Time-Resolved MR Angiography for Detecting Ovarian Venous Reflux: Comparison with Conventional Venography

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Purpose

The purpose of this study was to compare the diagnostic accuracy of time-resolved MR angiography (TR-MRA) with that of conventional venography for the detection and grading of ovarian venous reflux, which aid for a diagnosis of pelvic venous congestion.
Methods and Materials

Patients

Our institutional review board approved this retrospective study and informed patient consent was waived. We performed a review of the clinical records of the TR-MRA and conventional venography examinations that were performed from 1 January 2009 to 30 August 2009 for evaluating pelvic venous congestion.

The criteria for inclusion in the study were a high degree of clinical suspicion of pelvic venous congestion because of chronic pelvic pain of at least 6 months duration and the patients underwent both TR-MRA and conventional venography.

In addition, the patients underwent conventional venography within one month after TR-MRA. The retrospective analysis included 19 patients (age range: 31-75 years, mean age: 56 years). They were all premenopausal women (17 parous and 2 nonparous).

Time-Resolved MR angiography

MR imaging was performed on a 1.5 T system (Achieva 1.5 T, Philips Systems, Best, The Netherlands) and using a SENSE body coil. All the patients were initially examined with a routine MRI protocol for the pelvis that included the axial, coronal and sagittal T2-weighted images, the axial T1-weighted images and the contrast-enhanced T1-weighted images.

Time-resolved MR angiography was acquired using the contrast-enhanced timing robust angiography (CENTRA) keyhole technique. The acquisition parameters of the TR-MRA were the following: a TR/TE of 5.5/1.5, a flip angle of 35°, a matrix of 350 x 210, a slices/slab of 70, a slice thickness of 1.6 mm and a field of view of 40 x 40 cm. During shallow breathing, four phases (arterial, late arterial, venous and late venous) of imaging of the pelvis were performed in the coronal plane for 1-2 minutes after IV injection of 0.1 mmol/kg body weight of contrast media, at a rate of 2 mL/s, and this was followed by a 20 ml saline flush with a power injector. The acquisition time per phase was 15 seconds and the intervals between phases were 3 seconds. Timing for the TR-MRA was achieved through the use of a MR fluoroscopic bolus detection technique. The scanning of the arterial phase was started after initial abdominal aortic enhancement at the renal artery level on the MR fluoroscopic images. The post-enhanced MR images for each phase were subtracted from the pre-contrast MR images, and then the subtracted MR images for each phase were used to generate MRA by using maximum intensity projection (MIP).

Venography and embolization
The patients with chronic pelvic pain and a high degree of clinical suspicion for pelvic congestion underwent venographic evaluation for pelvic congestion with subsequent coil embolization if it was indicated. Selective ovarian venography was performed via the transfemoral approach. With the patient in a supine position, venographic access was obtained with the Seldinger technique via the right femoral vein. The guidewire was advanced into the inferior vena cava and after placement of a 6 Fr introducer sheath and a 5 Fr Cobra catheter, selective right ovarian venography was performed to evaluate the right ovarian vein both during with performing Valsalva’s maneuver. After the right ovarian venography, the left ovarian vein was selectively catheterized and venography was performed.

An enlarged or incompetent ovarian vein was treated with transcatheter coil embolization. However, we did not perform selective small collateral vein embolizations along the main ovarian vein. The indications for coil embolization included dilatation of the ovarian vein (> 5 mm), ovarian vein reflux into the pelvic cavity involving an incompetent valve, severe congestion of the pelvic venous plexus, significant stasis of contrast medium in the pelvic veins, abnormal filling of the pelvic veins across the midline and filling of vulvovaginal or thigh varicosities.

Among the 19 patients, 16 patients underwent left unilateral ovarian venous embolization using coils. Three patients did not undergo ovarian venous embolization because these patients had nutcracker syndrome, which requires surgery or endovascular stenting for alleviating symptoms. Embolizations were performed using an optimal size and number of coils (0.035 inch, 6-12 mm, Cook, Bloomington, IN, USA). After embolization, repeat venography was performed to confirm occlusion of the ovarian vein as well as that of the concomitant parallel trunks.

**Image analysis**

Analysis of all the MR images was performed with a picture archiving and communications system (PACS) workstation monitor. Two experienced radiologists, each with more than five years of experience in the practice and interpretation of pelvic MR, independently evaluated both source images and volumetric maximum intensity projection reconstructions of the TR-MRA. An experienced interventionalist with more than five years of experience in the field reviewed the conventional venography images. The conventional venography images were used as a reference standard. The observers were blinded to the clinical history and the reports of the MR imaging and venography.

The images were reviewed to determine if differences in the detection and grading of ovarian venous reflux were seen between the TR-MRA and conventional venography. The grades of ovarian venous reflux were divided into two grades. **Grade 1 reflux** means the reflux was confined in the left ovarian vein and/or left parauterine veins. **Grade 2 reflux** means the reflux was found in the right ovarian vein, the left internal iliac vein and the right internal iliac vein, and varicosities of the vulva and thighs in addition to the Grade
1 reflux. For the cases with combined reflux, isolated treatment of the ovarian vein or conservative treatment can cause a poor clinical outcome. However, bilateral ovarian and internal iliac vein embolization provides improvement of the symptoms related to pelvic congestion syndrome without a significant change of the ovarian function. In patients with Grade 1 reflux, the clinical symptoms are improved by ovarian vein embolization only. However, in the patients with Grade 2 reflux, embolization of multiple venous channels is needed for relieving the symptoms related to pelvic congestion syndrome. Each reader indicated with arrows the presence of ovarian venous reflux and they saved the digital images on the workstation. We recorded the detected ovarian venous reflux on a data sheet on which the reflux site was listed (left ovarian vein, left parauterine plexus, right parauterine plexus, right ovarian vein, left internal iliac vein, right internal iliac vein, and varicosities of the vulva and thighs). The maximal diameters of the left ovarian veins and left parauterine veins were measured by one blinded radiologist. When there was more than one vein on the same side, the largest vein was measured.

**Statistical analysis**

The primary objective was to determine the diagnostic performance of TR-MRA for detecting ovarian venous reflux, with conventional venography as the reference standard. Statistical analysis was performed using the McNemar test to compare the TR-MRA and conventional venography for assessing the ability of grading ovarian venous reflux. Probability values less than 0.05 were considered to be statistically significant. Separate determinations were made of the sensitivity, specificity and accuracy of TR-MRA, including the 95% confidence intervals (CIs) derived from a generalized estimating equation analysis.

The sensitivity for correct grading of ovarian venous reflux was defined as the number of correctly identified cases of grade 2 reflux evaluated on TR-MRA divided by the total number of cases of grade 2 reflux evaluated on conventional venography. Specificity was defined as the number of cases of correctly identified grade 1 reflux evaluated on TR-MRA divided by the total number of cases of grade 1 reflux evaluated on conventional venography. Accuracy was defined as the number of correctly identified cases of grade 1 and grade 2 reflux evaluated on TR-MRA divided by the total number of cases of reflux evaluated on conventional venography. The data was analyzed using a statistical software package (SPSS, version 18, Chicago, IL USA).

Weighted k statistics were calculated to assess the interobserver agreement for the grading of ovarian venous reflux. The level of agreement was defined as follows: k values of 0.00-0.40 indicated poor agreement, k values of 0.41-0.75 indicated good agreement and k values of 0.76-1.00 represented excellent agreement.
Results

The comparison between TR-MRA and conventional venography for grading ovarian venous reflux is shown in Table 1. In all 19 patients, the left ovarian venous reflux was seen on both TR-MRA and conventional venography (Figs. 1 and 2). On TR-MRA, left ovarian venous reflux was seen on the arterial phase and/or late arterial phase in all 19 patients. For both observers, there was no significant difference between TR-MRA and conventional venography for correctly grading the degree of ovarian venous reflux ($P > 0.05$).

The sensitivity, specificity and diagnostic accuracy of TR-MRA are listed in Table 2. The sensitivity, specificity, and diagnostic accuracy of TR-MRA for grading ovarian venous reflux were found to be 66.7%, 100% and 78.9%, respectively, for observer 1 and 75%, 100% and 84.2%, respectively, for observer 2. In our study, TR-MRA showed a relatively high accuracy compared with venography (Fig. 1). Of the 19 patients, four patients and three patients were incorrectly categorized as grade 2 reflux to grade 1 reflux with TR-MRA by observer 1 and observer 2, respectively (Fig. 2). There was no false positive diagnosis of grade 1 reflux to grade 2 reflux on TR-MRA by both observers.

The mean diameter of the left ovarian vein was $7.8 \pm 1.2$ mm (range: 5.2-9.7 mm) on TR-MRA and $9.2 \pm 1.7$ mm (range: 5.7-11.7 mm) on conventional venography. The mean diameter of the left parauterine veins was $4.7 \pm 0.7$ mm (range: 3.5-5.7 mm) on TR-MRA and $5.3 \pm 0.9$ mm (range: 3.4-6.7 mm) on conventional venography.

The weighted $k$ values indicated excellent agreement between the two observers for grading ovarian venous reflux on TR-MRA ($k = 0.894$).
Fig. 0: FIG 1A. 61-year-old woman with grade 2 ovarian venous reflux. This case was correctly categorized to grade 2 reflux on TR-MRA. Coronal MIP image of time-resolved MR angiography obtained during arterial phase shows retrograde opacification of contrast media from left renal vein to left ovarian vein (arrows).

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**Fig. 0:** Fig 1B. On late arterial phase, there is dilatation of right ovarian vein and right parauterine veins, and right parauterine veins and right ovarian vein are opacified (arrows) due to retrograde flow that crossed midline with passing uterus from left into right parauterine veins.

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Fig. 0: Fig 1C, D, Selective left renal venography with performing Valsalva maneuver shows dilated left ovarian vein (thick arrows) and left parauterine veins. Right ovarian vein and right parauterine veins (thin arrows) are opacified due to retrograde flow that crossed midline from left into right parauterine plexus.

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**Fig. 0:** Fig 1C, D, Selective left renal venography with performing Valsalva maneuver shows dilated left ovarian vein (thick arrows) and left parauterine veins. Right ovarian vein and right parauterine veins (thin arrows) are opacified due to retrograde flow that crossed midline from left into right parauterine plexus.

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**Fig. 0:** Fig 1E. Transcatheter embolization of left ovarian vein was performed using multiple coils.

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Fig. 0: Fig 2A. 41-year-old woman with grade 2 ovarian venous reflux. This case was incorrectly categorized to grade 1 reflux on TR-MRA. Coronal MIP image of time-resolved MR angiography obtained during arterial phase shows retrograde opacification of contrast media of left ovarian vein and left paraurine veins (arrows). However, there is no evidence of opacification of left internal iliac vein.

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**Fig. 0:** Fig 2B, C, Selective left renal venography with performing Valsalva maneuver shows dilated left ovarian vein and left parauterine veins (thick arrows). Left internal iliac vein (thin arrows) is opacified due to retrograde flow from the left parauterine varices.

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Conclusion

TR-MRA is an accurate method for accessing pelvic venous congestion.


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