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PELVIS

MR venography using time-resolved imaging in interventional management of pelvic venous insufficiency

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Abstract

Purpose of Review To evaluate the utility of magnetic resonance venography with time-resolved imaging (MRV TRI) in the diagnosis of pelvic vein insufficiency (PVI).

Recent Findings A retrospective single-center review of $N = 17$ consecutive patients who underwent pelvic MRI for the assessment of PVI was performed. $N = 8/17$ (47%) studies were positive for PVI. TRI imaging demonstrated $N = 6/8$ patients with Grade 0–3 PVI and $N = 2/8$ patients with May–Thurner Syndrome. $N = 4/8$ patients underwent elective endovascular management, all of which were technically successful.

Summary In the assessment of PVI, MRV TRI provides a dynamic assessment of venous insufficiency, serving as an adjunct to the imaging diagnosis of this pathology.

Keywords Pelvic vein insufficiency · Magnetic resonance venography · Time-resolved imaging

Introduction

Pelvic venous insufficiency (PVI), also known as pelvic congestion syndrome, is an under-diagnosed condition responsible for chronic pelvic pain (CPP). 15% of hysterectomies and 35% of diagnostic laparoscopies are performed for CPP [1].

Angioembolization of ovarian veins and varices is the treatment of choice for PVI.

Conventional catheter venography has been the gold standard for diagnosis and treatment, adequately demonstrating ovarian vein reflux, dilatation of ovarian veins, uterine and pelvic venous engorgement, and vulvovaginal/thigh varicosities [2], also readily demonstrating the iliac vein, renal vein, and IVC to rule out secondary causes of PVI. However, recent advances have made non-invasive cross-sectional imaging modalities, including ultrasonography (US), computed tomography (CT), and now magnetic resonance imaging (MRI), the preferred choice for diagnostic evaluation of patients with suspected PVI, providing excellent anatomic assessment of the extensive differential of chronic pelvic pain, evaluating for gynecologic, urologic, gastrointestinal, or musculoskeletal sources of pain.

Despite adequate appreciation of pelvic varicosities with Doppler ultrasonography, visualization of the ovarian vein is difficult, resulting in a significantly lower sensitivity [3]. Although computed tomography (CT) can demonstrate varices and ovarian vein dilatation, it does not provide dynamic evaluation and use of ionizing radiation is a pertinent issue as most of these patients are young.

Pelvic MRI with MR Venography and Time-Resolved Imaging (TRI) may serve as a 'One-Stop Shop' to optimally diagnose PVI and assist and guide treatment planning and to rule out non-PVI etiologies of pelvic pain. Time-Resolved Imaging (TRI), a specialized MRI sequence with high temporal resolution, enables the visualization and assessment of the dynamic flow patterns within the pelvic arterial and venous vasculature, readily assessing the implicated vessels with similar flow information as is provided by conventional venography. The anatomic findings on MRI include dilated ovarian vein > 8 mm [3], presence of pelvic, perineal, vulva/labial and thigh varices, and secondary causes of PVI such as a retroaortic left renal vein, mesoaortic compression of renal vein (nutcracker syndrome), May–Thurner syndrome, IVC obstruction, vascular malformations, portal hypertension, or vascular thrombosis can also be detected with MRI.

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The excellent anatomic detail and flow information also provide a detailed roadmap for the embolization procedure, detecting variant anatomy and ruling out non-PVI etiologies [2].

Materials and methods

MRI with MR Venography was performed in our institution on a 1.5 T scanner (Siemens Magnetom Avanto). High-resolution axial T1, and axial, sagittal, and coronal T2 sequences of the pelvis are performed to reveal anatomic detail, followed by axial TruFISP and T2 single-shot sequences providing white and black blood imaging flow information, respectively. Then 3D contrast-enhanced MRV is performed with Time-Resolved Imaging (TRI) to provide temporal dynamic flow information (presence and direction of flow) and vascular anatomy as described below. All the studies were performed using either Gadofosveset trisodium (Ablavar, Lantheus Medical, North Billerica, MA) or Gadobutrol (Gadovist, Bayer Schering AG, Berlin, Germany), a 20-ml bolus injected using an automated power injector at a rate of 2 ml/s followed by saline flush. Pre- and post-contrast gradient sequencing with a large FOV acquired in the coronal plane with axial and sagittal reformats provided further excellent visualization of the vascular anatomy.

The technical parameters of the essential sequences described above are as follows:

Time-resolved imaging: 76 acquisitions of 2 s each started 12 s after injection. TA: 3:07, TR: 2.33 ms, TE: 0.85 ms, Flip angle: 25 deg, FOV: 500 mm, Voxel size: 1.6 × 1.6 × 1.6 mm, Bandwidth: 780 Hz/Px, PAT: 3, GRAPPA.

3D Gradient echo sequence: Plane of acquisition: Coronal, TR: 7.21 ms, TE: 2.09 ms, Flip angle: 25 deg, Bandwidth: 130 Hz/Px, FOV: 400 mm, Voxel size: 0.9 × 0.9 × 0.9 mm, 192 slices, Fat suppression: Q-fat sat, TA: 4:37 PAT: 2, GRAPPA.

The study was approved by our institutional review board.

Discussion

TRI is a specialized 3D contrast-enhanced MR angiographic sequence which allows one to overcome the limitations of timed or bolus-chase contrast-enhanced MR angiography. The technique is particularly useful for venous imaging, when timing of the exam and arrival time of the bolus is uncertain, especially in abdominal imaging in free breathing patients and when the presence and direction of flow are critical to the diagnosis. The MR physics of TRI is based on the oversampling of central K space (which provides contrast signal) and undersampling of peripheral K space (which provides more spatial resolution). The use of a short TR, rectangular FOV, partial Fourier, and parallel imaging further reduces the time of acquisition enabling sub-second acquisitions [4]. The sequence provides non-invasive high temporal and contrast resolution

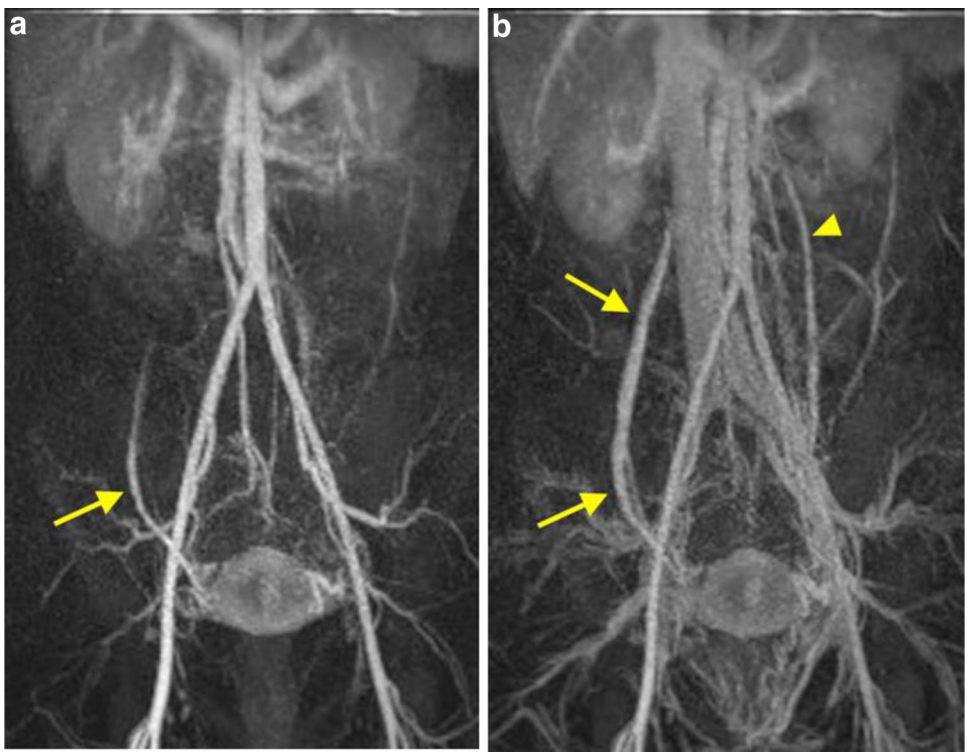

Fig. 1 A 31-year-old G2P1 with grade 0 PVI on sequential MR TRI (**a**, **b**). Dilated right ovarian vein (9 mm) with normal antegrade flow (arrows). The left ovarian vein was competent (arrowhead)

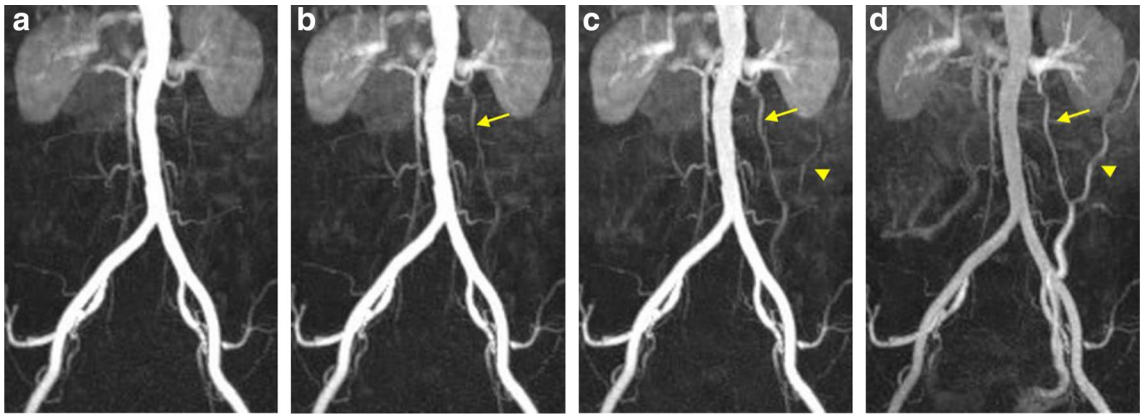

Fig. 2 A 32-year-old G2P1 with grade 1 PVI on sequential MR TRI. **a**–**d** Retrograde flow in the left ovarian vein which is normal in caliber (arrows). The caudal portion of the ovarian vein is dilated due to filling from a variant branch of the left ovarian vein (arrowheads)

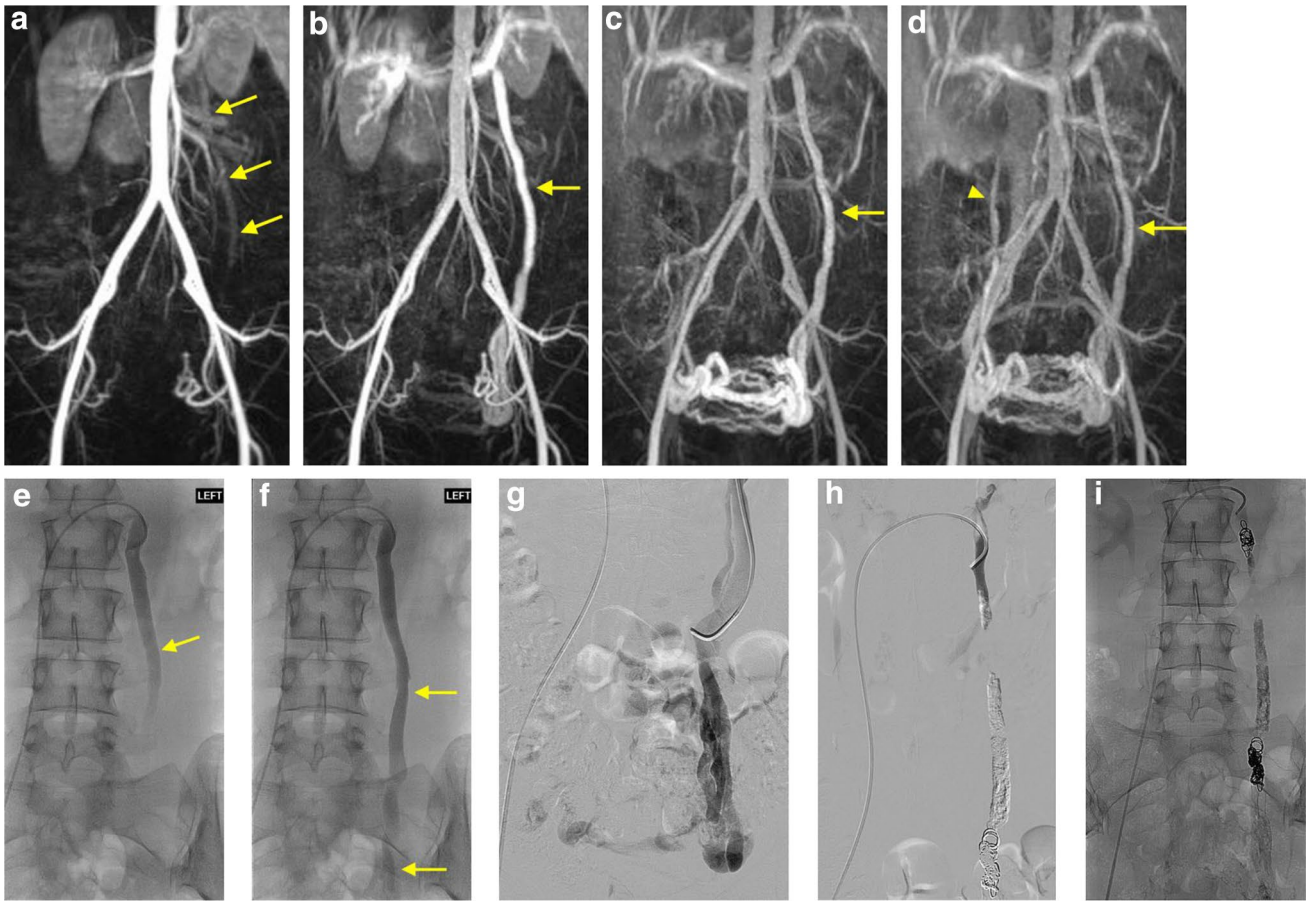

Fig. 3 A 39-year-old G3P3 woman with grade 2 PVI on sequential MR TRI. **a**–**c** Retrograde flow in the left ovarian vein (arrows) and filling of the left (ipsilateral) parauterine veins (arrowhead). **d**, **e** Venography confirms the left ovarian vein (arrow) reflux into the left parauterine veins (arrowhead). **f** Successful embolization with coils and sclerosant

allowing dynamic evaluation such as is acquired with conventional venography.

A baseline mask is acquired initially to enable subtraction imaging followed by multiple dynamic 3D volume acquisitions. In our institution, 76 phases are acquired beginning 12 s after contrast injection with the time of acquisition for each phase being 2 s in duration. This enabled dynamic visualization of contrast flow characteristics for a duration

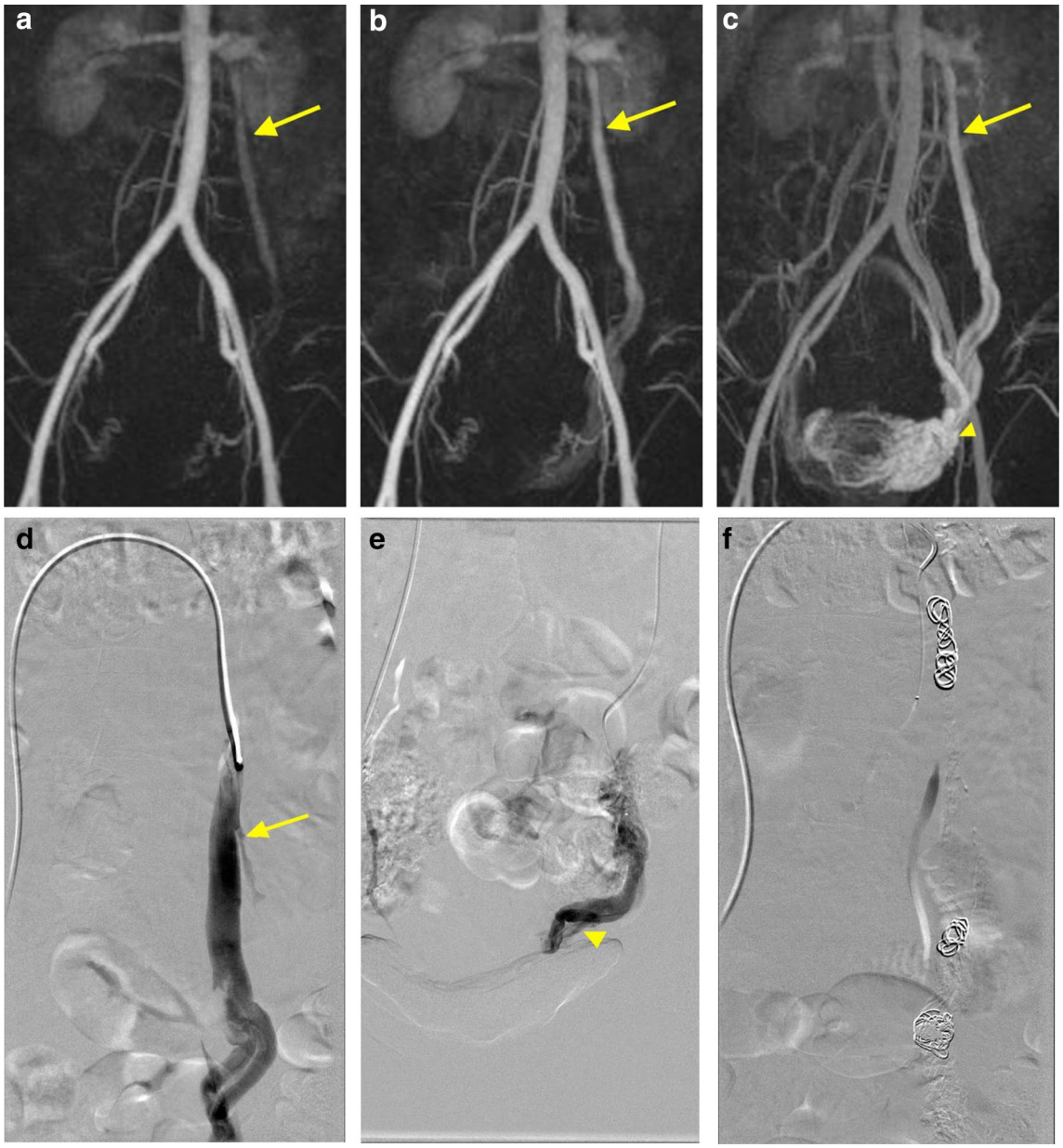

Fig. 4 A 34-year-old G2P2 with grade 3 PVI on sequential MR TRI. **a**–**d** Retrograde flow in the left ovarian vein (arrows) which eventually crosses midline and fills the right ovarian vein (arrowhead). **e**–**g** Corresponding venographic images confirm these findings in the left ovarian vein (arrows). **h**, **i** Successful embolization with sclerosant, glue, and coils

of up to 3 min, long enough to capture pelvic venous flow, including gonadal vein reflux. The ability to provide such detailed temporal information is critical in patients being considered for endovascular management of PVI.

The diagnosis of PVI on CT and MRI (without TRI) is based mainly on anatomic imaging, specifically the diameter of the ovarian veins. Several studies [5–7] have reported reflux in asymptomatic women based on the ovarian dilatation to be 38–47% (see Fig. 1). Belenky et al. [8] reported a considerably lower incidence of ovarian vein reflux (9.9%) using indirect venography in their study on 273 renal donors. This discrepancy suggests that using ovarian vein vessel caliber alone for diagnosis of incompetence can lead to false-positive results. Thus, TRI which provides critical directional flow data under physiologic conditions (as opposed to the non-physiologic injection of a conventional venogram) may increase overall accuracy of diagnosis, by

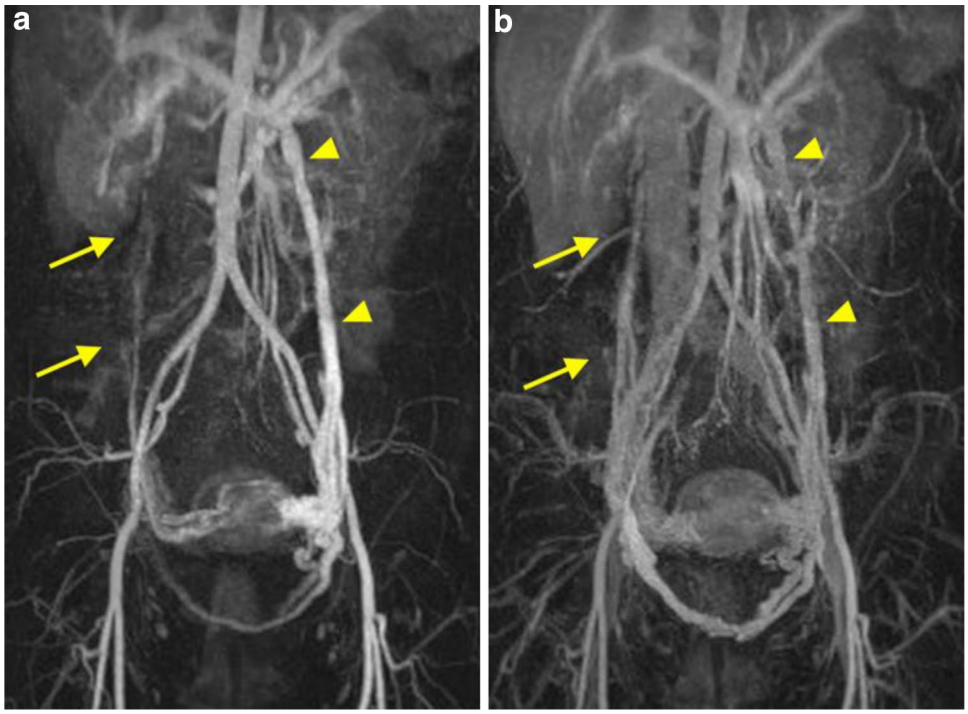

Fig. 5 A 30-year-old G3P3 with grade 3 PVI on sequential MR TRI. **a**, **b** Dilated right ovarian vein with normal antegrade flow (arrows). The dilatation was due to cross filling from the incompetent left ovarian vein (arrowheads)

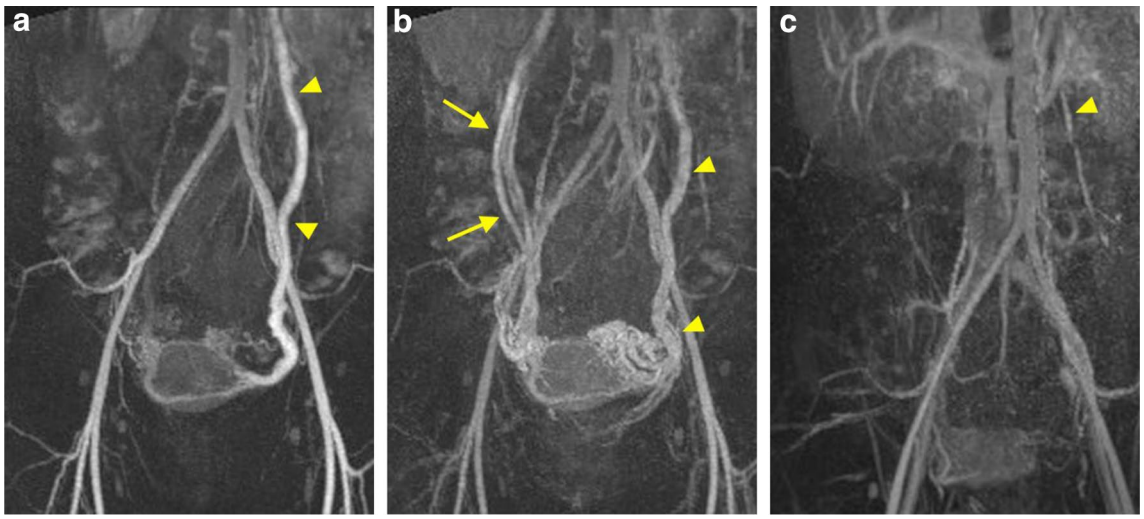

Fig. 6 A 30-year-old G3P3 woman with grade 3 PVI on sequential MR TRI. **a**, **b** Left ovarian vein reflux (arrowheads) filling the right ovarian vein (arrows), which is competent. **c** TRI images performed 2 years post-embolization demonstrate a normal caliber left ovarian vein (arrowhead) with no opacification of the pelvic veins or the right ovarian vein

reducing false-positive results based on anatomic criteria and imaging alone (see Figs. 2 and 5).

The ovarian vein can be competent, but dilated in the presence of fibroids or due to cross filling from the incompetent contralateral ovarian vein (see Fig. 3) [9]. Conversely, the ovarian veins can be incompetent, but non-dilated or normal in caliber in cases of early reflux or due to variant insertion (see Fig. 4). TRI increases the sensitivity and specificity of MRI by demonstrating non-dilated incompetent ovarian veins and dilated but competent ovarian veins (Fig. 5).

Furthermore, the true flow dynamics in conventional venography can be altered due to the pressure of direct injection which can result in a false-positive diagnosis [9]. As the injection of contrast in TRI is through a peripheral intravenous access, the flow characteristics on TRI are more truly physiologic.

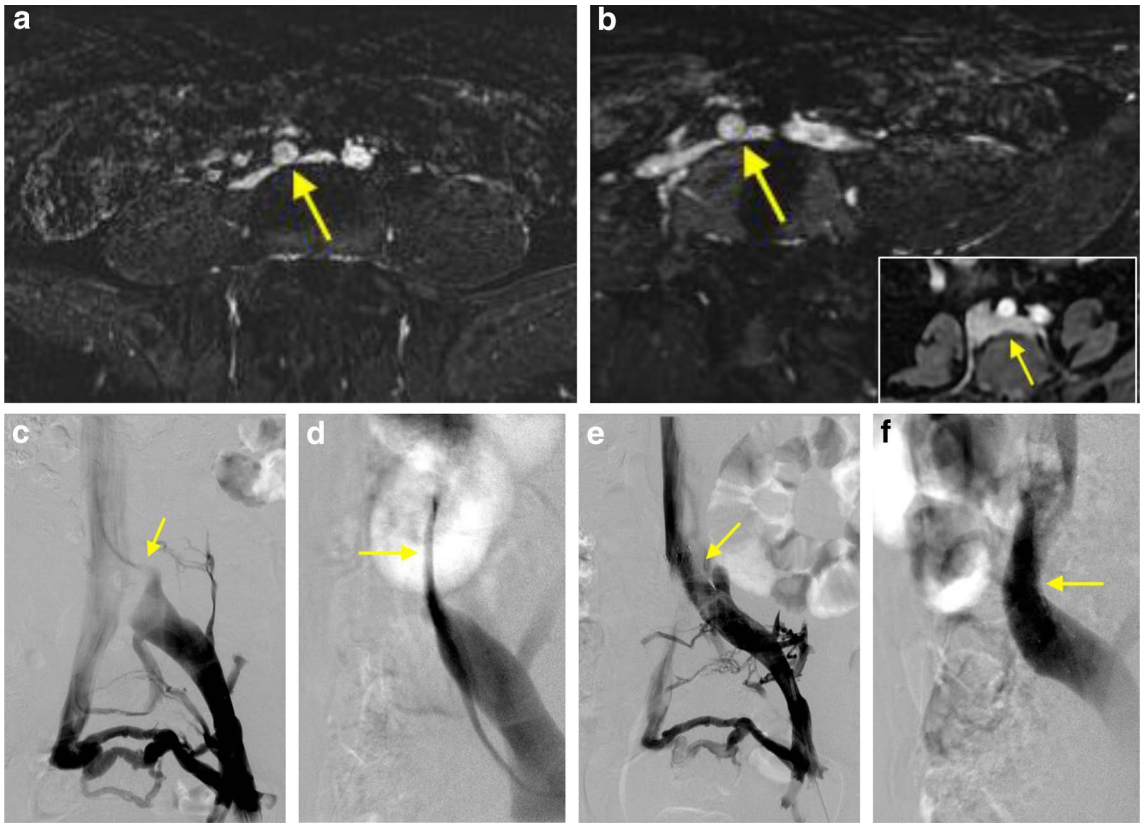

Fig. 7 A 37-year-old female with May–Thurner Syndrome. **a**, **b** Axial and oblique post-contrast VIBE MR images, respectively, demonstrate severe compression of the left common iliac vein by the right common iliac artery (arrows). For comparison (inset image), VIBE MR images from a different patient show the normal configuration. **d**, **e** Venographic AP and lateral images, respectively, confirm the severe compression (arrows) and also show the pelvic varices. **f**, **g** Venographic AP and lateral images, respectively, post-stent grafting demonstrate luminal restoration (arrows) and reduction in the pelvic varices

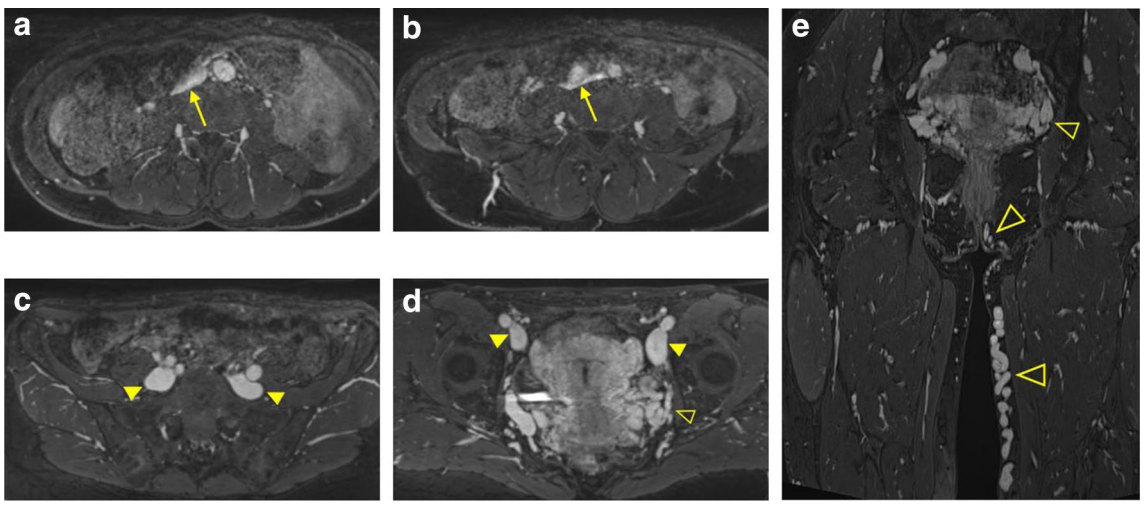

Fig. 8 A 42-year-old female with variant May–Thurner Syndrome demonstrated on sequential axial post-contrast images. **a** IVC cranial to the site of compression is normal in caliber (arrow). **b** Severely narrowed slit-like IVC (arrow) due to compression by the right common iliac artery. **c**–**e** Dilated common and external iliac veins (arrowheads) and varices in pelvis, left labia, and medial thigh (empty arrowheads). TRI did not reveal any ovarian vein reflux

TRI also provides information about arterial anatomy and flow characteristics (see Fig. 6) and thus can detect any incidental AV malformations, which is not possible with conventional venography [10]. One of the caveats of TRI in the diagnosis of PVI is that early subtle reflux can be missed on TRI due to supine patient positioning; however, this can occur on conventional venography without table tilt (Figs. 7, 8).

MR Venography with TRI provides a roadmap for the embolization procedure. It provides an excellent depiction of anatomical variants facilitating pre-procedural planning. Overall, in our experience, TRI added to Pelvic MRI and MRV is an indispensable pre-procedural planning tool which increases the accuracy of the diagnosis.

Conclusion

MR Venography with TRI is a quick, efficient, and accurate non-invasive technique for the evaluation and diagnosis of CPP, specifically PVI. In addition to providing the required anatomic information to make the diagnosis of PVI, and revealing important possible secondary causes, MR Venography with TRI provides physiologic assessment of the direction of flow within the veins, and by confirming or excluding ovarian vein reflux further increases the accuracy of diagnosis. MRV with TRI provides all this pre-operative planning for possible endovascular management of PVI without the risk of ionizing radiation exposure, and in doing so, in our experience, may also indirectly reduce the radiation dose of the actual embolization procedure by providing a pre-procedural 'roadmap,' This has become the standard of practice for the work-up of these patients at our institution.

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Compliance with ethical standards

Conflict of interest All the above authors declare that they have no conflicts of interests.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of our institutional review board and with the 1964 Helsinki declaration and its later amendments.

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