) had at least one CT with contrast, and 79.2% of the cohort's initial screening chest CT was ordered with contrast. Furthermore, with the release of the ACR recommendations in 2015, a significant difference was notable statistically but did only mildly affect total percentages (Figure 3). To further understand these numbers, we also explored the specialty of providers' CT orders, which is represented in Figure 4. The high utilization of contrast was not limited to one department with most providers across all specialties ordering a chest CT with contrast for staging purposes at our institution. This represents an area that our institution could specifically target to improve compliance with ACR guidelines, although this did not account for most contrast studies performed. Importantly, this speaks to the idea that the guidelines published by both the ACR and NCCN were not regularly referenced when providers were ordering these studies. Additionally, there is an opportunity to significantly reduce the unsupported use of contrast with chest CT scans for sarcoma surveillance.

In an era in healthcare where cost utilization is of increasing importance, the results of our value analysis demonstrate that improving compliance with the ACR guidelines at our institution could represent an area for cost-of-care improvement, not only for our patients but also for the institution. Importantly, we found that the initiation of the present study was significantly associated with fewer orders of CT scans with contrast, 83.2% (before) and 55.6% (after) for STS surveillance. In exploring the costs further, our analysis found that over the period of our study, institution and individual patients may have incurred up to $ 297,704 in unnecessary costs over the study period. Additionally, there are likely unrealized costs due to the increased burdens on schedule and patients due to lower efficiency in scheduling scans that require the personnel and equipment for contrast administration. This also does not account for costs associated with additional laboratory exams, such as personnel time, delayed scheduling, or patient satisfaction.

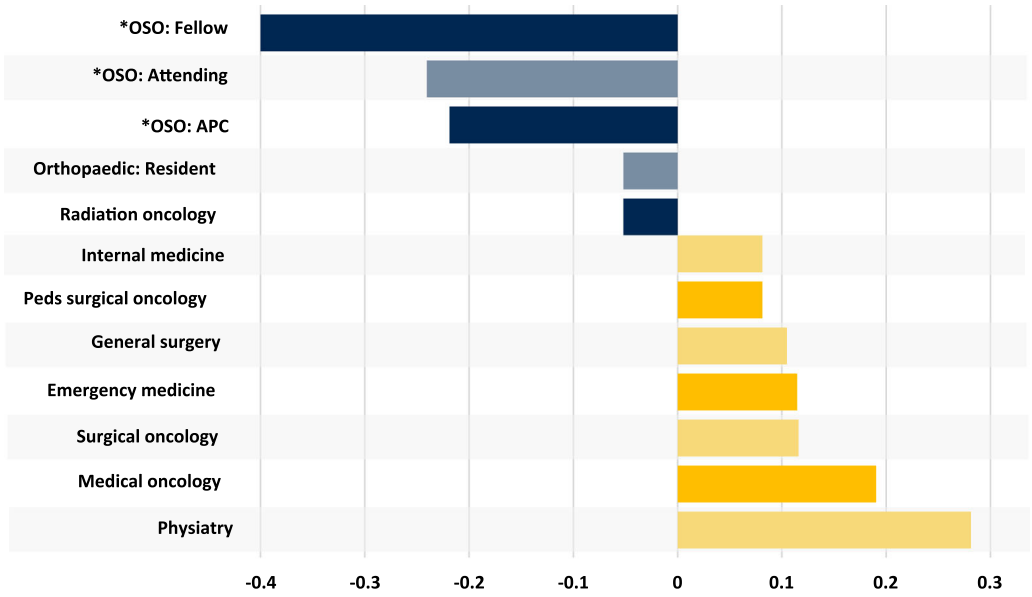

FIGURE 4 Comparison of CT ordering by specialty. Value is listed as the difference from the average of all groups when considering the percentage of CTs ordered compared to the total CTs ordered (with and without). Average of all orthopedic oncology, −23%. CT, computed tomography; *OSO, orthopedic surgical oncology. *APC, advanced practice clinician (e.g., NP or PA)

As described, no prior study has demonstrated the superiority of CT with contrast for extremity sarcoma staging or screening.[17] In fact, the National Cancer Institute performed the National Lung Screening Trial to determine the most effective dose of radiation for lung metastasis screening regardless of cancer type and all studies were performed without contrast.[18] There have been studies that have established the ability of low-dose CT to detect pulmonary nodules compared to traditional "high dose" studies, but there was no comparison of with and without contrast.[19] Furthermore, in this study, there were very few mentions of "enhancement" and the modality of imaging did not impact the interpretation of any nodules interpreted on CT exams, including those less than 5 mm in size.

Our study does have limitations. First, it is an isolated retrospective review of a single institution, which was primarily based on existing radiology interpretations rather than overreads by the authors. This also means the present study was not powered to statistically analyze the efficacy of contrast utilization in the screening and surveillance of extremity sarcomas. Second, the uneven distribution of imaging modalities at our institution limited the type of statistical analyses that we could perform, which included an overall lack of many non-contrast chest CTs to compare assessment of nodules between imaging modalities. Nodule characteristics are important to consider in future studies, as even indeterminate nodules (<5 mm) have been shown to progress to metastatic disease.[20] Third, our analysis of contrast-related adverse events was limited by a small incidence of adverse events, and therefore, we were unable to determine any significance from these events. Fourth, our secondary analysis of cost-related considerations is limited to the direct costs realized in contrast materials, which do not include patient, personnel, hospital system, or insurance considerations. Although we believe our study shows adequate evidence for the reduction in utilizing contrast in chest CTs for extremity sarcomas, future studies would need to examine additional costs and the efficacy of nodule identification with and without contrast.

5 | CONCLUSION

This single-institution study demonstrated high utilization of contrast in chest CT imaging in extremity sarcoma patients, which is against recommendations established in 2015 by the ACR. We demonstrated minimal change in the ordering patterns after the release of the ACR guidelines, which was significantly improved after the initiation of the present study. The results of our study represent an area for improvement that may have a significant impact on reducing healthcare utilization at other institutions, where multidisciplinary education should be conducted to improve guideline adherence. Future prospective multicenter studies are required to definitively show the noninferiority of noncontrasted versus contrast chest CT imaging in the staging and surveillance of extremity sarcoma metastasis with chest CT.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions

ORCID

Jacob I. Priester http://orcid.org/0000-0001-6954-9219
Samuel K. Simister http://orcid.org/0000-0001-6441-7815
Robert J. Canter http://orcid.org/0000-0002-3331-5418

R. L. Randall http://orcid.org/0000-0002-3660-774X
Steven W. Thorpe http://orcid.org/0000-0003-3127-4912

REFERENCES

1. Billingsley KG, Burt ME, Jara E, et al. Pulmonary metastases from soft tissue sarcoma: analysis of patterns of disease and postmetastasis survival. *Ann Surg*. 1999;229(5):602-612.
2. Digesu CS, Wiesel O, Vaporciyan AA, Colson YL. Management of sarcoma metastases to the lung. *Surg Oncol Clin N Am*. 2016;25(4):721-733.
3. Dangoor A, Seddon B, Gerrand C, Grimer R, Whelan J, Judson I. UK guidelines for the management of soft tissue sarcomas. *Clin Sarcoma Res*. 2016;6:20.
4. National Comprehensive Cancer Network.*NCCN Clinical Practice Guidelines in Oncology Bone Cancer (Version 2.2023)*. National Comprehensive Cancer Network; 2022.
5. National Comprehensive Cancer Network. NCCN Clinical Practice Guidelines in Oncology. Soft tissue sarcoma (Version 2.2022). Accessed December 4, 2022. https://www.nccn.org/professionals/physician_gls/pdf/sarcoma.pdf
6. SAFETY Investigators. The Surveillance After Extremity Tumor Surgery (SAFETY) trial: protocol for a pilot study to determine the feasibility of a multi-centre randomised controlled trial. *BMJ Open*. 2019;9(9):e029054. doi:10.1136/bmjopen-2019-029054
7. Dabrowska M, Krenke R, Korczynski P, Maskey-Warzechowska M, et al. Diagnostic accuracy of contrast-enhanced computed tomography and positron emission tomography with 18-FDG in identifying malignant solitary pulmonary nodules. *Medicine (Baltimore)*. 2015;94(15):e666
8. Swensen SJ, Brown LR, Colby TV, Weaver AL. Pulmonary nodules: CT evaluation of enhancement with iodinated contrast material. *Radiology*. 1995;194(2):393-398.
9. Roberts CC, Kransdorf MJ, Beaman FD, et al. ACR appropriateness criteria follow-up of malignant or aggressive musculoskeletal tumors. *J Am Coll Radiol*. 2016;13(4):389-400. doi:10.1016/j.jacr.2015.12.019
10. Dobbs MD, Lowas SR, Hernanz-Schulman M, Holt GE, Yu C, Kan JH. Impact of abdominopelvic CT on Ewing sarcoma management. *Acad Radiol*. 2010;17(10):1288-1291.
11. Bhalla AS, Das A, Naranje P, Irodi A, Raj V, Goyal A. Imaging protocols for CT chest: a recommendation. *Indian J Radiol Imaging*. 2019;29(3):236-246. doi:10.4103/ijri.IJRI_34_19. National Lung Screening Trial Research Team, Aberle DR, Adams AM, et al. Reduced lung-cancer mortality with low-dose computed tomographic screening. *N Engl J Med*. 2011;365(5):395-409.
12. Hochhegger B, Rottenfusser R, Marchiori E. When is the use of contrast media in chest CT indicated? *J Bras Pneumol*. 2017;43(5):400. doi:10.1590/S1806-37562017000000179
13. Purysko CP, Renapurkar R, Bolen MA. When does chest CT require contrast enhancement? *Cleve Clin J Med*. 2016;83(6):423-426. doi:10.3949/ccjm.83a.15037
14. Swensen SJ, Morin RL, Schueler BA, et al. Solitary pulmonary nodule: CT evaluation of enhancement with iodinated contrast material—a preliminary report. *Radiology*. 1992;182(2):343-347. doi:10.1148/radiology.182.2.1732947
15. Bottinor W, Polkampally P, Jovin I. Adverse reactions to iodinated contrast media. *Int J Angiol*. 2013;22(3):149-154.
16. Utter DP. Survey of contrast media use in southeastern U.S. hospitals. *Radiol Technol*. 1997;68(5):386-390.
17. Yi CA, Lee KS, Kim EA, et al. Solitary pulmonary nodules: dynamic enhanced multi-detector row CT study and comparison with vascular endothelial growth factor and microvessel density. *Radiology*. 2004;233(1):191-199. doi:10.1148/radiol.2331031535
18. National Lung Screening Trial Research Team, Aberle DR, Adams AM, et al. Reduced lung-cancer mortality with low-dose computed tomographic screening. *N Engl J Med*. 2011;365(5):395-409. doi:10.1056/NEJMoa1102873
19. Gartenschläger M, Schweden F, Gast K, et al. Pulmonary nodules: detection with low-dose vs conventional-dose spiral CT. *Eur Radiol*. 1998;8(4):609-614. doi:10.1007/s003300050445
20. Rissing S, Rougraff BT, Davis K. Indeterminate pulmonary nodules in patients with sarcoma affect survival. *Clin Orthop Relat Res*. 2007;459:118-121.

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