Non-CE MRA

Reflections on (first) experiences with “some new” & “some known” Siemens sequences in Jessa Hospital

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Disclaimer

- No conflict of interest
- Not in depth technical review
- Not a scientific validation
Overview

- Introduction

- Arteries from lower extremities and Renal Arteries
  - Technique
  - Examples
  - Strengths – weaknesses - indications

- Conclusion
Introduction

- Current use of NCE MR angiography
  - Circle of Willis: standard
  - Carotid and vertebral arteries: frequent
  - Renal arteries: occasional
  - Aorta/leg arteries: occasional
Why is there a need for using Non-CE MRA techniques?
Discussion and Conclusion

The surveys conducted in this paper suggest that many high-MR-volume institutions have had no recent NSF cases (1). In addition, changes in GBCA use since the association between NSF and GBCA was reported in 2006 have virtually eliminated new cases reported to the FDA (9), European Medicines Agency, and manufacturers. The data compiled in this review of 370 reported cases suggest that reductions in risk may be attained with each of the following: 1) avoiding high doses of GBCA (>0.1 mmol/kg); 2) avoiding nonionic linear chelates in patients undergoing dialysis and patients with GFR <30 ml/min, especially in the setting of proinflammatory conditions; 3) dialyzing quickly after GBCA administration for patients already on dialysis; and 4) avoiding GBCA in acute renal failure, especially while serum creatinine level is rising.

Figure 1.
For 346 consecutive patients examined over a decade the diagnosis is significant fibrosis (SF) or oropharyngeal systemic fibrosis in each patient. The number of patients with high-dose GBCA was 370, and no NSF cases were reported in patients with acute renal failure. The graph shows the distribution of GBCA doses based on patient age and renal function.

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Renal function, nephrogenic fibrosis and other adverse reactions following gadolinium-based contrast media: a short review

Table 2. Chronology and evolution of the term "nephrogenic systemic fibrosis"

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>First report of NSF in the literature as a skin condition “scleromyxedema-like” in dialysis patients¹</td>
</tr>
<tr>
<td>2001</td>
<td>Nephrogenic fibrosing dermopathy is reported as a new disease²</td>
</tr>
<tr>
<td>2003</td>
<td>The systemic involvement of the disease becomes known for the first time²⁴</td>
</tr>
<tr>
<td>2005</td>
<td>The term “nephrogenic systemic fibrosis” is recorded for the first time⁷²</td>
</tr>
</tbody>
</table>

Table 8. Administration of gadolinium adjusted to renal function

- **GFR >60mL/min**
  - There are no limitations on the administration of Gd, but it is necessary to always try and respect the measures with regard to dose and administration time.

- **GFR 30-60mL/min**
  - It may be administered whenever the maximum measures of safety are taken into account in the doses administered and at intervals of 1 week between MRI.

- **GFR <30mL/min**
  - Do not administer Gd. Seek diagnostic alternatives.

GFR: glomerular filtration rate, Gd: gadolinium.
correlations. Finally, it remains unclear whether this deposition effect is limited to gadodiamide, to linear chelated GBCAs in general, or whether it manifests in both linear and the more thermodynamically stable macrocyclic gadolinium chelates; recent indirect evidence from Kanda et al. (32) suggest this deposition may be limited to linear agents. Although our findings are limited to a single linear ion GBCA (gadodiamide), established data on the chemical and biophysical properties of GBCAs suggest that this deposition is likely to occur with multiple agents and that the extent of this deposition likely correlates with the thermodynamic stability of these chelates (33).

In conclusion, our findings suggest that intravenous administration of GBCA is associated with dose-dependent deposition in neuronal tissues that is unrelated to renal function, age, or interval between exposure and death. Although we were unable to clearly identify a histologic phenotype of gadolinium deposition within neuronal tissues, our findings strongly argue for future research to assess the in vivo stability and safety of GBCAs.

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Figure 1


24. Van Wagener M, Worah D. Gadodiamide injection: first human experience with the nonionic magnetic resonance imaging enhance-
Available techniques

- Time of Flight (TOF) COW

- Contrast mechanism:
  - T1 saturation of the stationary tissue
  - In-flow signal enhancement from moving spins

MR Images Aff. Hospital of JS University
Time of Flight (TOF) Carotid vs CE-MRA
Available techniques

**Syngo NATIVE**
- consists of two non-ce MRA applications:
  - *syngo NATIVE TrueFISP*: Non-ce MRA optimized for the use in thorax (e.g. thoracic aorta) and abdomen (e.g. renal arteries)
  - *syngo NATIVE SPACE*: Non-ce MRA optimized for the use in peripheral angiography – with Inline Subtraction & MIP
**syngo NATIVE SPACE**
MR Angiography – Intrinsic Contrast Mechanism

- **Contrast mechanism:** difference in intravascular signal between maximum and minimum flow during the cardiac cycle.
Images acquired in systole (dark blood) are subtracted from images acquired in diastole (bright blood) and maximum intensity projection (MIP) images are calculated.
Rule of Thumb for Calculation TD time:

- TD min flow = 0 ms
- TD max flow = Trigger Time mean Curve - 30 ms
syngo NATIVE TrueFISP – Non-contrast MRA for chest/abdomen

- TrueFISP-based non-contrast MRA technique with intrinsic contrast mechanism
- Magnetization preparation using graphically positioned selective IR
- Sequence accommodates
  - 3D & 2D approach
  - Breathhold, navigated and respiratory triggered approaches, depending on clinical requirements
- Modified chest protocols

J. Carr, Northwestern University
**Contrast mechanism:** inflow of non-inverted spins during TI period
1 Basic principles of syngo NATIVE TrueFISP
(2) Connectie voor Resp kussen

Overzicht van het protocol

<p>| | | |</p>
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<td>1</td>
<td>---respiratoire triggering---</td>
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</tr>
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<td>---kussentje plaatsen+koppelen aan...</td>
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<tr>
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<td>t2_haste_cor_p2_mbh</td>
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<td>---NotSet klikken in physiokaart vr tri...</td>
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Planning transversale reeks

In de coronale reeks de Nierarteries zoeken
Sequentie openen en “coupled graphics” activeren alvorens volume te verschuiven.
Vierkante rasters zijn “inversie-volumes” die dan mee verschuiven tijdens de planning
Bovenste coupe 1.5cm onder de nier bovenpool plaatsen
Inclineren op het sagittaal beeld volgens verloop van de AORTA
Planning coronale reeks

In de transversale reeks de Nierarteries zoeken
Sequentie openen en “coupled graphics” activeren alvorens volume te verschuiven.
Vierkante rasters zijn “inversie-volumes” die mee verschuiven tijdens de planning
Inclinatie volgens verloop van de AORTA (zie SAGITTAAL beeld)
Centraal punt van het scanvolume komt net boven de nierarteries (zie CORONAAL beeld)
In Physio-kaart “Signal1”-tab Resp./Trigger synchroniseren via -not set-
syngo NATIVE TrueFISP
Scan planning for Kidney Transplant

Positioning of inversion recovery and imaging slab
New evolutions (WIP’s) once become product

- QISS publications (1.5 Tesla)

- QISS publications (3 Tesla)
  
  Nonenhanced peripheral MR-angiography (MRA) at 3 Tesla: evaluation of quiescent-interval single-shot MRA in patients undergoing digital subtraction angiography.
  > Wagner-Int J Cardiovasc Imaging-2015-Feb

  Evaluating Peripheral Arterial Disease With Unenhanced Quiescent-Interval Single-Shot MR Angiography at 3T
  > Amin-AJR-202-886

  Nonenhanced ECG-Gated Quiescent-Interval Single Shot MRA: Image Quality and Stenosis Assessment at 3 Tesla Compared With Contrast-Enhanced MRA and Digital Subtraction Angiography
  > Hansmann-JMRI-39-1486

  ECG-gated quiescent-interval single-shot MR angiography of the lower extremities: initial experience at 3 T.
  > Knobloch-ClinRadiol-69-485

  Non-contrast-enhanced MR angiography at 3 Tesla in patients with advanced peripheral arterial occlusive disease.
  > Thierfelder-PLoS-9-e91078

- QISS publications (7 Tesla)
General Requirements

System
MAGNETOM Aera
MAGNETOM Skyra

Minimum Software Version
syngo MR E11

Other
Additional technical prerequisites may apply. Upon receiving your request, your local Siemens representative will clarify whether your system meets the requirements.
Aorta – arteries lower extremities

- Technique: QISS
  - Quiescent-Interval Single Shot Magnetic Resonance Angiography (QISS)
  - Rapid, sequential two-dimensional (2D) steady-state free precession acquisition acquired using ECG-gating
  - Acquires one slice per heartbeat

Figure: Pulse sequence diagram of the QISS sequence (Edelman et al, MRM 2009).
QISS* pulse sequence diagram (1A, top) and schematic of vasculature (1B, bottom) showing the effect of pulse-timings on signal manipulation to maximize arterial conspicuity. In-plane saturation and tracking venous saturation RF pulses are applied TD ~ 100 ms after the R-wave; these pulses suppress background and venous signal. Following a preset quiescent interval (QI) of 228 ms, during which unsaturated arterial blood flows into the imaging slice, a fat suppression RF pulse is applied, followed by single-shot TrueFISP readout. This process is repeated in subsequent heart-beats to acquire other slices, usually in foot-to-head direction. In the basic configuration used for survey examinations, one 3 mm-thick slice is acquired per RR interval with 1 x 1 mm in-plane spatial resolution.
Interdisciplinary discussion of the case, a two-stage treatment strategy for the left leg was adopted. In the first stage, the stenosis of the left femoral bifurcation was surgically corrected by means of thromboendarterectomy (TEA) and application of a patch graft. Then another catheter angiography was carried out and the STA occlusion was successfully recanalized and stented (Fig. 4). Shortly thereafter, the patient was discharged home with significantly improved running.

Discussion

QISS MRA was successfully used in the diagnosis of a patient with PAD. Compared to the Doppler ultrasound exam, QISS MRA provided additional information on the extent and localization of significant stenoses regardless of the level of the stenoses, allowing early treatment decisions and planning.

In a previous study [1], the diagnostic accuracy of QISS MRA was evaluated in 53 patients with suspected or known PAD. QISS MRA showed high sensitivity (89.7%) and specificity (87.0%, two readers) and specificity (96.5% and 94.6%, two readers) using CE-MRA as reference standard. In a subset of 15 patients (279 segments), conventional DSA was performed during a therapeutic intervention procedure and when MRA revealed pathologic conditions that warranted further investigation. In these vessel segments, QISS MRA had high sensitivity (91.0%, mean values) and specificity (95.6%, mean values) using conventional DSA as reference standard. The high sensitivity and specificity of QISS MRA at 1.5T have been confirmed in two other studies, which also included patients with PAD and mainly used CE-MRA as reference standard [1, 3, 14]. Nowadays, 3T MR scanners are increasingly being used in clinical practice. A recent volunteer study indicated that QISS MRA benefits from higher field strengths [15]. However, clinical studies of QISS MRA at 3T have not yet been published. One advantage of QISS MRA over other MRA techniques is that it is easy to use and does not require preplanning of slice blocks or calibration of sequence parameters, according to arterial flow patterns.

In our experience so far, QISS MRA takes only slightly longer considering the preparation time for planning scans and tests of different contrast-enhanced MRA. A limitation in the present QISS examination was the suboptimal suppression of the venous signal. However, this had no substantial impact on the assessment of the peripheral arteries.

In summary, QISS MRA is an easy-to-use, robust technique for unenhanced imaging of the peripheral arteries. QISS MRA could be a future alternative to CE-MRA for preparative diagnosis and treatment planning for patients with PAD.

References


Clinical Validation

QISS MRA has been evaluated at field strengths ranging from 1.5 Tesla to 7 Tesla*, with the reported accuracy at 1.5 Tesla and 3 Tesla generally approaching or matching that of CEMRA.[20-26] The technique has also been specifically evaluated in a diabetic patient population in whom CTA may be problematic due to the frequent presence of vascular calcifications and poor renal function.[27]

Using CEMRA as the reference standard, QISS showed excellent diagnostic performance with sensitivity of 89.8%, specificity of 96.4%, positive predictive value of 92.4%, and negative predictive value of 95.0%. An example illustrating the advantage of QISS MRA over CTA for the evaluation of diabetic PAD patients is given in

ease, and advanced age [9]. CT angiography has the disadvantage of exposing patients to ionizing radiation and there is also the associated risk of contrast-induced nephropathy (CIN), which is of particular concern because nearly 40% of patients with PAD have significant renal dysfunction [10]. Contrast-enhanced magnetic resonance angiography (CEMRA) has also been shown to be highly accurate for the detection of stenoses ≥50% within the lower extremity arterial tree [11]. Unfortunately, the administration of gadolinium-based contrast agents in patients with severely impaired renal function is contraindicated due to the risk of nephrogenic systemic fibrosis (NSF) [12].

Non-enhanced MRA Techniques

Non-enhanced MRA (NEMRA, i.e. MRA without contrast agents) avoids the potential risks of NSF and CIN, as well as ionizing radiation. Two-dimensional time-of-flight NEMRA methods have been available for decades [13, 14]. However, lengthy acquisition times (typically approaching an hour or more) and image artifacts have limited their routine use in favor of contrast-enhanced techniques. Newer subtractive approaches for NEMRA of the peripheral arteries have been proposed which allow efficient depiction of arteries over large fields-of-view and suppress venous signal. These include ECG-gated subtractive 3D turbo spin echo (TSE) imaging such as fresh blood imaging (FBI) [15] and NATIVE SPACE (NATIVE = Non-contrast angiography of the arteries and veins; SPACE = Sampling perfection with application optimized contrast by using different flip angle evolution) [16], as well as variants predicated on 3D balanced steady-state free precession (bSSFP) imaging such as flow-sensitive dephasing [17]. Of these, subtractive TSE MRA techniques have the most clinical validation and are commercially available. However, subtractive TSE MRA is not robust due to its sensitivity to patient motion, pulse wave timing, and abnormal flow patterns [16].

The Quasirectangular Single-Shot (QISS) NEMRA technique was developed as a safer, simple ‘push button’ non-enhanced alternative to CTA and CEMRA (Fig. 1) [18]. Moreover, QISS MRA eliminates the need for point-of-service blood draw to determine A+FA and yields significant cost savings ($180 per study at our institution) compared with CEMRA by eliminating the MR contrast agent and injector kit. QISS offers several advantages over previously described NEMRA techniques (Fig. 2) [19]. It is highly robust with minimal sensitivity to patient motion and cardiac arrhythmias. It has the particular advantage of enabling a simple and efficient workflow, thereby eliminating the need for special technologist expertise.

*QISS is pending 510(k) clearance and is not commercially available in the US.
QISS

Antennes

Possible coils: Body 18 (2-3) depending on the size of the patient, Spine 32, Peripheral Angio 36
<table>
<thead>
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<th>Step</th>
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<td>1</td>
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<tr>
<td>2</td>
<td>Positieve patiënt feet first</td>
</tr>
<tr>
<td>3</td>
<td>Laser Center op col plug periferie</td>
</tr>
<tr>
<td>4</td>
<td>I Localizer feet 00:11</td>
</tr>
<tr>
<td>5</td>
<td>II Localizer legs 00:11</td>
</tr>
<tr>
<td>6</td>
<td>I Localizer legs 00:11</td>
</tr>
<tr>
<td>7</td>
<td>II Localizer legs 00:11</td>
</tr>
<tr>
<td>8</td>
<td>III Localizer upper legs 00:11</td>
</tr>
<tr>
<td>9</td>
<td>IV Localizer abdomen 00:11</td>
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</tr>
<tr>
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</table>
Aorta – arteries lower extremities

- Technique: QISS
- Scan time: approx. 30 minutes
Aorta – Leg arteries

- Technique: QISS
- Examples (good vs the bad and ugly)
- Limitations
  - Stents/metal artifacts
  - In-plane signal loss
  - MIP's small steps due to movement
  - Arrhythmia, poor ECG (fast AF, high HR)
Aorta – Leg arteries

- Technique: why not NATIVE SPACE?
- Poor image quality Aorto-iliac station (S:N issues?)

Images: presentation AM Lyndon, Aug 2013
Healthy volunteer  (PN: WD)
Healthy volunteer (PN: WD)
NCE (PN 175628)
NCE vs CE (PN 490961)
NCE vs CE (PN 196382)
NCE - CE MR + CE CT (PN 425802)
NCE
NCE and NCE CT (calcifications)
88-year-old male with claudication and type-2 diabetes. **(3A)** CTA; **(3B)** QISS MRA. The CTA was non-diagnostic due to the presence of extensive vascular calcifications. However, QISS MRA was completely unaffected by the vascular calcifications and demonstrated the patency of proximal vessels and occlusions of calf vessels. In this case, note that QISS MRA image quality was adequate despite the fact that the patient had atrial fibrillation.

*Adapted with permission from ref. 20*
NCE vs CE
NCE
NCE
NCE
Aorta – Leg arteries

- Technique: QISS
- Examples
- Limitations
- Strengths/indications
  - No IV Gd or access
  - Relatively easy to use
  - No patient specific parameters
  - Minimal flow dependence
  - Less sensitive to motion artifacts compared to subtraction
Aorta – Leg arteries

- Technique: QISS
- Very helpfull part population
  - elderly, renal impairment, difficult iv access,…
  - Confirm or exclude significant stenoses
- Know your sequences and what to expect
  - Strengths
  - Weaknesses
  - Pitfalls
  - Inform your clinician
Renal arteries

- Technique: NATIVE True Fisp - technique (Non-contrast MRA of ArTerIes and VEins)
  - Inversion pulse
  - Respiratory triggering
Renal arteries

- Technique: NATIVE True Fisp
  - Coils:
  - Scan time: 10 to 20 minutes
    - Breathing
    - Constitution
    - Cor and/or ax acquisition
Renal arteries

- Technique: NATIVE True Fisp

- Examples (good vs the bad and ugly)

- Limitations:
  - Stents/ metal artifacts
  - Low cardiac output, dehydration/ hypovolemia
  - Patient movement
  - Characterisation of renal and other abdominal masses
Renal arteries

- Technique: Native
- Examples
- Limitations:
- Strengths/indications
  - No IV Gd
  - Relatively easy to use
CE vs NCE (PN 20468)
NCE (PN 553216)
NCE (PN 553216)
NCE (PN 666285)
Correlating NCE CT: ostial calcifications

(PN 666285)
Correlating NCE CT: ostial calcifications
(PN 666285)
NCE (PN 693236)
NCE (PN 36402)
NCE (PN 32568)
“Complex” exam due to quadriplegic patient: arms not on the side of the body
NCE (PN 93504)
NCE (PN 77912)
NCE (PN 23548)
Stent/metal artifact (PN 726076)
In conclusion:

- Leg arteries: QISS and renal arteries: NATIVE
- Relatively robust sequences
- “Quick” and easy to use
- Potentially of great value in cases where patients are unable to receive Gadolinium contrast agent.
- Beware of limitations and pitfalls.
Dank aan

- MR-Teams VJ en SA
- Radiologen Jessa
- Siemens voor ondersteuning en samenwerking
- …
Bedankt voor Uw aandacht

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Campus Virga Jesse
Hasselt

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Hasselt

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