

Case report

MRI FINDINGS IN SEROUS ATROPHY OF BONE MARROW IN SPINAL IMAGING

Andrej BREZNIK, * Tomaž ZAKRAJŠEK, Boris TURK

Department of Radiology, General Hospital Celje, Oblakova ulica 5, 3000 Celje

* Corresponding author: andrej.breznik@sb-celje.si

Received: 20. 11. 2022

Accepted: 9. 1. 2023

<https://doi.org/10.47724/MIRTJ.2022.i01.a003>

ABSTRACT

Introduction: Serous atrophy of bone marrow (SABM) is a rare, and potentially reversible, cause of diffuse look, irregular bone marrow and subcutaneous adipose tissue appearances on magnetic-resonance imaging (MRI). SABM has also been named gelatinous bone marrow transformation (GTMB) or 'starvation marrow'.

Purpose: The aim of the article is to represent a case report of 'flip-flop' phenomenon in SABM and GTBM pathology.

Material and methods: This case report highlights an unexpected image appearance of an occurrence 'flip-flop' effect which is characteristic in the condition of serous atrophy of bone marrow (SABM). The literature search was conducted using medical scientific electronic databases such as PubMed, ScienceDirect, Cochrane and Google Scholar.

Results / Case Study: An 44-year old man was appointed for an MRI examination. MRI images result like a technical failure, but are actually a specific imaging pattern related to the clinical problem. For clarity of unexpected images appearances, the radiographer repeated scans on a second vendor of MRI machine, but there still was the same appearance, like on the first scanner. The result of the literature review and the characteristics indicate We describe an example of the »flip-flop« phenomenon in SABM and GTBM.

Discussion and Conclusion: Serous atrophy or gelatinous malformations of bone marrow is not a normal disease, but indicates an underlying illness that starves the bone marrow, particularly the fatty marrow. We describe a case report of 'flip-flop' phenomenon in SABM and GTBM pathology, where MRI images result like a technical failure, but are actually a specific imaging pattern related to the clinical problem.

Keywords: serous atrophy of bone marrow, mDIXON, flip-flop phenomenon

IZVLEČEK

Uvod: Serozna atrofija kostnega mozga (angl. SABM - Serous atrophy of bone marrow) je zelo redka oblika bolezni. Je reverzibilnega vzroka in se kaže kot difuzno nepravilen prikaz kostnega mozga in podkožnega maščobnega tkiva v primeru izvedbe magnetno-resonančne preiskave (MR). SABM je mogoče opisati tudi kot stanje želatinozne kostne transformacije (angl. GTBM - Gelatinous bone marrow transformation) ali stanje stradajočega kostnega mozga.

Namen: Predstavitev 'flip-flop' fenomena pri prikazu SABM in GTBM s pomočjo MR preiskave.

Metodologija in materiali: Študija primera izvedene preiskave na dveh magnetno resonančnih aparatih s pregledom literature v znanstveno-raziskovalnih člankih. Literaturo smo zbrali s pomočjo elektronskih podatkovnih baz PubMed, ScienceDirect, Cochrane in Google Scholar.

Rezultati: Opisali smo študijo primera pojava 'flip-flop' fenomena pri 44-letnemu pacientu z SABM in GTBM patološkim stanjem pri izvedbi z magnetno resonančno preiskavo (MR). Pri MR preiskavi smo pridobili slike, katerim bi pripisali pojav tehnične napake MR tomografa. Zaradi izključitve tehnične napake smo slikanje izvedli na MR aparatu drugega proizvajalca, kjer smo izvedli še dodatne mDIXON sekvence. Karakteristike slikovnih podatkov so potrdili SABM in GTBM patološko stanje pacienta.

Razprava in zaključek: Patološki pojav SABM in GTBM se odraža kot specifičen pojav na MR slikah, kateri spominja na pojav tehnične napake povezane s kliničnim primerom. Za dodatno opredelitev in potrditev slikovnih karakteristik MR preiskave smo dodatno opravili mDIXON obteženo slikanje. Bolezenski stanje povzroči izstradanje kostnega mozga, še posebno rumenih (maščobnih) teles, katerega izpolnijo polisaharidi.

Ključne besede: serozna atrofija kostnega mozga, mDIXON, flip-flop fenomen

INTRODUCTION

This article presents a case report of the 'flip-flop' phenomenon in serous atrophy of bone marrow (SABM) and GTBM pathology, where MR images appear to be a technical failure but are a specific imaging pattern related to the clinical problem.

SABM is the rare and potentially reversible cause of diffuse changes in the bone marrow and subcutaneous adipose tissue, which appear on MR images (1-5). SABM is also referred to as gelatinous bone marrow transformation (GTMB) or 'starvation marrow', more frequently in adult male patients. GTBM was first described by Paul Michael in the 1930s as a rare hematologic entity.

The vast majority of literature is centred around anorexia nervosa and malnutrition. Features include the hypoplasia of fat cells with focal loss of hematopoietic cells, followed by the accumulation of extracellular gelatinous substances, such as mucopolysaccharides (6, 10). SABM is clinically associated with weight loss and anaemia and carries a higher risk for limb fractures (3).

CASE STUDY

The case study report highlights the unexpected appearance of the 'flip-flop' phenomenon, which is characteristic of the condition of SABM. It is the uncommon and potentially reversible cause of diffuse changes in the bone marrow and subcutaneous adipose tissue. We want to share the random results of our examination of a patient with SABM and GTMB, how images look and highlight some learning points.

A 44-year-old man was scheduled for an MRI examination of the lumbar spine for further evaluation of suspected spondylodiscitis. More recently, the patient developed anaemia, cachexia and weight loss. Three days before the MRI, the patient had a CT of the abdomen with iodine intravenous contrast media, where we approved renal cysts pathology (Bosniak IV classification).

An MRI scan of the lumbar spine was requested by the infectologist to explain lower back pain, with suspected spondylodiscitis, using a Philips Achieva® 1.5T MRI scanner. The initial report of the quality check of MRI images by the radiographer indicated abnormal contrast for classical MRI weighting, such as spin-lattice relaxation (T1-weighted), spin-spin relaxation (T2-weighted) and proton density (PD-weighted) weighted images. The radiographer who performed the examination immediately suspected a technical malfunction or error of the MRI scanner, a problem with the radio frequency (RF) pulse generator or a shimming malfunction. Because the T1-weighted image looked like a fat suppression sequence, the fat saturation technique was not used (Figure 1) and the T2-weighted image with the fat suppression option was unexpectedly not suppressing fat (Figure 2).

To explain the unexpected contrast appearances on MR images, the patient was recalled and the examination was repeated on a second device (a Siemens Aera® 1.5T MRI scanner) at our hospital. The repeat scan demonstrated the same results as the first scanner. The results were recognized as SABM, which can be seen in severe anorexia or cachexia, and many other conditions (1-3). Specifically, SABM changes are predominantly seen in the appendicular skeleton and

with additional subcutaneous adipose tissue involvement (1). The research was approved by the ethics committee of Celje General Hospital.

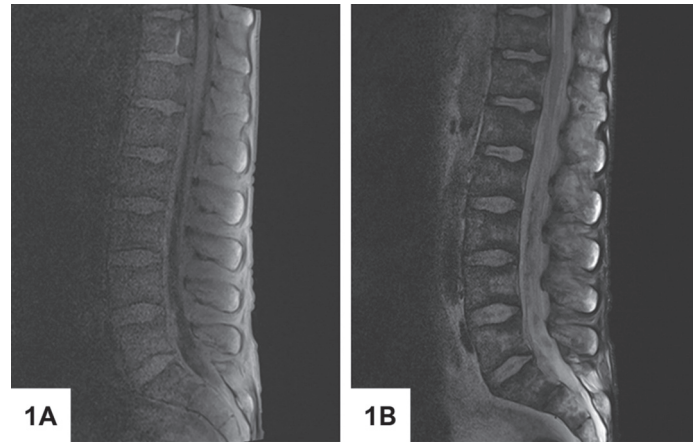


Figure 1: 44-year-old male with 'flip-flop' phenomenon – first examination

FINDINGS: Figure 1(A), T1-weighted, shows the diffuse hypointense signal intensity of retroperitoneal fat with subcutaneous fat. Figure 1(B), T2-weighted TSE image with fat suppression, image shows irregular and patchy hyperintense signals from vertebral marrow with respect to skeletal muscle. Moreover, we can interpret image hyperintense signals in the lumbar spine, which indicates the lesions are not fatty marrow.

TECHNIQUE: Philips Achieva® 1.5T MRI scanner

A. Sagittal T1-weighted TSE, TR 450ms, TE 10ms, slice thickness 3.0 mm

B. Sagittal T2-weighted TSE, TR 4500ms, TE 100ms, slice thickness 3.0 mm

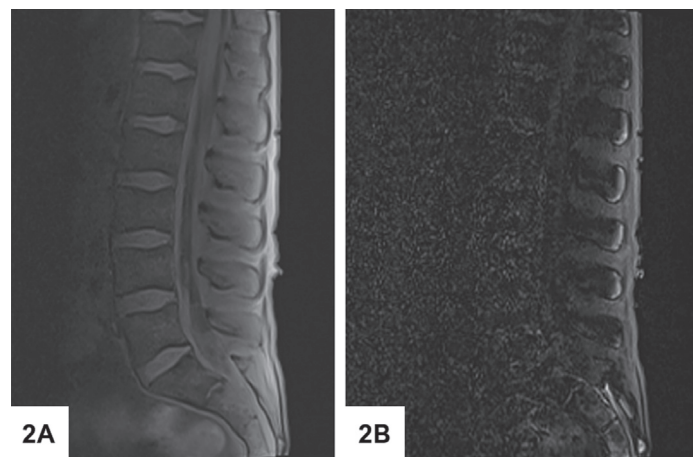


Figure 2: 44-year-old male with 'flip-flop' phenomenon – second examination

FINDINGS: Figure 2(A), T2-weighted mDIXON F and Figure 2(B), T2-weighted mDIXON W, show the diffuse hypointense signal intensity of retroperitoneal and subcutaneous fat. Figure 2(B), T2-weighted mDIXON W with fat suppression images, shows irregular fat signals and patchy hyperintense signals from vertebral marrow with respect to skeletal muscle.

TECHNIQUE: Siemens Aera® 1.5T MRI scanner

A. T2-weighted mDIXON F+W, TR 4000ms, TE 91ms, slice thickness 3.0 mm



Figure 3: MR images of Glucerna dietary supplement in a plastic bottle

FINDINGS: Figure 3(A), T1-weighted sequence, shows the hyperintense signal of Glucerna. Figure 3(B), T2-weighted sequence, shows a hyperintense signal to bound liquid products. Figure 3(C), susceptibility weighted imaging (SWI) with maximum intensity projection (MIP) reconstructions, shows susceptibility artifacts (small black dots indicated by yellow arrow), which are related due to the content of metals in the Glucerna dietary supplement.

TECHNIQUE: Siemens Aera® 1.5T MRI scanner

- Axial T1-weighted TSE, TR 450ms, TE 10m, slice thickness 3.0 mm
- Axial T2-weighted TSE, TR 4500ms, TE 100ms, slice thickness 3.0 mm
- Axial SWI MIP reconstruction, TR, TE, slice thickness 1.6 mm

INVESTIGATION

Serous fat atrophy (gelatinous bone marrow transformation) is a rare condition that results in weight loss and anaemia. Although the pathogenesis is unknown, serous fat atrophy has been associated with cachexia, acute febrile states, anorexia nervosa and poor nutrition. It is characterized by the atrophy of fatty marrow and the loss of hematopoietic cells in the body or skeleton, replaced by an accumulation of extracellular mucinous substances. The gelatinous malformation of bone marrow is not a normal disease but instead indicates an underlying illness that starves the bone marrow, particularly the fatty marrow (6-9,11-12).

DISCUSSION

An MRI examination demonstrated unusual bone marrow and subcutaneous fat signal tissue appearances, referred to as the 'flip-flop' phenomenon. During the examination, we thought we encountered a technical malfunction of the MRI scanner. However, we repeated the MRI examination on another MR tomograph device at our hospital and again different tissue contrasts were demonstrated. The results were identified as serous atrophy of bone marrow, most commonly seen in severe cachexia and anorexia nervosa.

Strict MRI protocols for diagnostic criteria have never been established in the case of SABM. As we saw in the above-

described case, report, these include mildly hypointense signal intensity in the bone marrow and adipose subcutaneous tissue on T1-weighted sequences (Figure 1A) with hyperintense signal intensity in the bone marrow and adipose subcutaneous tissue on T2-weighted fluid-sensitive or T2-weighted fat suppression sequences (Figure 1B). These chemical changes resulted in increased fluid and reduced fat signal, leading to increased T1 and T2 relaxation times (7,13). In Figure 3(C), on SWI sequence with MIP reconstruction, we can identify numerous susceptibility artifacts (indicated by yellow arrow). The main reason is nutrition with a dietary supplement called Glucerna because the latter contains many traces of ferromagnetic materials (iron, copper, zinc, manganese, chrome and molybdenum) (14). It is used for special medical purposes, such as dietary nutrition for diabetes.

Additionally, we can solve this problem by using an MR spectroscopy sequence and the mDixon technique. In spectroscopy, rather than both profound lipid and water peaks, a small lipid peak and a profound water peak would be expected in SABM. Using the mDixon technique, which uses the basic chemical shift of water and lipid molecules, lipid-poor and fluid-rich tissues seen in SABM can be confirmed (1, 8, 11).

CONCLUSION

We have described a case report of the 'flip-flop' phenomenon in SABM and GTBM pathology, where MR images appear to be a technical failure but are a specific imaging pattern related to the clinical problem. Typically, a reference for the weighting of an MRI sequence for the determination of the proper signal could be used in fluid-filled structures such as the spinal canal or bladder. MR findings showed a marked increase in signal intensity on T2-weighted images, indicating a prominent increase in free-water content, while another indicator is that T2-weighted images are not fat saturation tissue. These patterns are predominantly disturbed at the skeleton and in a diffuse manner.

REFERENCES

1. Kalamar V, Davies A, Wright P, Suresh P. MRI findings were seen in serous atrophy of bone marrow. *BMJ Case Rep* 2021;14:e243770. DOI:10.1136/bcr-2021-243770.
2. Varotto A, Vitale V, Mansour M, Di Pascoli L, Iannucci G. Spinal 'flip-flop' effect in anorexia nervosa: A case report. *J Med Imaging Radiat Oncol* 2020;64:534–6. DOI: 10.1111/1754-9485.12985.
3. 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;25:2771–8. DOI: 10.1007/s00330-015-3692-5
4. Kirchgessner T, Acid S, Perlepe V, Lecouvet F, Vande Berg B. Two-Point Dixon fat-water swapping artifact: lesion mimicker at musculoskeletal T2-weighted MRI. *Skeletal Radiol* 2020;49:2081–6. DOI: doi: 10.1007/s00256-020-03512-x.
5. Lee J, Hwa Yoo Y, Lee S, Sun Kim H, Kim S. Gelatinous Transformation of Bone Marrow Mimicking Malignant Marrow-Replacing Lesion on Magnetic Resonance Imaging in a Patient without Underlying Devastating Disease. *iMRI* 2018;22:50-55. DOI: 10.13104/imri.2018.22.1.50.
6. Bohm J. Gelatinous transformation of the bone marrow: the spectrum of underlying diseases. *Am J Surg Pathol* 2000;24:56-65. DOI: 10.1097/0000478-200001000-00007.
7. Vande Berg BC, Malghem J, Devuyt O, Maldague BE, Lambert MJ. Anorexia nervosa: correlation between Mr appearance of bone marrow and severity of disease. *Radiology* 1994;193:859–64. DOI: 10.1148/radiology.193.3.7972838.
8. Ma J. Dixon techniques for water and fat imaging. *J Magn Reson Imaging* 2008;28:543–58. DOI: 10.1002/jmri.21492.
9. Sen R, Singh S, Singh Hm Gupta A, Sen J. Clinical profile in gelatinous bone marrow transformation. *J Assoc Physicians India* 2003; 51:585-588. DOI:
10. Shergill KK, Shergill GS, Pillai HJ. Gelatinous transformation of bone marrow: rare or underdiagnosed? *Autopsy Case Rep* [Internet]. 2017;7(4):8-17. DOI: 10.4322/acr.2017.039.
11. Mondal, Monojit, and Suchi Gaba. "Flip-Flop Phenomenon« - Magnetic Resonance Imaging Pitfall: A Case Report." *Journal of radiology case reports* vol. 15,6 19-25. 30 Jun. 2021, DOI:10.3941/jrcr.v15i6.4271.
12. Lee J, Yoo YH, Lee S, Kim HS, Kim S. Gelatinous Transformation of Bone Marrow Mimicking Malignant Marrow-Replacing Lesion on Magnetic Resonance Imaging in a Patient without Underlying Devastating Disease. *MRI*. 2018 Mar;22(1):50–55. DOI: doi.org/10.13104/imri.2018.22.1.50.
13. DiVasta AD, Mulkern RV, Gordon CM, Kirsten E. MR Imaging in a case of severe anorexia nervosa: the 'flip-flop' effect. *Pediatr Radiol*. 2015 Apr;45(4):617–620. DOI: doi: 10.1007/s00247-014-3145-3.
14. Lekarna Nove Poljane. *Glucerna* [Internet]. [2023 Jan 8]. Available from: <https://www.lekarnar.com/izdelki/glucerna>