Non-Contrast Breath-Hold 3D Renal Artery MR Imaging

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Background

Non-contrast free-breathing 3D renal artery MR imaging (Native_Trufi3d_tra_resp_trig) has become one of the preferred methods for detecting nephrogenic hypertension. This is because of its safety and simplicity, with no need for contrast agent injections. Rising living standards are leading to an increase in the number of patients with hypertension, which in turn is causing a gradual rise in the clinical demand for renal artery imaging. However, free-breathing renal artery imaging places high demands on patients, and irregular breathing can easily lead to imaging failure. In addition, the scan time is related to the patient's breathing rate, so if the patient is breathing relatively slowly, the scan will take longer. This paper will show how modifying sequence parameters and optimizing scan time can enable breath-hold 3D renal artery MR imaging (Native_Trufi3d_tra_bh), resulting in a new method for non-contrast 3D renal artery MR imaging.

Introduction

The acquisition time of a conventional non-contrast free-breathing 3D renal artery imaging sequence is about 4 minutes and 50 seconds. By modifying sequence parameters, we were able to reduce the time to 18 seconds, thereby enabling breath-hold imaging. Going from 4 minutes and 50 seconds to 18 seconds doesn't just mean faster imaging: It also makes imaging easier because there is no need to place the respiratory belt, cushion, and the Physiologic ECG & Respiratory Unit (PERU) – if you are not using the BioMatrix Respiratory Sensor. The success rate of breath-hold renal artery imaging is also better than that of conventional free-breathing renal artery imaging.

Materials and methods

The images shown in Case 1 were acquired on a 3T MAGNETOM Lumina system using *syngo* MR XA20 software and a combination of the 18-channel body and the integrated spine coil. We used the system's BioMatrix Respiratory Sensor as the respiratory trigger.

The images shown in Case 2 were acquired on a 3T MAGNETOM Vida system using *syngo* MR XA10 software and a combination of the 18-channel body and the integrated spine coil. We used the BioMatrix Respiratory Sensor as the respiratory trigger.

	TA	Slices	Slice thickness [mm]	Base resolution × phase resolution × slice resolution	Trigger	Slice partial Fourier	Phase partial Fourier	TI [ms]
Free-breathing	4:50 min	64	1.1	256 × 100% × 81%	Respiratory	off	off	1500
Breath-hold	18–19 sec	36–40	1.5	256 × 70% × 50%	None (breath-hold)	6/8	5/8	1100–1200

Table 1: Parameter changes.

The images shown in Case 3 were acquired on a 1.5T MAGNETOM Sempra system using *syngo* MR XA12 software and a combination of the 6-channel body and the integrated spine coil. We used the respiratory belt, cushion, and PERU.

For the free-breathing renal artery imaging, we used the default sequence from Siemens Healthineers, without any parameter changes. For the breath-hold renal artery imaging, we adapted the parameters to patient needs. All the main parameter changes are shown in Table 1.

For the breath-hold acquisition, the resolution must be reduced in order to reduce the sequence time. Therefore, the resolution of breath-hold renal artery imaging is not as good as that of free-breathing renal artery imaging. However, the low resolution does not affect the display of renal artery branches and will not hamper clinical diagnosis.

Case 1

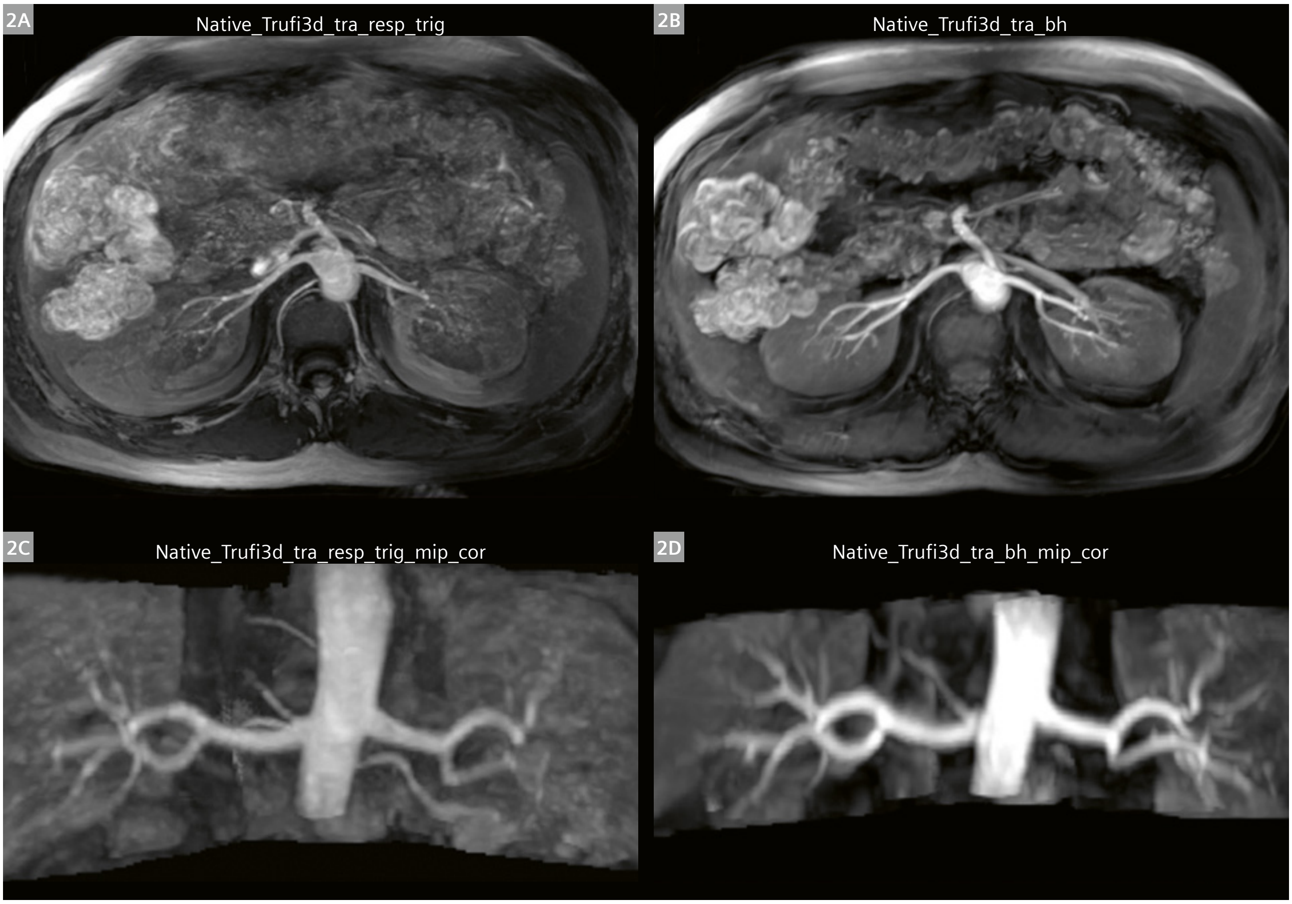
Healthy 47-year-old female volunteer.

1 **(1A)** Non-contrast free-breathing 3D renal artery imaging. **(1B)** Non-contrast breath-hold 3D renal artery imaging. **(1C)** Coronal MIP image of non-contrast free-breathing 3D renal artery. **(1D)** Coronal MIP image of non-contrast breath-hold 3D renal artery.

Both imaging methods were successful. The image-quality comparison found that the free-breathing imaging showed the branch of the renal artery more clearly, but the difference was not significant. The free-breathing method took longer: While the sequence time is 3 minutes and 41 seconds, the patient's slow respiratory rate meant that the actual acquisition time was more than 5 minutes. The sequence time of the breath-hold renal artery imaging was 18 seconds, and the actual acquisition time was 18 seconds. Breath-hold renal artery imaging therefore has a better balance between time and image quality.

Case 2

Healthy 33-year-old male volunteer.



2 **(2A)** Non-contrast free-breathing 3D renal artery imaging. **(2B)** Non-contrast breath-hold 3D renal artery imaging. **(2C)** Coronal MIP image of non-contrast free-breathing 3D renal artery. **(2D)** Coronal MIP image of non-contrast breath-hold 3D renal artery.

The free-breathing method hardly shows the distant segmental branches of the renal artery, and imaging fails. The breath-hold method clearly shows the more distant segmental branches of the renal artery. A series of tests comparing the two imaging methods found that the success rate of breath-hold renal artery imaging is much higher than with free-breathing imaging. Both methods only failed in one case – a patient with malignant hypertension (blood pressure of 220 mmHg).

Because non-contrast renal artery imaging relies on blood-flow imaging, and because blood flows very slowly in patients with malignant hypertension, the renal artery begins to appear when the inversion time (TI) is set for more than two seconds, and the display effect of both methods is not good. Breath-hold renal artery imaging has a higher success rate.

Case 3

A 36-year-old female patient with polycystic liver and kidney disease.

3 **(3A)** Non-contrast free-breathing 3D renal artery imaging. **(3B)** Non-contrast breath-hold 3D renal artery imaging. **(3C)** Coronal MIP image of non-contrast free-breathing 3D renal artery. **(3D)** Coronal MIP image of non-contrast breath-hold 3D renal artery. **(3E and 3F)** Conventional T2 fat-suppression coronal imaging of the abdomen.

The breath-hold method showed the branch of the renal artery more clearly than with free-breathing. Faster imaging leads to smaller breathing motion artifacts and a clearer view of the renal artery.

Conclusion

Breath-hold 3D renal artery imaging is faster, has a higher success rate, and achieves better imaging quality than the free-breathing method. We also tested non-contrast breath-hold renal artery imaging on other MR systems with different field strengths, such as a 1.5T MAGNETOM Area, a 3T MAGNETOM Skyra, and a 3T MAGNETOM Prisma, and used the respiratory belt, cushion, and PERU. All were successful, and parameter modifications were similar.

Discussion

In patients with good breath-hold ability, non-contrast breath-hold 3D renal artery imaging can be used as a good alternative to the conventional free-breathing method. For patients whose breath-hold abilities are not good, we conducted a series of tests with free-breathing renal artery imaging and found a feasible method to improve the success rate of this type of imaging. The method will be presented in the next article.

References

1 Maki JH, Wilson GJ, Eubank WB, Glickerman DJ, Pipavath S, Hoogeveen RM. Steady-state free precession MRA of the renal arteries: breath-hold and navigator-gated techniques vs. CE-MRA. J Magn Reson Imaging. 2007;26(4):966–973.
2 Zhang Y, Xing Z, Liu Y, She D, Zeng Z, Cao D. Nonenhanced renal MR angiography using steady-state free precession (SSFP) and time-spatial labeling inversion pulse (Time-SLIP): repeatability and comparison of different tagging location. Abdom Imaging. 2014;39(5):1000–1008.
3 Lanzman RS, Kröpil P, Schmitt P, Freitag SM, Ringelstein A, Wittsack HJ, et al. Nonenhanced free-breathing ECG-gated steady-state free precession 3D MR angiography of the renal arteries: comparison between 1.5 T and 3 T. AJR Am J Roentgenol. 2010;194(3):794–798.
4 Glockner JF, Takahashi N, Kawashima A, Woodrum DA, Stanley DW, Takei N, et al. Non-contrast renal artery MRA using an inflow inversion recovery steady state free precession technique (Inhance): comparison with 3D contrast-enhanced MRA. J Magn Reson Imaging. 2010;31(6):1411–1418.
5 Zhang W, Lin J, Wang S, Lv P, Wang L, Liu H, et al. Unenhanced respiratory-gated magnetic resonance angiography (MRA) of renal artery in hypertensive patients using true fast imaging with steady-state precession technique compared with contrast-enhanced MRA. J Comput Assist Tomogr. 2014;38(5):700–704.
6 Katoh M, Buecker A, Stuber M, Günther RW, Spuentrup E. Free-breathing renal MR angiography with steady-state free-precession (SSFP) and slab-selective spin inversion: initial results. Kidney Int. 2004;66(3):1272–1278.

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