Radiology Case Reports 17 (2022) 1440–1444

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/radcr

Case Report

Pitfall for systemic artery aneurysms evaluation using electrocardiogram-gated subtracted three-dimensional fast spin echo sequence of magnetic resonance imaging in patients with Kawasaki disease[☆,☆☆]

Haruki Nonaka, RT[a,*], *Takanori Masuda, PhD*[b], *Masami Yoneyama, MT*[c], *Masahiro Tahara, MD*[d], *Mio Okano, RT*[a], *Yuko Morikawa, RT*[a], *Kazuya Sanada, MD*[d], *Tomoyasu Sato, PhD, MD*[e]

[a] *Department of Radiological Technology, Tsuchiya General Hospital, Nakajima-cho 3-30, Naka-ku, Hiroshima 730-8655, Japan*
[b] *Department of Radiological Technology, Faculty of Health Science and Technology, Kawasaki University of Medical Welfare, Kurashiki, Okayama, Japan*
[c] *Philips Japan, Tokyo, Japan*
[d] *Department of Pediatric Cardiology, Tsuchiya General Hospital, Hiroshima, Japan*
[e] *Department of Diagnostic Radiology, Tsuchiya General Hospital, Hiroshima, Japan*

ARTICLE INFO

Article history:
Received 16 July 2021
Revised 24 January 2022
Accepted 25 January 2022

ABSTRACT

Kawasaki disease (KD) is described as a syndrome that causes both coronary and systemic artery aneurysms (SAAs). This report describes the pitfall for SAAs' evaluation when using electrocardiogram (ECG)-gated subtracted three-dimensional fast spin echo (3D FSE) sequence of magnetic resonance imaging in KD patients. A 12-year-old male was diagnosed with KD at 3 months of age. We acquired ECG-gated 3D FSE images in the diastole and systole phases with coronal sections. Subtraction was then performed from diastolic phase imaging to systolic phase imaging. A 15.5 mm right axillary artery aneurysm and an 8.0 mm left axillary artery aneurysm were identified with ECG-gated 3D FSE in the diastolic phase. However, we observed signal loss in the right axillary artery aneurysm when sub-

☆ Acknowledgments: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

☆☆ Competing Interests: Masami Yoneyama is an employee of Philips Japan. Other authors have no conflicts of interests.

* Corresponding author.
E-mail addresses: swing_by_byp@yahoo.co.jp (H. Nonaka), takanorimasuda@yahoo.co.jp (T. Masuda), masami.yoneyama@philips.com (M. Yoneyama), mttahara@qg7.so-net.ne.jp (M. Tahara), mion_nchan@yahoo.co.jp (M. Okano), happyberryyimail@yahoo.co.jp (Y. Morikawa), kazsanada@gmail.com (K. Sanada), tomoyasu_satou@yahoo.co.jp (T. Sato).

https://doi.org/10.1016/j.radcr.2022.01.083
1930-0433/

Keywords:
Magnetic resonance imaging
Kawasaki disease
Systemic artery aneurysms
Non-contrast magnetic resonance angiography
Electrocardiogram-gated subtracted three-dimensional fast spin echo

traction was performed to selectively detect arteries; further, the brachial artery was poorly detected. ECG-gated subtracted 3D FSE sequence of magnetic resonance imaging can compromise the image quality of both aneurysm and peripheral artery images when detecting SAAs.

Introduction

Kawasaki disease (KD) is described as an acute systemic vasculitis of medium-sized arteries that affects the coronary arteries. However, in approximately 2% of untreated patients, this syndrome can also cause systemic artery aneurysms (SAA) [1]. The incidence of SAA has not changed significantly in recent years, even with the introduction of intravenous immunoglobulin treatment [2]. SAA is associated with ruptured iliac aneurysms [3], axillary artery occlusion [4], and artificial blood vessel replacement for thoracic aneurysms [5]. Therefore, patients with KD should be evaluated for both coronary and systemic arterial aneurysms. The evaluation of SAA is mainly performed via angiography (AG) [1], computed tomography angiography [6], and contrast-enhanced magnetic resonance angiography (CE-MRA) [2]. However, since those examination are intended for pediatric patients, there are concerns regarding radiation exposure and the use of contrast media [7]. Recently, we reported that non-contrast magnetic resonance angiography (NC-MRA) is a successful and minimally invasive method for evaluating SAA in KD patients [8]. With the application of electrocardiogram (ECG)-gated subtracted three-dimensional fast spin echo (3D-FSE), which is used to selectively visualize arteries, we detected signal loss within the aneurysm and poor detection of the brachial artery.

This report describes the pitfall for systemic artery aneurysm evaluation by using the ECG-gated subtracted 3D FSE sequence of magnetic resonance imaging (MRI) in KD patients.

Case report

This a case of a 12-year-old male who, at 3 months of age, presented with high fever, conjunctival congestion, changes of the lips and oral cavity and polymorphous rash, and extremity edema. The patient was diagnosed with KD and received a dose of intravenous immunoglobulin. A right coronary artery aneurysm measuring around 5.4 mm and a 7.4 mm aneurysm from the left main trunk to the left anterior descending coronary artery were detected via echocardiography. The internal diameter of the coronary arteries in KD patients is evaluated by the Z-score, and the average normalized for body surface area represents the degree of coronary aneurysm [9]. The Z-scores of the internal diameter of the coronary arteries were +10.1 for right coronary artery and +13.6 for the aneurysm from left main trunk to left anterior descending, respectively. Although both aneurysms regressed initially, a right axillary artery aneurysm measuring 12.0 mm and a left axillary artery aneurysm measuring 8.0 mm were detected by using the NC-MRA after 3 years. AG was performed to confirm the preliminary diagnosis; however, bilateral axillary aneurysms were also detected as well as for the MRI imaging. After 12 years, we performed ECG-gated subtracted 3D FSE sequence of MRI while sedating the patient with 350 mg of thiopental sodium to evaluate SAA. We used a 1.5-Tesla MRI clinical imager (Ingenia, Philips Healthcare, Best, The Netherlands) by using the torso coil. Imaging parameters were as follows: repetition time 1333.3 ms (2 beats); echo time 73 ms (shortest); field of view 550 mm; matrix 320 × 256; slice thickness 4.0 mm; reconstruction slice thickness 2.0 mm; number of slices 50; flip angle (FA) 90°; refocusing flip angle (RFA) 180° (Diastolic phase), 80° (systolic phase); echo train length 48; inversion time 165 ms (diastolic phase), 140 ms (systolic phase); sensitivity encoding factor 2.0; half scan factor Y 0.8, Z 1.0; trigger delay 1016.4 ms (diastolic phase), 155.0 ms (systolic phase); scan time 91 s (diastolic phase), 91 s (systolic phase). ECG-gated 3D FSE images in the diastolic and systolic phases were acquired with coronal sections. Following image acquisition, subtraction was performed from diastolic phase imaging to systolic phase imaging. Diastolic phase imaging allowed for the efficient detection of bilateral axillary aneurysms, and, more specifically, of 15.5 × 24.5 mm aneurysms in the right and 8.0 × 20.0 mm aneurysms in the left axillary artery, respectively. Although subtracting imaging enhanced arterial clarity, a signal loss was detected within the right axillary artery aneurysm (Fig. 1), whereas the brachial artery was poorly detected (Fig. 2). In contrast, systolic imaging allowed the detection of hyperintensity in the right axillary aneurysm (Fig. 2). Systemic arteries such as renal arteries and iliac arteries were clearly detected on subtraction images, but they could also be evaluated on diastolic phase images to a similar degree (Fig. 3).

Discussion

In this case, signal loss in axillary artery aneurysm and poor detection of the brachial artery were observed when evaluating SAA in KD patients with ECG-gated subtracted 3D FSE sequence of MRI. However, ECG-gated subtracted 3D FSE should be carefully used when performing such evaluations.

ECG-gated subtracted 3D FSE sequence of MRI can cause poorly delineation in subtracted images when the acquisition of flow void in systolic phase is insufficient. The imaging sequence is the difference in obtaining phases between the diastole phase and the systole phase. Arteries in the systole phase with higher flow velocity have a lower signal; however, arteries

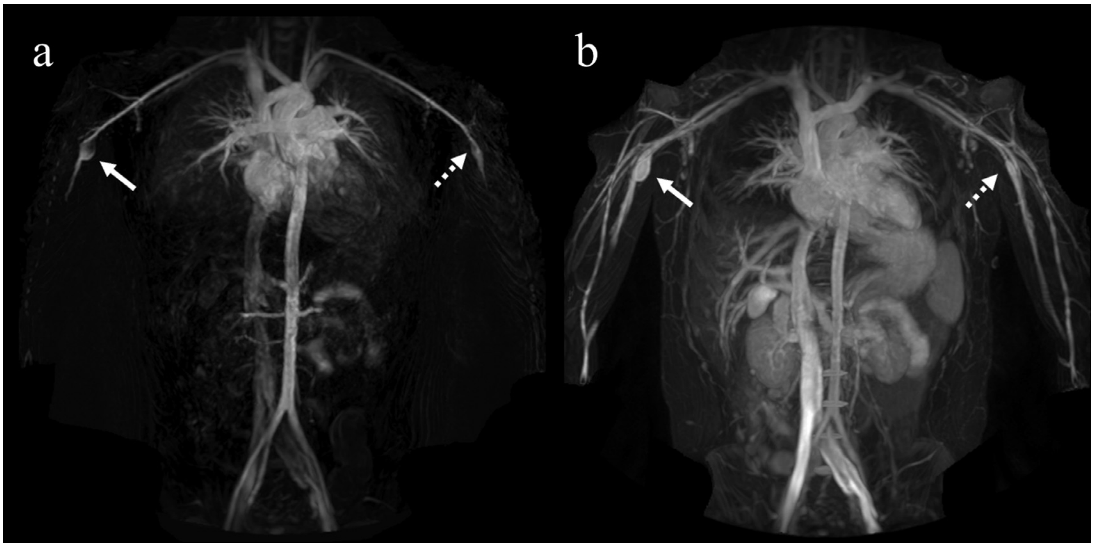

Fig. 1 – Maximum intensity projection images using the electrocardiogram (ECG)-gated subtracted three-dimensional fast spin echo (3D FSE) (a) and ECG-gated 3D FSE in the diastolic phase (b) were able to observe 15.5 mm right axillary artery aneurysms of (solid arrows) and 8.0 mm left axillary artery aneurysms (dashed arrows). Although ECG-gated subtracted 3D FSE improved the visibility of arteries, signal loss was observed in the right axillary artery aneurysm.

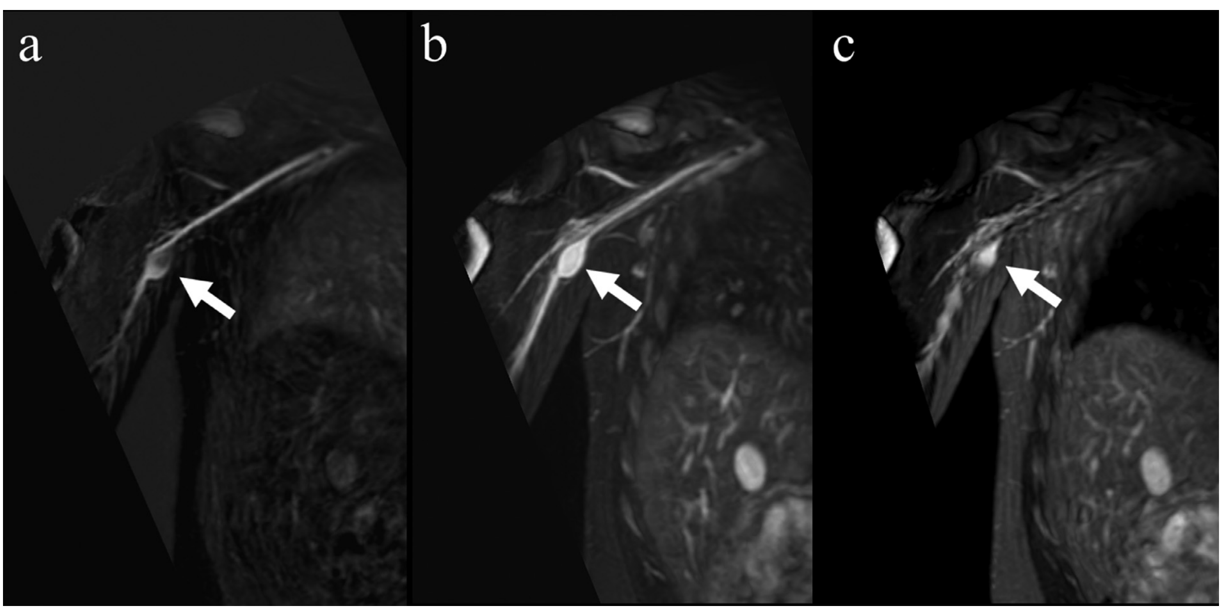

Fig. 2 – Maximum intensity projection images using the electrocardiogram (ECG)-gated subtracted three-dimensional fast spin echo (3D FSE) (a) and ECG-gated 3D FSE in the diastolic phase (b) and ECG-gated 3D FSE in the systolic phase (c). A signal loss within the aneurysm was observed in the subtraction image (solid arrows), whereas no signal loss was detected during diastolic phase imaging (solid arrows). We observed a residual signal within the aneurysm in systolic phase imaging (solid arrows). The brachial artery was poorly detected in the subtraction images compared to the diastolic phase images.

in the diastole phase with a slower flow velocity have a higher signal. Since veins have a slow flow, they have high signals in both phases. Therefore, the arterial signal can be selectively visualized by subtracting the images acquired in these two different phases [10]. However, the blood flow in aneurysms is known to be turbulent [11], and, even in the systole phase, flow is noted to be stagnant. Consequently, flow void acquisition can be very challenging. As a result, we believe that the signal from the right axillary artery aneurysm in the systolic phase image remains high, it can be lost during subtraction when using an insufficient flow void image. Selective detection of arteries may facilitate diagnosis and increase the clinical usefulness. However, the ECG-gated subtracted 3D FSE method can lose important information due to subtraction.

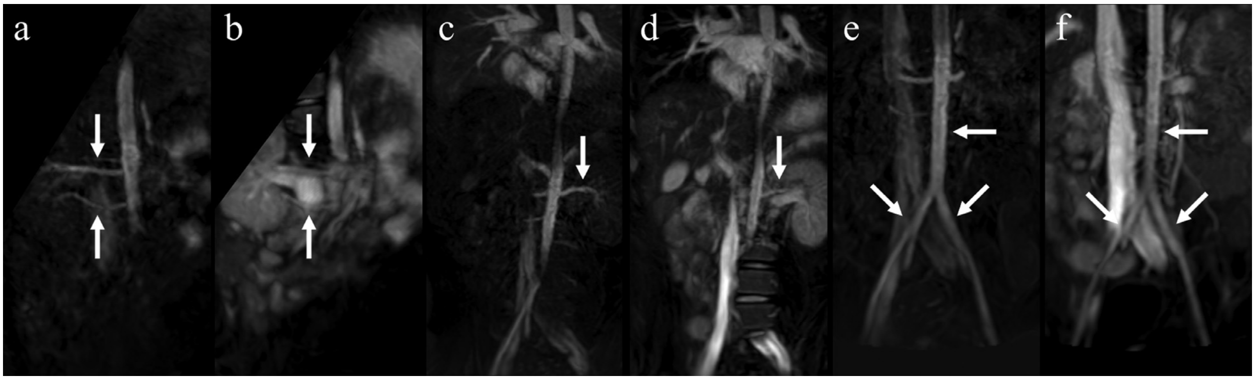

Fig. 3 – Multi planar reconstruction using the electrocardiogram (ECG)-gated subtracted three-dimensional fast spin echo (3D FSE) (a,c,e), and ECG-gated 3D FSE in the diastolic phase (b,d,f) were able to observed whole-body blood vessels such as the right renal artery (a,b), the left renal artery (c,d), and the abdominal aorta the iliac artery (e,f). Diastolic phase images could evaluate whole-body blood vessels as well as subtraction images.

It has been suggested that an effective way to suppress the slow velocity signal during flow void acquisition in clinical settings is the use of a very low RFA [12]. However, it can be difficult to optimize this process when evaluating SAA using ECG-gated subtracted 3D FSE sequence of MRI. This is due to the fact that this technique facilitates the acquisition of flow void in aneurysms, but the venous signal can become flow void as well [13]. If the vein signal becomes low during the systolic phase, the venous signal remains after subtraction, the process of subtraction doesn't make sense. Therefore, it is necessary to set the RFA and acquire a correct flow void in the aneurysm. However, the problem with this approach is that it can be substantially difficult to acquire the flow void only in the aneurysm area by using the same RFA in all examinations due to differences in intravascular flow velocity that depend on the respective morphology and part of the body, as well as on individual anatomical differences observed among patients. Multiple imaging sessions may be required to determine optimal RFA, yet this necessitates an extended examination time for the sedated patients, which can compromise patient safety due to the possibility of arousal.

ECG-gated subtracted 3D FSE sequence of MRI may reduce peripheral depiction. In this case study, the use of ECG-gated subtracted 3D FSE was able to also reduce the visualization of the periphery of the brachial artery. It is difficult to obtain the same flow void as the central blood vessel because the arterial flow velocity decreases in the peripheral blood vessel. The reason for this poorly detected signal from the brachial artery is the same as the cause of the signal loss of the aneurysm, because subtraction was performed using systolic phase images for which flow void was not acquired.

Signal loss in axillary artery aneurysms and poor detection of the brachial artery can be resolved by the use of ECG-gated subtracted 3D FSE in the diastolic phase to provide optimal images. Our results demonstrate that we could detect a high signal for stagnant blood flow vessels, which does not cause any signal loss in the aneurysm and can thus facilitate the detection of peripheral arteries. Although both arteries and veins are detected, MPR can facilitate effective arterial evaluation, and there is no risk of signal loss compared to the process of subtraction. This method is also very efficient because it does not require multiple image acquisitions, thus reducing the scanning time. When evaluating SAA in KD, it is not necessary to perform subtraction to selectively depict arteries; thus, diastolic imaging will suffice.

In conclusion, ECG-gated subtracted 3D FSE sequence of MRI may cause signal loss of SAA and poor detection of the peripheral artery in KD patients. Subtraction with systole phase imaging is not a necessary process for the evaluation of SAA because diastolic phase imaging can be more appropriate.

Authors' contributions

All authors contributed to the study conception and design. Material preparation and data collection were performed by Haruki Nonaka. The first draft of the manuscript was written by Haruki Nonaka. Takanori Masuda and Masahiro Tahara were commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Ethics approval

This study was approved by our institutional review board.

Availability of data and material

Not applicable.

Code availability

Not applicable.

Consent to participate

Written informed consent was obtained from the parents.

Consent for publication

Written informed consent was obtained from the parents.

REFERENCES

[1] Kato H, Sugimura T, Akagi T, Sato N, Hashino K, Maeno Y, et al. Long-term consequences of Kawasaki disease. A 10- to 21-year follow-up study of 594 patients. Circulation 1996;94:1379–85. doi:10.1161/01.cir.94.6.1379.

[2] Zhao QM, Chu C, Wu L, Liang XC, Sun SN, He L, et al. Systemic artery aneurysms and kawasaki disease. Pediatrics 2019;144. doi:10.1542/peds.2019-2254.

[3] Hsu B, Soriano B, Salamet MS, Reeder S B, Ralphe JC. Systemic arterial aneurysms in a 5 month old male with severe refractory Kawasaki's disease. Pediatr Dimens 2016;1. doi:10.15761/pd.1000123.

[4] Ozdemir E, Peterson RE. Systemic arterial aneurysm complicated by thrombosis in an infant with resistant Kawasaki disease. Ann Pediatr Cardiol 2019;12:147–9. doi:10.4103/apc.APC_73_18.

[5] Kaouthar H, Rafik B, Lilia C, Fatma O. Giant aortic arch aneurysm complicating Kawasaki disease. Ann Pediatr Cardiol 2014;7:201–3. doi:10.4103/0974-2069.140845.

[6] Kantarcı M, Güven E, Ceviz N, Oğul H, Sade R. Vascular imaging findings with high-pitch low-dose dual-source CT in atypical Kawasaki disease. Diagnostic Interv Radiol 2019;25:50–4. doi:10.5152/dir.2018.18092.

[7] Kanda T, Fukusato T, Matsuda M, Toyoda K, Oba H, Kotoku J, et al. Gadolinium-based contrast agent accumulates in the brain even in subjects without severe renal dysfunction: evaluation of autopsy brain specimens with inductively coupled plasma mass spectroscopy. Radiology 2015;276:228–32. doi:10.1148/radiol.2015142690.

[8] Nonaka H, Masuda T, Nakaura T, Tahara M, Nitta T, Yoneyama M, et al. Evaluating for systemic artery aneurysms using noncontrast magnetic resonance angiography in patients with Kawasaki disease: a report of two cases. Radiol Case Reports 2021;16:621–7. doi:10.1016/j.radcr.2020.12.062.

[9] Kobayashi T, Fuse S, Sakamoto N, Mikami M, Ogawa S, Hamaoka K, et al. A new Z score curve of the coronary arterial internal diameter using the Lambda-Mu-Sigma method in a pediatric population. J Am Soc Echocardiogr Off Publ Am Soc Echocardiogr 2016;29:794–801.e29. doi:10.1016/j.echo.2016.03.017.

[10] Miyazaki M, Sugiura S, Tateishi F, Wada H, Kassai Y, Abe H. Non-contrast-enhanced MR angiography using 3D ECG-synchronized half-Fourier fast spin echo. J Magn Reson Imaging 2000;12:776–83 10.1002/1522-2586(200011)12:5<776::aid-jmri17>3.0.co;2-x.

[11] Egelhoff CJ, Budwig RS, Elger DF, Khraishi TA, Johansen KH. Model studies of the flow in abdominal aortic aneurysms during resting and exercise conditions. J Biomech 1999;32:1319–29. doi:10.1016/S0021-9290(99)00134-7.

[12] Yoneyama M, Nakamura M. Optimization of 3D-variable refocusing flip angle RARE imaging for high-resolution volumetric black-blood angiography. Radiol Phys Technol 2012:270–6. doi:10.1007/s12194-012-0161-6.

[13] Wu G, Xie R, Zhang X, Morelli J, Yan X, Zhu X, et al. The diagnostic value of 3-dimensional sampling perfection with application optimized contrasts using different flip angle evolutions (SPACE) MRI in evaluating lower extremity deep venous thrombus. Invest Radiol 2017;52:734–40. doi:10.1097/RLI.0000000000000399.