

Magnetic resonance venography and computed tomography venography in pelvic venous disease

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ABSTRACT

The purpose of this article is to highlight the advantages and disadvantages of magnetic resonance venography (MRV) and computed tomography venography (CTV) in diagnosing and evaluating pelvic venous disease (PeVD).

Keywords: PCS, PeVD, MRV, CTV, imaging, venous.

The treatment of pelvic venous disease (PeVD), including pelvic congestive disease (PCS), as the root cause of chronic lower abdominal complaints and pain, has received increasing attention in the last decade. Additionally, patients that present with the combination of (extensive) pelvic venous collaterals and/or insufficient veins with (predominantly) upper leg, groin and pelvic floor varicosities have been reported to benefit from treating the pelvic insufficiency first.^[1] Traditionally, the work-up of these patients was a combination of clinical presentation and Duplex ultrasound (DUS). Additionally, not only trans-abdominal, but also transvaginal ultrasound (TVU) has been proposed by the experts of these techniques. Alternatively, magnetic resonance venography (MRV) and computed tomography venography (CTV) have been utilized.^[2] In this article, the techniques and data regarding the MRV and CTV studies are elaborate on and their limitations are discussed. In my opinion, it is important to emphasize that, only as an addition to (not as a substitute for), a detailed and thorough clinical examination, imaging, using computed

tomography (CT) and magnetic resonance imaging (MRI) can truly provide benefits to investigating patients suffering from PeVD. The highly variable outcomes of previous studies reporting on the identification (with imaging) and treatment of PCS are a testament to this assumption.^[3,4] Only while starting from a solid clinical base, both DUS and the adjunctive three-dimensional (3D) MRV and CTV techniques provide more (non-invasive) certainty with regard to treatable PeVD.

WHY MAGNETIC RESONANCE VENOGRAPHY OR COMPUTED TOMOGRAPHY VENOGRAPHY?

While evaluating PCS, some signs and venous disease can be analyzed perfectly with DUS.^[5] To illustrate, upper leg or groin varicosities, as well as labial varicosities are among them. Transabdominal DUS provides, in suitable cases (preferably not those having morbid obesity and preferably with limited bowel gas), a window of opportunity to also assess the abdomen and pelvis evaluating both renal veins, the inferior

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vena cava (IVC), iliac veins, and even the pelvic plexus around the ovaries, uterus and vagina. However, in my experience, there are limitations and routinely getting a clear anatomical overview is complicated. This is where MRV and CTV provide benefits. Both techniques allow for a complete 3D overview of the anatomy, easy identification of anatomical normal variations (e.g., double caval vein, aberrant origin of renal and/or gonadal veins, extend of dilation in the pelvic plexus, relation with the presacral plexus, paralumbar plexus and internal iliac plexus).^[6] While DUS is superior regarding the patient mobility, this can not be applied for all venous segments or abdominopelvic regions, hampering all imaging techniques being performed in the supine position. There are, however, also dynamic options that can be applied with MRV and, on occasion, asking the patient to perform the Valsalva technique while scanning which may provide ('dynamic') information. The main advantages of using a 3D technique in addition to DUS is the non-invasive nature (outpatient diagnostics), the anatomical information, the ability to plan ahead of any invasive procedure and the opportunity to share with your patients 'on screen' what has been diagnosed.^[7] As a note of caution, it should be kept in mind that occasionally undiagnosed malignancy, thrombosis and other relevant findings can be identified on 3D imaging that may direct the actual treatment in other, unsuspected directions.

MAGNETIC RESONANCE VENOGRAPHY-TECHNIQUE AND INDICATIONS

The MRV, as an adjunct to DUS, should be considered for several reasons. Inconclusive DUS is the first, confirmation of disease the second, and anatomical information, ideally combined with a dynamic evaluation is the third. In my experience, being able to acquire some dynamic information is of great importance to confirm and inform the patient 'on screen'.

There are different ways to perform MRV including non-contrast enhanced, contrast-enhanced, and four dimensional (4D for short), with the fourth dimension being time, also called dynamic MRV.^[7-9]

NON-CONTRAST ENHANCED MAGNETIC RESONANCE VENOGRAPHY

Non-contrast enhanced MRV has the advantage of not requiring any (gadolinium-based) contrast

material. Consequently, there is a limit to the amount of detail that can be captured with this sequence and due to its balanced nature (both T1 and T2 contrast elements), not all soft tissue contrast can be distinguished (in as much detail) as with, for instance, the commonly used post-contrast sequences. However, since it is safe, quick, and easy, it can be used for body imaging and it does provide an anatomical overview. An example is shown in Figure 1.

CONTRAST-ENHANCED MAGNETIC RESONANCE VENOGRAPHY

There are two techniques for contrast-enhanced imaging. The first is the direct technique, in which for the evaluation of leg-veins and the abdominopelvic region contrast is injected through in a (superficial) vein in the foot. Advantageous of this technique is the natural outflow direction; there is a direct passage of high-intensity contrast material in the blood without attenuation of arterial structures or non-relevant venous pathways. However, the technique is cumbersome and can be painful (and unfortunately not always successful) which limits its use in the clinical practice.

Alternatively, the indirect technique can be used. The contrast is injected into the circulation remote from the body parts evaluated, usually a cubital vein. Contrast is followed by a saline tracer to ensure (rapid) arrival in the central circulation. This is the routine approach for contrast administration for most of the patients undergoing a MRI scan and, thus, easily



Figure 1. Non-contrast enhanced MRI of the pelvis showing the common iliac vein confluence, and both left and right gonadal vein (not dilated).
MRI: Magnetic resonance imaging.

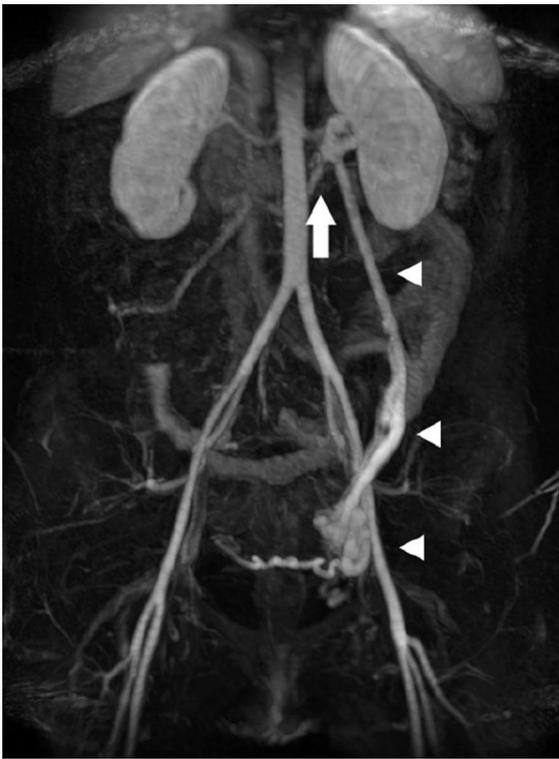


Figure 2. 'Single shot' image from a dynamic MRV study showing an anatomical variation of the left renal vein (arrow) and dilation of the left ovarian vein (arrowheads) and ovarian plexus in the pelvis on the left. One vein cross over the uterus left to right can be seen. The varicose disease at the level of the labia (bottom of the image) is unmarked.

MRV: Magnetic resonance venography.

which implies a degree of dilution of signal intensity. However, due to the nature of gadolinium-based contrasts and the average circulation time (relative long retention time in the circulation), there is an adequate amount of time (20 min) to acquire post-contrast images.

In our center, the protocol starts with the 4D acquisition, directly after completing the contrast injection. This sequence has a limited field of view, indicating that it must be planned specifically in the area of interest. This is usually the abdominopelvic region, but can be pelvis and upper leg or thoracic outlet and superior caval vein in some cases. The non-contrast enhanced images are helpful for the technicians to plan this accurately and align the volume correctly. The acquisition lasts approximately 90 sec covering the arterial to (late) venous phase in 3 to 6-sec steps. Once the dynamic acquisition is complete, the steady-state imaging is initiated to acquire high-detail anatomical images. Examples of the MRV sequences are shown in figures 2, 3 and 4.

As mentioned previously, MRV is useful in patients where DUS examinations are inconclusive or a detailed pelvic and/or abdominal (anatomical) deep venous information is crucial. The detection of anatomic variations can be easily performed and this should not be underestimated, since the variations are more frequent than expected and not routinely reported. These anatomic variations are an interventional challenge or lead to other approaches or even diagnosis. The dynamic acquisition techniques allow for both a relative fast acquisition and an additional dynamic aid (4D imaging, 3D moving images).

implemented. Its main disadvantage (even though much less than for CTV which is hampered by this) is the distribution of contrast through the entire body

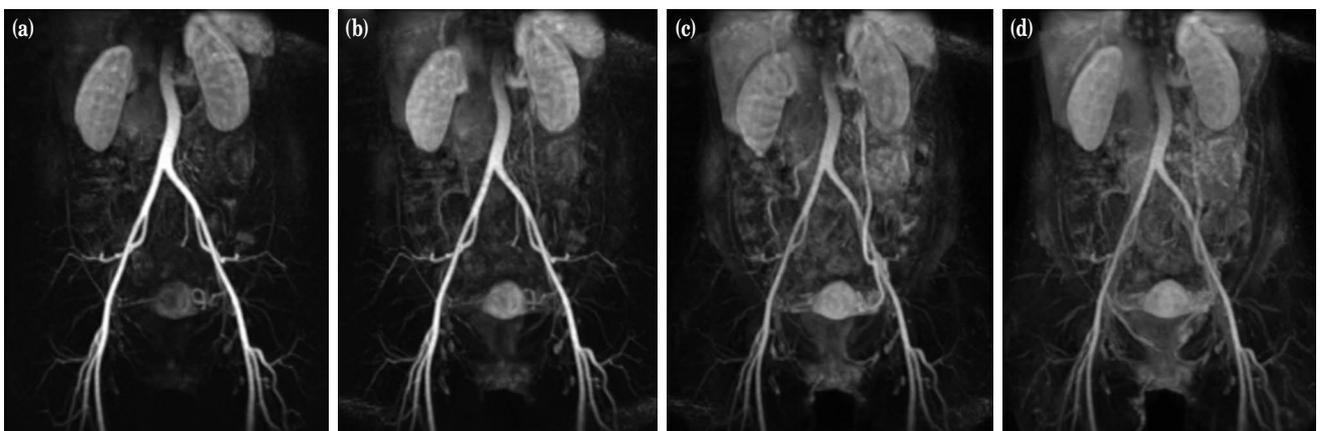


Figure 3. Multiphase dynamic MRV in extensive PCS. (a) Arterial system. (b) Insufficiency of left ovarian vein, ovarian plexus. (c) Descending pattern to parauterine, paravaginal, and pelvic floor plexus. (d) Further descending varicose veins in the labia extending down the right thigh.

MRV: Magnetic resonance venography; PCS: Pelvic congestive syndrome.

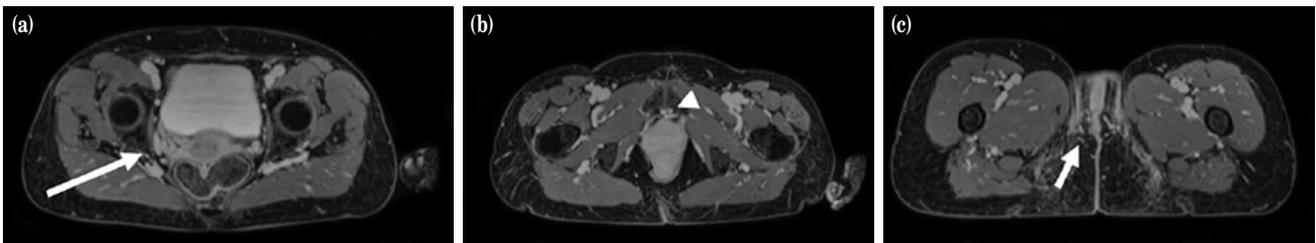


Figure 4. Axial MRV images showing: (a) Dilated pelvic plexus (arrow). (b) Dilated internal pudendal vein (arrowhead). (c) Varicose veins deep in the labia (arrow). MRV: Magnetic resonance venography.

In addition to the anatomical and high-detail superiority over DUS (and often CTV), advantages of MRV for this often-younger patient population include no radiation exposure and, for all patients, the limited impact on renal function. Also, it does not require iodine contrast, since contrast material for MRI is gadolinium-based.

COMPUTED TOMOGRAPHY VENOGRAPHY-TECHNIQUE AND INDICATIONS

The CTV of the abdomen and pelvis is routinely performed for many indications other than PCS,

and this also helps in differentiating any PeVD from non-vascular (venous) disease. Obtaining access to an abdominal CT for a patient is relatively easy.

In addition to ultrasound, it provides additional (3D) anatomical information, presence or absence of IVC filters, orientation of confluences, and presence or absence of pelvic varicosities (even in ‘deep’ regions that are less accessible for DUS).^[7-9] An example is shown in figure 5.

There are two techniques for CTV. The first is indirect CTV, which can be combined with pulmonary angiography in case of a suspected or extensive thrombosis; however, it is not often utilized

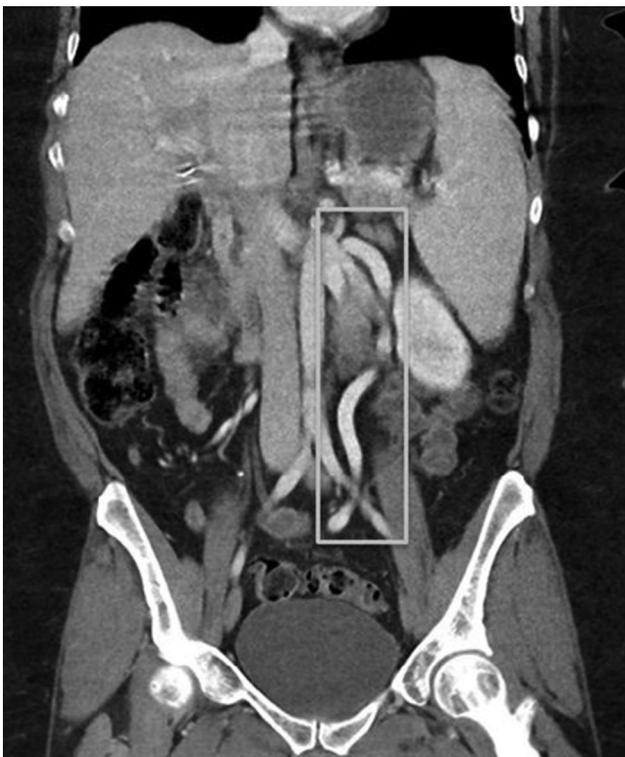


Figure 5. Example of a coronal reconstruction of a CTV study showing dilation of the left ovarian vein (box).

CTV: Computed tomography venography.

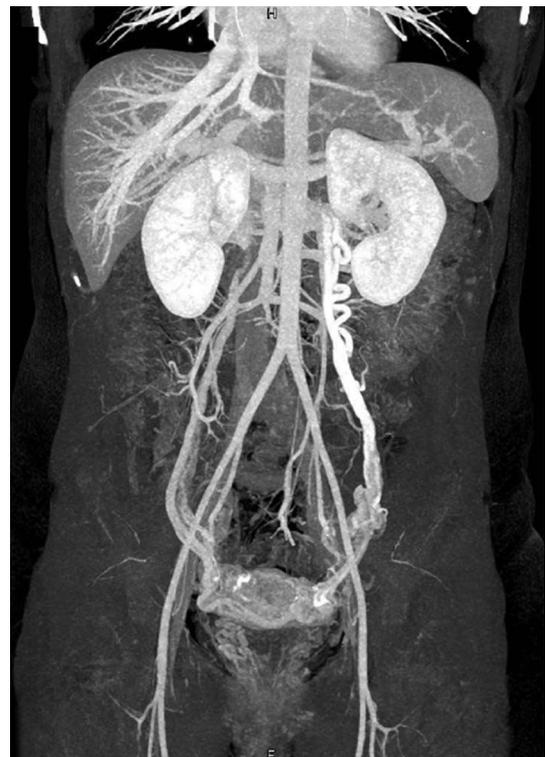


Figure 6. Multiphase CTV showing both arterial and venous anatomy and insufficient ovarian veins.

CTV: Computed tomography venography.

in daily practice. Indirect means include a CT angiography (CTA), where the intravenous contrast material is injected through a cubital vein, and a 50 to 80 sec after contrast injection the patient is scanned. The delay dictates that it is not a CTA, timed for the arterial vessels, but a CTV, timed for the venous structures. Timing depends on cardiac output, the flow rate at which the contrast is injected, and general hydration state of the patient. Also, the aforementioned scan parameters are for the abdominopelvic region. Additionally, indirect CTV requires all the contrast to pass through the arterial system prior to the return through the venous system. Hence, the contrast is more 'diluted' through the body and less dense. This is also the reason why this technique has varying results. Due to the lower degree of opacification, reconstructions such as maximum intensity projection (MIP) do not provide much benefit. With newer scanners, it is possible to acquire a multiphase CTA-CTV with the option to subtract or add these phases to highlight vasculature. This allows for a more sophisticated visualization of the veins and is less prone to be a false-negative study, as the operator is less dependent on one scan phase. An example is shown in Figure 6. Obviously, acquiring multiphase CTA-CTV implies a higher dose of radiation, compensated for by the newer scanners having many techniques to lower the overall dose. Still, the main CTVs limitations are the need for iodine contrast material and its adverse effect on the renal function and the exposure to radiation. Since it is usually attempted to keep radiation as low as reasonably possible (ALARA principle), alternatives to this should be preferred.

Alternatively, albeit still limited for the same reasons, there is direct CTV. For this scan, a thigh-high compression stocking is placed on the affected limb or limbs, venous access is created in any superficial foot vein and, then, iodinated contrast is injected at approximately 3 mL/sec. The contrast injection, as with the indirect technique, is followed by a so-called saline chaser (30 to 50 mL) to ensure that the contrast is distributed to the more central veins. After injection, the compression is released and images are acquired from the upper leg to the heart. It is important to maintain a balance in the iodine load of the contrast and the volume to ensure that there are no beam hardening artifacts from the contrast in the veins. Compared to the indirect CTV, the opacification is by far superior, only a single phase is required, and intraluminal changes have been described as visible and interpretable. However, for PeVD/PCS, this

technique is considered inferior, since the filling of gonadal veins and the pelvic plexus are limited compared to the indirect technique.

Of note, CTV should be limited in young patients, when repeated imaging is likely to be required (in the long-term). The need for CTV should be avoided in patients that are pregnant or with extensive metallic implants, as these factors would hamper imaging to such an extent (beam hardening artifacts) that the study becomes non-diagnostic. It is important to underline that, with the increased utilization of CT for many indications, many patients are increasing their radiation exposure dose. This has already been shown to cause exposure-induced disease and even death in the long-term.

In conclusion, both MRV and CTV provide benefits in the patient work-up without being truly invasive. In my opinion, they should be used as adjuncts to the clinical work-up and DUS examination to provide more certainty that there is PCS, provide an anatomical overview to plan the procedure on, and display your patients what is diagnosed. Any case in which an invasive procedure (such as diagnostic venography) can be withheld from the patient implies less risk and less radiation. In the presence of a conclusive non-invasive work-up, the clinicians would be more accurate, most likely faster and, thus, both staff and patient benefit from a shorter and safer procedure with less exposure to radiation. In my opinion, MRV provides the most benefits, but if access to MRI is complicated or restricted, CTV can be a valuable alternative.

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