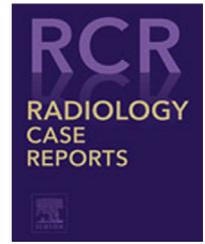


Available online at [www.sciencedirect.com](http://www.sciencedirect.com)

ScienceDirect

journal homepage: [www.elsevier.com/locate/radcr](http://www.elsevier.com/locate/radcr)

## Case Report

# Pseudo fat-saturated appearance of magnetic resonance head and neck images in 2 cachectic patients ☆,☆☆

Vibeeshan Jegatheeswaran, BHSc<sup>a</sup>, Michael Chan, MD<sup>a,b</sup>, Walter Kucharczyk, MD<sup>a,c</sup>, Yingming Amy Chen, MD<sup>a,b,\*</sup>

<sup>a</sup> University of Toronto, 27 King's College Cir, Toronto, Ontario, Canada

<sup>b</sup> Trillium Health Partners, 100 Queensway W, Mississauga, ON L5B 1B8, Canada

<sup>c</sup> Joint Department of Medical Imaging, University Health Network, Toronto, Ontario, Canada

## ARTICLE INFO

## Article history:

Received 9 September 2020

Revised 10 October 2020

Accepted 10 October 2020

## Keywords:

Cachexia

Orbits

MRI technique

Cancer imaging

## ABSTRACT

Cachexia is a significant contributor to cancer mortality as it is responsible for up to 30% of cancer deaths. Magnetic resonance imaging offers a noninvasive approach to detect features of cachexia. T1-weighted images of cachectic patients have a “pseudo fat-saturated” appearance secondary to disappearance of subcutaneous and fascial fat throughout the body, as well as fat in the bone marrow. Orbital fat remains preserved until late disease. We present 2 cases with these classic imaging findings of cancer cachexia in the subcutaneous tissues of the head, neck, and spine. This imaging phenomenon is often misinterpreted by radiologists and may lead to delayed diagnosis or unnecessary repeat imaging.

© 2020 Published by Elsevier Inc. on behalf of University of Washington.

This is an open access article under the CC BY-NC-ND license

(<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

## Introduction

Cachexia is a wasting syndrome that is characterized by anorexia and marked progressive loss of adipose tissue and muscle mass. It has been estimated that at the time of death, over 50% of cancer patients are cachectic [1]. Notably, cachexia is responsible for up to 30% of cancer deaths [2]. It has a complex underlying pathophysiology driven by tumor-induced metabolic and hormonal dysregulation, leading to imbalanced

energy use [3]. Cachexia is shown to be associated with diminished tolerance to and effect of cancer treatment, as well as reduced quality and quantity of life [4]. As such it is an important aspect to identify in cancer patients. Non-invasive imaging provides a safe method to detect certain features of cachexia. For instance, magnetic resonance imaging (MRI) studies of cachectic patients have a unique “pseudo fat-saturated” appearance. Although characteristic, this finding can frequently be misinterpreted. We present 2 cases with this classic, but often misdiagnosed, imaging finding of cancer cachexia.

☆ We are writing to notify you that informed consent for publication of their case was obtained from the patients.

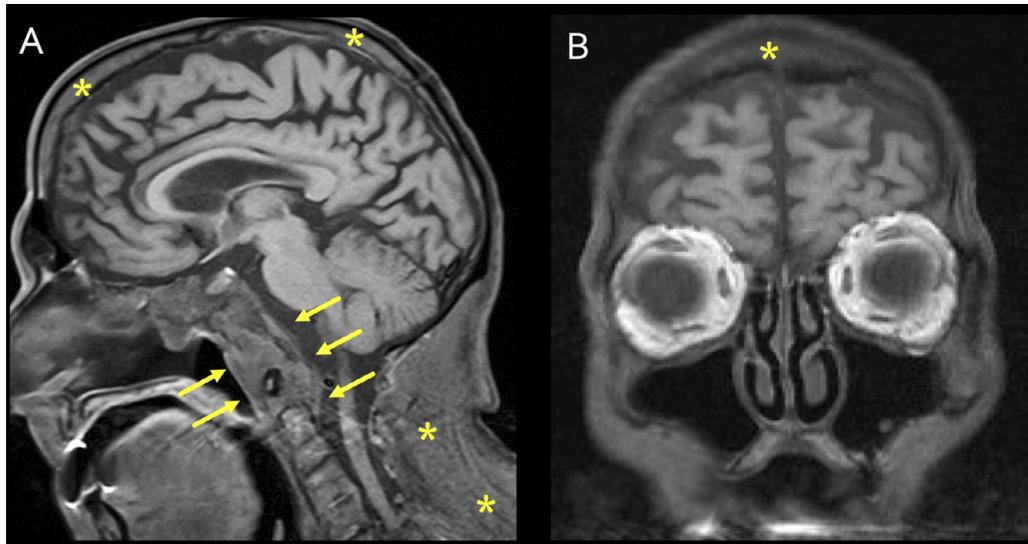
☆☆ Competing Interests: The authors have declared that no competing interests exist.

\* Corresponding author.

E-mail address: [yingmingamy.chen@thp.ca](mailto:yingmingamy.chen@thp.ca) (Y.A. Chen).

<https://doi.org/10.1016/j.radcr.2020.10.022>

1930-0433/© 2020 Published by Elsevier Inc. on behalf of University of Washington. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>)



**Fig. 1 – Case 1: Three weeks after presentation during the same admission, sagittal (A) and coronal (B) nonfat saturated T1-weighted MRI images through the head demonstrate diffuse hypointensity of the scalp, neck soft tissue, and calvarial marrow (\*). Bilateral orbital fat remained hyperintense (B). A large nasopharyngeal tumor infiltrating the skull base (arrows) is seen in (A).**

## Case report

### Case 1

A 74-year-old male with no previous history of malignancy, presented to the emergency department with multiple falls and 30-pound weight loss over 6 months. At the time of presentation he appeared cachectic and had a body mass index of 14.2 kg/m<sup>2</sup>. MRI head during admission revealed a large nasopharyngeal mass with extensive skull base invasion (Fig. 1). The T1-weighted images demonstrated diffusely hypointense signal within the scalp, neck tissue, and bone marrow, resembling a fat-saturated sequence (Fig. 1). However, the bilateral orbital fat remained hyperintense. The scan parameters were reviewed to ensure the correct TR and TE times (492 ms/11 ms) and to confirm that a fat suppression technique was not used. The infratemporal fat appeared preserved on computed tomography (CT) (Fig. 2) but demonstrated T1 hypointensity and T2 hyperintensity. There was also avid post-gadolinium enhancement in this region, which likely reflects a state of active lipolysis with edema/inflammation.

Correlation with CT head and body scans from the same admission confirmed findings of extreme cachexia, with near-complete absence of subcutaneous fat in the scalp and body wall (Fig. 3). Residual subcutaneous and visceral fat were found in classic locations of brown adipose tissue (axilla, supra- and infraclavicular fossa, around solid organs) and demonstrated increased density, which is thought to reflect smaller fat cell size with inflammatory/edematous change during lipolysis [5]. This patient declined treatment and died 2 months later with palliative measures.

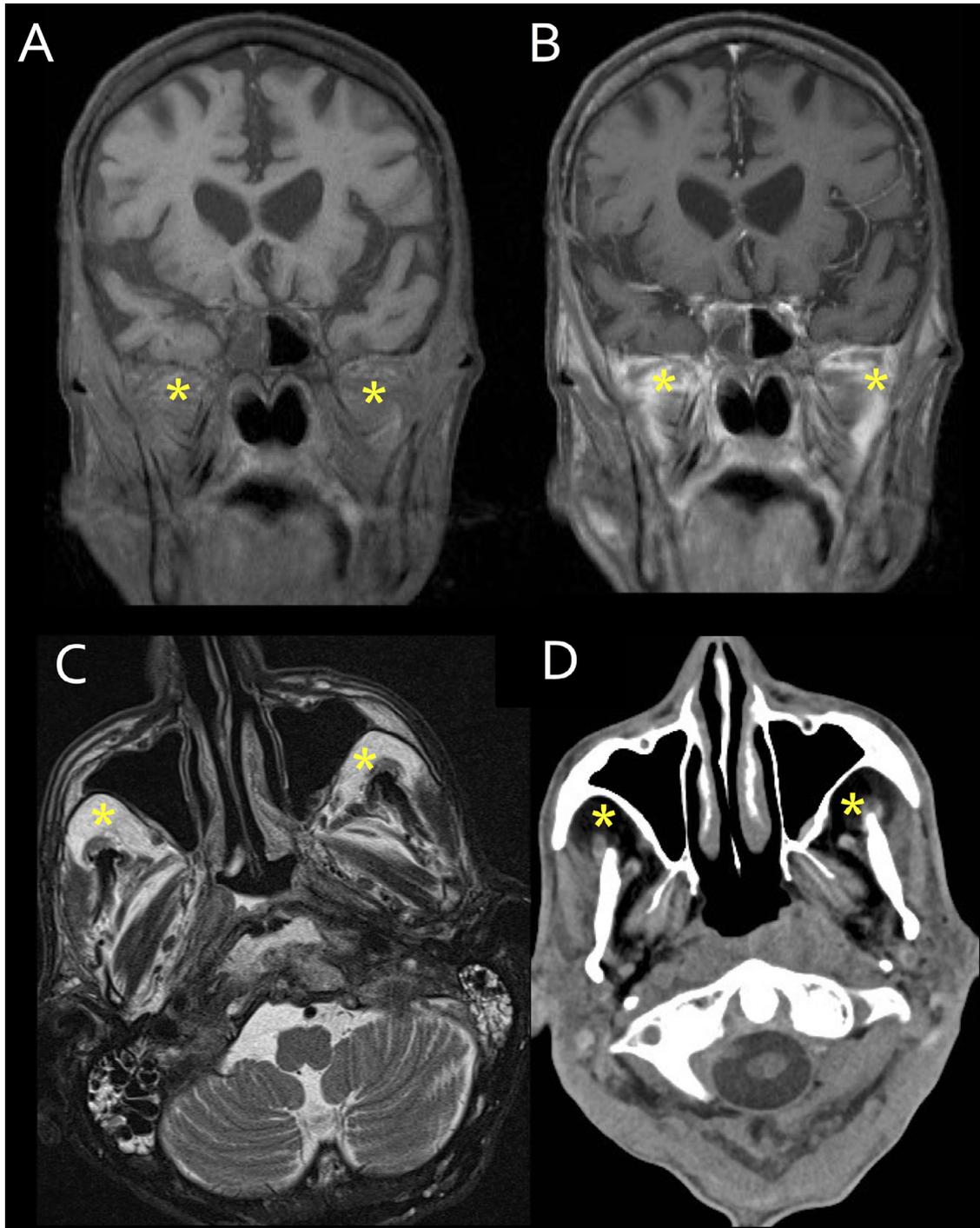
### Case 2

A 66-year-old male with a known history of metastatic bladder cancer experienced progressive weight loss of 10 pounds over a span of 6 months. Body mass index at first diagnosis was 19.9 kg/m<sup>2</sup>, down to 18.5 kg/m<sup>2</sup> 6 months later. Initial MRI images of the head showed a relatively normal amount of scalp and neck subcutaneous fat (Fig. 4). However, follow-up images of the head 6 months later acquired using conventional non-fat-saturated T1-weighted technique (TR 448 ms/TE 8.4 ms) showed total disappearance of subcutaneous fat and diffuse T1-hypointensity of bone marrow, simulating fat-saturated images (Fig. 5). Similar to the first case there is preservation of orbital fat. This patient ultimately underwent chemotherapy.

## Discussion

Our cases illustrate the characteristic imaging features of long-term cachexia. In both cases, T1-weighted images demonstrated the absence of the usual high signal of the subcutaneous fat in the scalp, fat in the fascial planes of the face and neck, and fat in the bone marrow, yielding an appearance typically seen on fat-saturated images. This pseudo fat-saturated appearance is secondary to near complete disappearance of adipose tissue and is characteristic of MRI images of cachectic patients.

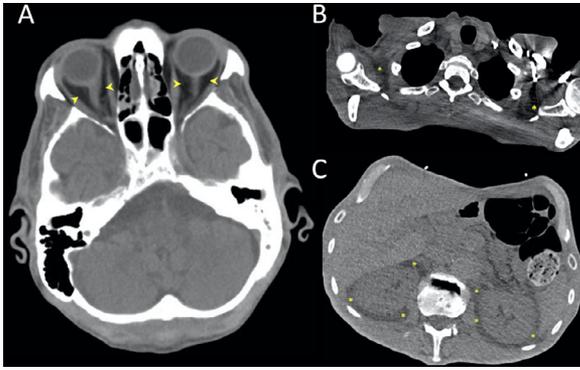
This is in accordance with other medical conditions that are characterized by generalized abnormal fat distribution, such as eating disorders. For example, Yamamoto et al showed



**Fig. 2 – Case 1: Three weeks after presentation during the same admission, infratemporal fat (x) produces low T1 signal in (A), but high T2 signal (C). It appears preserved on CT (D) and demonstrates avid gadolinium enhancement (B), which likely reflects a state of active lipolysis with edema/inflammation.**

diminished subcutaneous fat and diffuse T1 hypointense marrow signal in an individual with bulimia nervosa [5]. Kraeft et al reported that individuals with severe anorexia nervosa demonstrate loss of fat signal in both bone marrow and subcutaneous tissues on MRI [6].

Interestingly both cases displayed maintenance of orbital fat. Similarly, in a study of 11 patients with either anorexia or cachexia, Okamoto et al found a loss of signal from subcutaneous tissue and bone marrow of the skull on T1-weighted images, but high signal from the orbits in emaciated patients



**Fig. 3 – Case 1: Axial CT images of the head (A) and body (B,C) at presentation demonstrate near-complete absence of subcutaneous fat in the scalp and body wall, but with preserved orbital fat (arrows). Residual subcutaneous and visceral fat (\*) in the thorax and abdomen (B, C) were found in classic locations of brown adipose tissue (axilla, supra- and infraclavicular fossa, around solid organs) and demonstrated increased density.**

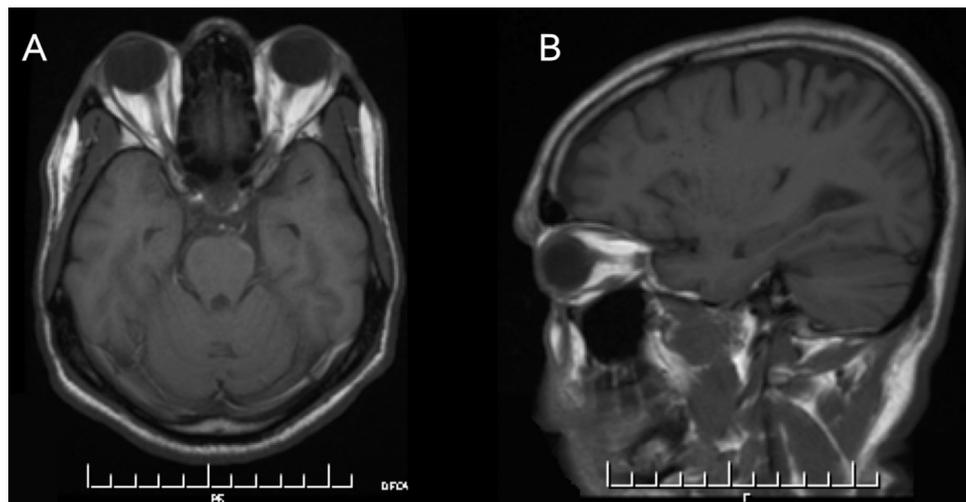
[7]. However, they also demonstrated signal loss from the orbits in severely emaciated patients, suggesting that orbital fat is usually one of the last to undergo lipolysis [7]. This finding is potentially due to the fact that orbital adipose tissue serves a mechanical purpose as opposed to being an energy store [7].

The presented cases additionally demonstrate diffuse T1 hypointense marrow signal. This is secondary to marrow fat lipolysis with replacement by extracellular mucopolysaccharide, a process called “gelatinous transformation” or “serous atrophy of bone marrow” (SABM) [8]. SABM

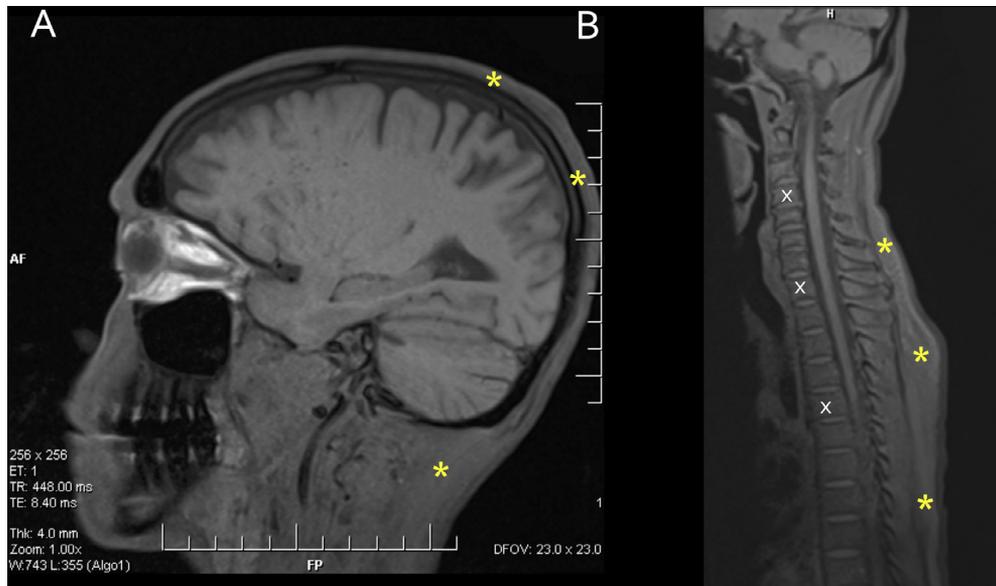
can be seen in cachexia, anorexia nervosa and chronic infections [8]. Furthermore, Boutin et al also showed T1 hypointense signal in the surrounding subcutaneous tissues in SABM [8].

A substantial amount of cancer patients begin to lose weight before diagnosis [9]. As such, cachectic features, similar to the ones in the presented cases, should prompt a search for a potentially unrecognized underlying disease and should serve as clues to the patient’s medical history and lifestyle. It is vital to detect cachexia early in the disease process to expedite diagnosis and optimize treatment strategies [10]. Dodson et al further explained that cachexia detection is crucial, as it is associated with a multitude of downstream repercussions including poorer response to treatments and quality of life [11]. Unfortunately, only a few imaging studies have been done on patients with cachexia [10]. However there are reports of CT assisting in the measurement of body composition in sarcopenic cancer patients and possibly predicting prognosis and chemotherapy toxicity [10,12,13]. Additionally, there is growing evidence of the role that chemotherapeutic agents play in the worsening of cachexia [14]. As such it is important to keep this factor in mind when reporting the degree of cachexia-related imaging findings.

Radiologists should be aware of this phenomenon in order to avoid attributing these findings to erroneous scan parameters or alternative diagnosis, leading to unnecessary repeat imaging or delayed diagnosis. The isolated hyperintensity of the orbits found in cachectic patients can lead to the misdiagnosis of orbital fat inflammation. The diffuse hypointense T1 signal of SABM may be entirely missed, or be misdiagnosed as other marrow-infiltrative conditions such as myelofibrosis, hemochromatosis, hematologic malignancies, or diffuse metastasis [15]. Boutin et al found SABM diagnosis was delayed in 23% of patients, often due to radiologist misinterpreting initial imaging as having technical errors such as failed fat suppression [8].



**Fig. 4 – Case 2: Initial axial (A) and sagittal (B) T1-weighted non-fat saturated MRI head at the time of presentation show normal amount of scalp and neck subcutaneous fat.**



**Fig. 5 – Case 2: follow-up T1-weighted images of head (A) and spine (B), 6 months after presentation, demonstrate total disappearance of subcutaneous fat (\*) and diffuse T1-hypointensity of bone marrow (x). There is preservation of orbital fat (A).**

## Conclusion

The presented cases both demonstrate the pseudo fat-saturated appearance of cachexia on T1-weighted MRI studies. This finding can lead to misdiagnosis or image misinterpretation. It is important for radiologists to be aware of this phenomenon in order to avoid such pitfalls.

## REFERENCES

- [1] Inagaki J, Rodriguez V, Bodey GP. Proceedings: causes of death in cancer patients. *Cancer* 1974;33(2):568–73. doi:10.1002/1097-0142(197402)33:2<568::aid-cnrcr2820330236>3.0.co;2-2.
- [2] Loberg RD, Bradley DA, Tomlins SA, Chinnaiyan AM, Pienta KJ. The lethal phenotype of cancer: the molecular basis of death due to malignancy [published correction appears in *CA Cancer J Clin*. 2007 Nov-Dec;57(6):380]. *CA Cancer J Clin* 2007;57(4):225–241. doi:10.3322/canjclin.57.4.225.
- [3] Bruggeman AR, Kamal AH, LeBlanc TW, Ma JD, Baracos VE, Roeland EJ. Cancer cachexia: beyond weight loss. *J Oncol Pract* 2016;12(11):1163–1171. doi:10.1200/JOP.2016.016832.
- [4] Fearon KC. Cancer cachexia and fat-muscle physiology. *N Engl J Med* 2011;365(6):565–567. doi:10.1056/NEJMcibr1106880.
- [5] Yamamoto A, Kikuchi Y, Kusakabe T, Takano H, Sakurai K, Furuji S, et al. Imaging spectrum of abnormal subcutaneous and visceral fat distribution. *Insights Imaging* 2020;11(1):24. Published 2020 Feb 13. doi:10.1186/s13244-019-0833-4.
- [6] Kraeft JJ, Uppot RN, Heffess AM. Imaging findings in eating disorders. *AJR Am J Roentgenol* 2013;200(4):W328–W335. doi:10.2214/AJR.12.9641.
- [7] Okamoto K, Ito J, Ishikawa K, Sakai K, Tokiguchi S. Change in signal intensity on MRI of fat in the head of markedly emaciated patients. *Neuroradiology* 2001;43(2):134–138. doi:10.1007/s002340000453.
- [8] Boutin RD, White LM, Laor T, Spitz DJ, Lopez-Ben RR, Stevens KJ, et al. MRI findings of serous atrophy of bone marrow and associated complications. *Eur Radiol* 2015;25(9):2771–2778. doi:10.1007/s00330-015-3692-5.
- [9] Blum D, Strasser F. Cachexia assessment tools. *Curr Opin Support Palliat Care* 2011;5(4):350–355. doi:10.1097/SPC.0b013e32834c4a05.
- [10] Penet MF, Winnard PT Jr, Jacobs MA, Bhujwala ZM. Understanding cancer-induced cachexia: imaging the flame and its fuel. *Curr Opin Support Palliat Care* 2011;5(4):327–333. doi:10.1097/SPC.0b013e32834c49ba.
- [11] Dodson S, Baracos VE, Jatoi A, Evans WJ, Cella D, Dalton JT, et al. Muscle wasting in cancer cachexia: clinical implications, diagnosis, and emerging treatment strategies. *Annu Rev Med* 2011;62:265–279. doi:10.1146/annurev-med-061509-131248.
- [12] Tan BH, Birdsell LA, Martin L, Baracos VE, Fearon KC. Sarcopenia in an overweight or obese patient is an adverse prognostic factor in pancreatic cancer. *Clin Cancer Res* 2009;15(22):6973–9. doi:10.1158/1078-0432.CCR-09-1525.
- [13] Prado CM, Baracos VE, McCargar LJ, Reiman T, Mourtzakis M, Tonkin K, et al. Sarcopenia as a determinant of chemotherapy toxicity and time to tumor progression in metastatic breast cancer patients receiving capecitabine treatment. *Clin Cancer Res* 2009;15(8):2920–6. doi:10.1158/1078-0432.CCR-08-2242.
- [14] Pin F, Barreto R, Couch ME, Bonetto A, O'Connell TM. Cachexia induced by cancer and chemotherapy yield distinct perturbations to energy metabolism. *J Cachexia Sarcopenia Muscle* 2019;10(1):140–54. doi:10.1002/jcsm.12360.
- [15] Silva JR Jr, Hayashi D, Yonenaga T, Fukuda K, Genant HK, Lin C, et al. MRI of bone marrow abnormalities in hematological malignancies. *Diagn Interv Radiol* 2013;19(5):393–399. doi:10.5152/dir.2013.067.