Letter to the Editor

MRI slow diffusion coefficient (SDC) shows liver pyogenic abscess has faster diffusion than adjacent liver parenchyma

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It is well known that pyogenic abscess fluid (i.e., pus) tends to demonstrate a very low magnetic resonance imaging (MRI) apparent diffusion coefficient (ADC) regardless of the location of the abscess (1-7). The same as pyogenic abscesses in other places, abscess pyogenic fluid in the liver is known to be associated with very low ADC (8-12). For example, *Figure 1* and *Figure 2* show abscesses in the brain and in the liver respectively, both demonstrating very low ADC values (1,8). It has been suggested that the low ADC of abscess fluid might be related to the high viscosity of the liquid, however, myxoma is known to have a very high ADC value (13,14).

We argue that there exists a 'T2-ADC curve', with ADC measure strongly affected by T2 relaxation time (15,16). T2 can be divided into short T2 band (<60 ms), intermediate T2 band (60–80 ms), and long T2 band (>80 ms). For the short T2 time band, there is a negative correlation between T2 and ADC. For the long T2 time band, there is a positive correlation between T2 and ADC. A tissue likely measures a low ADC if its T2 is close to 70 ms. ADC value is high when: (I) the signal decay between b=0 image and high b value image is fast such as the cases for tissues with short T2 (such as the cases for cartilage and muscle), or (II) tissue has a very long T2 and appear high signal on b=0 image so that there is large amounts of signal to decay between b=0 image and high b value image (such as the cases for intervertebral disc, myxoma, and chondrosarcoma) (16,17). ADC measures a low value when tissue T2 is in the intermediate range of 60–80 ms (15-17). Note that, an application of the diffusion gradients will lead to a slight decrease in observed T2 for tissues, which can be interpreted as an application of diffusion gradients is associated with a longer time of echo (TE) for data acquisition (18). We also found that the abscess pus is likely to have a T2 of about 70–80 ms, and the specific T2 of pyogenic abscess fluid likely contributes to its very low ADC measured by MRI (19). We argue that abscess pus may not have truly restricted diffusion compared with many other *in vivo* solid tissues (19). Of course, in real practice, abscess pus composition may vary which is partially dependent on the development stage of the abscess, and so does its ADC measure.

Recently, we proposed a metric termed 'slow diffusion coefficient (SDC)' (20). In its basic form, SDC is derived from a high b value diffusion-weighted imaging (DWI) image and a higher b value DWI image:

$$SDC = \left[S(b_1) - S(b_2)\right] / (b_2 - b_1) \quad [1]$$

where b_1 and b_2 refer to a high b value (e.g., 500 mm^2/s for the case of liver DWI) and a higher b value, respectively (e.g., 700 mm^2/s for the case of liver DWI); S(b_1) and S(b_2) denote the image signal-intensity acquired at the high b value and the higher b value, respectively. SDC is expressed in [arbitrary unit (au)/s].

With the conventional ADC measure, the spleen has a much lower ADC than liver, hepatocellular carcinomas (HCCs) have a lower ADC than liver parenchyma, and simple liver cysts have a higher ADC than liver hemangiomas. On the other hand, with SDC analysis, we showed that the spleen has a faster diffusion than the liver, HCCs have a faster diffusion than liver parenchyma, and

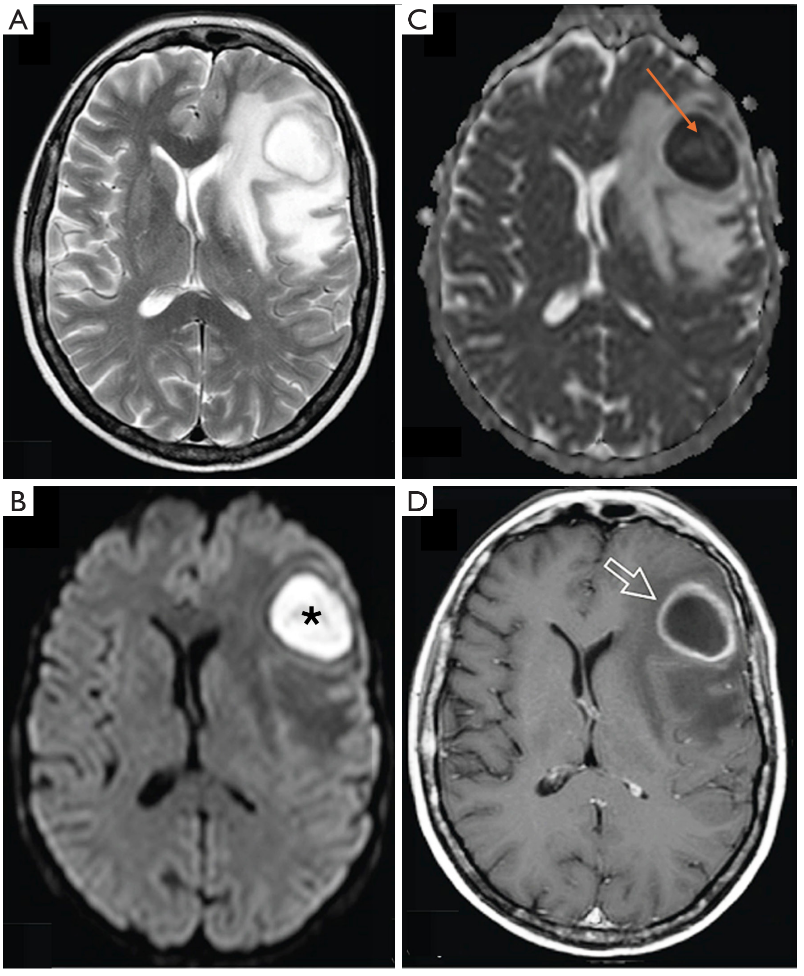

Figure 1 MRI of a 37-year-old woman with a pyogenic abscess in the left frontal lobe (A) T2 weighted image; (B) DWI; (C) ADC map; (D) contrast enhanced T1 weighted image. The central component of the lesion shows high signal on T2 weighted image, high signal on DWI (asterisk in B) and low value on ADC map (C, lower than the brain tissues, arrow). Arrow in (D) denotes a ring enhancement after contrast agent administration. It appears unreasonable that the abscess content has a so low ADC measure. Adapted from Feraco *et al*. (1). ADC, apparent diffusion coefficient; DWI, diffusion-weighted imaging; MRI, magnetic resonance imaging.

liver hemangiomas have a faster diffusion than simple liver cysts (20). The liver and spleen have a similar amount of blood perfusion, the spleen is waterier than the liver, and the spleen tissue has a higher contrast-enhanced computed tomography (CT) extracellular volume fraction than the liver (21,22). HCCs are mostly associated with increased blood supply and increased proportion of arterial blood supply and with edema. It is more reasonable with SDC results that the spleen and HCC have a faster diffusion than liver parenchyma. Due to the 'flushing' of blood flow inside the hemangioma, it is also more reasonable with SDC results that the diffusion of liver hemangioma liquid is faster than the more 'static' liquid of the liver cysts (20).

We have earlier collected liver intravoxel incoherent motion (IVIM) series images for a patient with a liver abscess. The data acquisition was conducted with institutional ethical approval and with informed consent obtained from the patient. Imaging was conducted with a Siemens Avanto 1.5T MR scanner. Parameters for DWI included: repetition time (TR) =6,900 ms, TE =81 ms, slice thickness =6 mm, inter-slice gap =1.8 mm, field of view =285×380 mm, matrix =115×192, number-of-excitations =2. SDC pixelwise map was reconstructed by b=500 and b=700 s/mm^2 DWI images, and the results are shown in *Figure 3*. *Figure 3* shows an abscess that has internal content with overall SDC signal higher than that of the adjacent liver parenchyma.

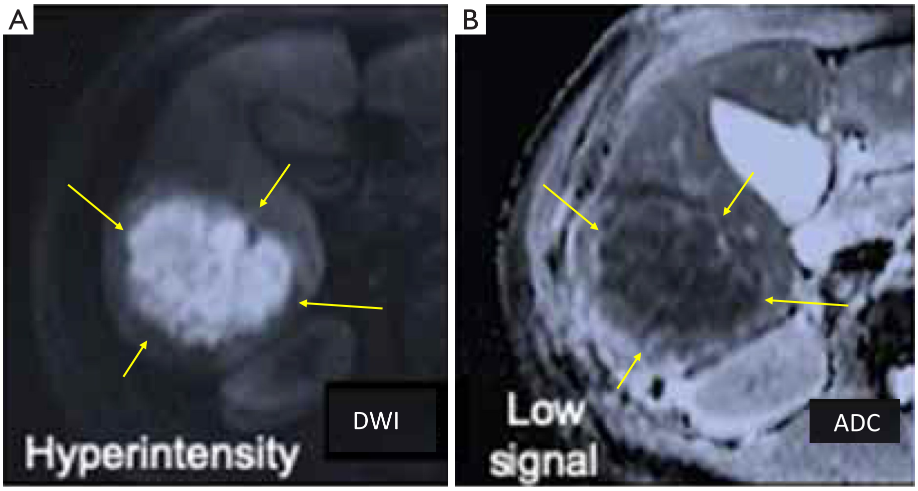

Figure 2 DWI (A) and ADC (B) map of a liver pyogenic abscess (arrows). The abscess liquid has very high DWI signal and very low ADC. It appears unreasonable that the abscess content has a so low ADC measure. Adapted from Castillo and Manterola (8). ADC, apparent diffusion coefficient; DWI, diffusion-weighted imaging.

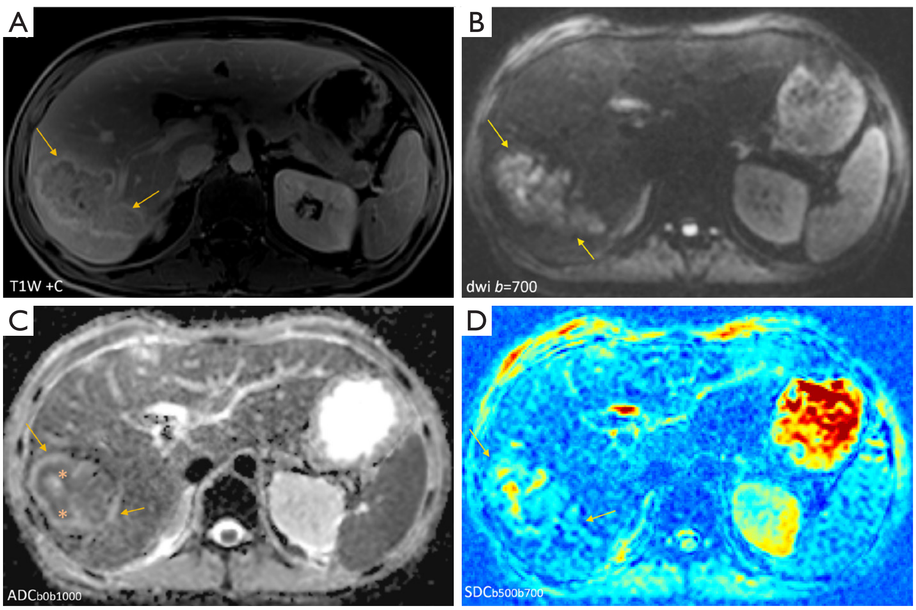

Figure 3 A 37-year-old diabetes mellitus man with a liver pyogenic abscess. (A) is post-gadolinium T1-weighted (T1W + C) image, a liver abscess is seen with peripheral rim (arrows). (B) is DWI of *b* value =700 s/mm^2, with the abscess showing high signal (arrows). (C) is ADC map (with *b* values of 0 and 1,000 s/mm^2), the abscess (arrows) had internal content with mixed signals and some areas showing slightly lower value (asterisks) than that of the adjacent liver parenchyma. The peripheral rim of the abscess has higher ADC, which is a sign for abscess as described by Park *et al*. (11). (D) is SDC map (with *b* values of 500 and 700 s/mm^2), the abscess (arrows) had internal content with mixed higher signals than that of the adjacent liver parenchyma. Note that, as shown in (C), ADC of the spleen is notably lower than ADC of the liver parenchyma. On (D), SDC of the spleen is faintly higher than SDC of the liver parenchyma, and the overall SDC of the abscess is higher than SDC of the spleen. Overall, SDC map of this case suffers from low signal-to-noise ratio. ADC, apparent diffusion coefficient; DWI, diffusion-weighted imaging; SDC, slow diffusion coefficient.

In conclusion, the data described in this letter support our earlier argument that the abscess pus does not have truly restricted diffusion compared with many other *in vivo* solid tissues, despite showing very low ADC value (19).

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

References

1. Feraco P, Donner D, Gagliardo C, Leonardi I, Piccinini S, Del Poggio A, Franciosi R, Petralia B, van den Hauwe L. Cerebral abscesses imaging: A practical approach. J Popul Ther Clin Pharmacol 2020;27:e11-24.
2. Erdogan C, Hakyemez B, Yildirim N, Parlak M. Brain abscess and cystic brain tumor: discrimination with dynamic susceptibility contrast perfusion-weighted MRI. J Comput Assist Tomogr 2005;29:663-7.
3. Chang SC, Lai PH, Chen WL, Weng HH, Ho JT, Wang JS, Chang CY, Pan HB, Yang CF. Diffusion-weighted MRI features of brain abscess and cystic or necrotic brain tumors: comparison with conventional MRI. Clin Imaging 2002;26:227-36.
4. Lotan E, Hoffmann C, Fardman A, Ziv-Baran T, Komisar O, Harnof S. Postoperative versus Spontaneous Intracranial Abscess: Diagnostic Value of the Apparent Diffusion Coefficient for Accurate Assessment. Radiology 2016;281:168-74.
5. Chou CP, Chiou SH, Levenson RB, Huang JS, Yang TL, Yu CC, Chiang AJ, Pan HB. Differentiation between pelvic abscesses and pelvic tumors with diffusion-weighted MR imaging: a preliminary study. Clin Imaging 2012;36:532-8.
6. Oto A, Schmid-Tannwald C, Agrawal G, Kayhan A, Lakadamyali H, Orrin S, Sethi I, Sammet S, Fan X. Diffusion-weighted MR imaging of abdominopelvic abscesses. Emerg Radiol 2011;18:515-24.
7. Harish S, Chiavaras MM, Kotnis N, Rebello R. MR imaging of skeletal soft tissue infection: utility of diffusion-weighted imaging in detecting abscess formation. Skeletal Radiol 2011;40:285-94.
8. Castillo S, Manterola C. Morphological characteristics of liver abscesses according its etiology. Int J Morphol 2020;38:406-14.
9. Oruç E, Yıldırım N, Topal NB, Kılıçturgay S, Akgöz S, Savcı G. The role of diffusion-weighted MRI in the classification of liver hydatid cysts and differentiation of simple cysts and abscesses from hydatid cysts. Diagn Interv Radiol 2010;16:279-87.
10. Chan JH, Tsui EY, Luk SH, Fung AS, Yuen MK, Szeto ML, Cheung YK, Wong KP. Diffusion-weighted MR imaging of the liver: distinguishing hepatic abscess from cystic or necrotic tumor. Abdom Imaging 2001;26:161-5.
11. Park HJ, Kim SH, Jang KM, Lee SJ, Park MJ, Choi D. Differentiating hepatic abscess from malignant mimickers: value of diffusion-weighted imaging with an emphasis on the periphery of the lesion. J Magn Reson Imaging 2013;38:1333-41.
12. Talati K, Lee KS. Magnetic Resonance Imaging of Hepatic Abscesses. Semin Roentgenol 2017;52:73-82.
13. Morán LM, Vega J, Gómez-León N, Royuela A. Myxomas and myxoid liposarcomas of the extremities: Our preliminary findings in conventional, perfusion, and diffusion magnetic resonance. Acta Radiol Open 2022;11:20584601221131481.
14. Einarsdóttir H, Karlsson M, Wejde J, Bauer HC. Diffusion-weighted MRI of soft tissue tumours. Eur Radiol 2004;14:959-63.

15. Wáng YXJ, Ma FZ. A tri-phasic relationship between T2 relaxation time and magnetic resonance imaging (MRI)-derived apparent diffusion coefficient (ADC). Quant Imaging Med Surg 2023;13:8873-80.
16. Wáng YXJ, Aparisi Gómez MP, Ruiz Santiago F, Bazzocchi A. The relevance of T2 relaxation time in interpreting MRI apparent diffusion coefficient (ADC) map for musculoskeletal structures. Quant Imaging Med Surg 2023;13:7657-66.
17. Wáng YXJ. An explanation for the triphasic dependency of apparent diffusion coefficient (ADC) on T2 relaxation time: the multiple T2 compartments model. Quant Imaging Med Surg 2025;15:3779-91.
18. Egnell L, Jerome NP, Andreassen MMS, Bathen TF, Goa PE. Effects of echo time on IVIM quantifications of locally advanced breast cancer in clinical diffusion-weighted MRI at 3 T. NMR Biomed 2022;35:e4654.
19. Wáng YXJ. The very low magnetic resonance imaging apparent diffusion coefficient (ADC) measure of abscess is likely due to pus's specific T2 relaxation time. Quant Imaging Med Surg 2023;13:8881-5.
20. Xu FY, Xiao BH, Wáng YXJ. The rationale for proposing a magnetic resonance slow diffusion metric and its proof-of-concept testing showing spleen parenchyma and hepatocellular carcinoma have faster diffusion than liver parenchyma. Quant Imaging Med Surg 2025;15:3792-806.
21. Ju ZG, Leng XM, Xiao BH, Sun MH, Huang H, Hu GW, Zhang G, Sun JH, Zhu MSY, Guglielmi G, Wáng YXJ. Influences of the second motion probing gradient b-value and T2 relaxation time on magnetic resonance diffusion-derived 'vessel density' (DDVD) calculation: the examples of liver, spleen, and liver simple cyst. Quant Imaging Med Surg 2025;15:74-87.
22. Yeung J, Sivarajan S, Treibel TA, Rosmini S, Fontana M, Gillmore JD, Hawkins PN, Punwani S, Moon JC, Taylor SA, Bandula S. Measurement of liver and spleen interstitial volume in patients with systemic amyloid light-chain amyloidosis using equilibrium contrast CT. Abdom Radiol (NY) 2017;42:2646-51.

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