A step by step approach to direct contrast enhanced MRV of the leg veins: Technique, anatomy and pathology

Poster No.: C-1277
Congress: ECR 2012
Type: Educational Exhibit
Authors: G. K. L. Wansaicheong, S. Punamiya, E. Quah, M. R. Ortiz, M. Saw, S. Narayanan; Singapore/SG
Keywords: Varices, Haemodynamics / Flow dynamics, Embolism / Thrombosis, Normal variants, Imaging sequences, Contrast agent-intravenous, MR-Angiography, Veins / Vena cava, Vascular, Anatomy
DOI: 10.1594/ecr2012/C-1277
Learning objectives

The reader will be shown how to prepare a patient and setup for direct contrast enhanced MRV of the leg veins. The pulse sequence and post processing will be discussed.

The following findings will be illustrated: normal and variant anatomy of the veins of the leg and pathology related to chronic venous insufficiency.
Background

Advances in the understanding and treatment of superficial vein disease in the leg have been made in recent years. We now know the aetiology of the varicose veins is often secondary to disease in the deep veins. Classification of disease is based on the clinical, etiological, anatomic and pathophysiologic (CEAP) data score\(^1\).

Accurate imaging and interpretation is essential in selecting appropriate treatment for CEAP class 4 patients who have skin changes ascribed to venous disease (pigmentation, venous eczema, lipodermatosclerosis). More severe classes of patients (CEAP 5 & 6) include those with healed or active ulcers in addition to the skin changes.
Imaging findings OR Procedure details

Our routine examination is described below.

After a review of the indications for the procedure and previous examinations (duplex ultrasound scan of the lower limbs), the patient is prepared for a MR scan of the lower extremity. Screening for contraindications is performed and the patient is changed into appropriate clothing.

Setting up the cannula

Venepuncture is performed using the "King’s" technique\(^2\). A 22G cannula is used (Fig. 1 on page 9).

We have found that a large alcohol wipe left draped over the foot for 15 to 30 seconds is useful in cleaning the skin and reducing the obscuration caused by desquamated skin. If an ulcer is present, a site as far away as possible is selected.

The cannulas are connected to three way taps to control the direction of flow of intravenous contrast. A pre-filled extension tubing and 10 ml syringe saline complete the set up.

The patient is transported the scan room with an MR compatible trolley. If the patient has had the cannula set up close to the scanner, he may walk to the scanner. We avoid setting up the cannula in the scan room to maximize efficient use of scan time.

Positioning the patient

The patient is positioned supine and foot first with the feet as far in as possible in the scanner to maximize the cephalad couch movement. The feet are placed close to each other with the toes pointing upwards.

Measurement from the level of the lateral malleolus to the level of the umbilicus (for the union of the iliac veins and aortic bifurcation) is used to estimate the coverage required. This is usually less than 150 cm.
It is important to ensure that the foot and leg are positioned so that the posterior aspect of the calf and popliteal fossa are not compressed. This can affect the appearance of the varicose veins and delay filling of the vein with IV contrast (Fig. 2 on page 9).

This is prevented by elevating the heel with a support (blue block), ensuring that it is possible to place the hand between the couch and the leg and removing additional padding between the patient and the couch (pink triangles). Tourniquets are placed around each ankle of each leg to be imaged but left untied (Fig. 3 on page 10).

Anterior surface coils (usually phased array) are used to increase spatial resolution while maintaining the same scan time. The same coils for liver imaging are used and these are placed over the calf and knee where the vessels are smaller. It is possible to increase the number of coils used but this depends on the number of channels the MR scanner can use during the scan (Fig. 4 on page 11).

Additional pads are placed between the patient and the anterior surface coils. These are done to ensure the anterior surface coils and posterior coils (in the couch) are as parallel as possible. This helps to reduce but does not eliminate moiré artifacts seen at the periphery of the field of view (Fig. 5 on page 11).

Initial scan for planning

The imaging sequence parameters are based the technique described by Muller et al\(^3\). We made some modifications described below.

After appropriate education of the patient on keeping still and how to use of the call bell, the zero point is set about 25 cm above the lateral malleolus. Coronal scout localizers are used to check the position of anatomic landmarks. The inferior pole of the kidney is easy to see and used to determine the most superior coverage required.

Usually three stations are required to cover the entire lower limb vein from the ankle to the union of the iliac veins. The centre of each station is usually the zero point, 45 cm and 80 cm cephalad to the zero point. A coronal volume data set with maximum FOV (50 cm) for each station is planned. Overlap between each data set (at least 5 cm) is used to ensure that no anatomy is missed.

A sagittal non-contrast TOF MRA is used in the thigh to estimate the anterior and posterior extent of the thigh veins. As they travel from the back of the knee to the front of the groin,
it is important to ensure they are included in the thigh station data set (Fig. 6 on page 12).

Allowing for each data set to be acquired within 40 seconds/station when 3 stations are needed or within 60 seconds/stations when 2 stations; the maximum possible spatial resolution is chosen. A slice thickness of 3 mm is usually adequate, even for the smaller calf veins, and may be used when the anterior-posterior dimension of the data set needs to be increased to accommodate the thigh and pelvis.

A non-contrast mask is obtained at the three stations. This is used for tissue subtraction in post processing. Subtraction increases the available scan time for image acquisition compared to using a chemical suppression technique. After assessing image quality and position, the direct contrast enhanced MRV is obtained.

Direct contrast enhanced MRV

The ankle tourniquets placed earlier are tightened. Dilute contrast (1 ml Dotarem: 15 ml saline) is injected at 1 ml/second either by hand or by pump. After 40 seconds (40 ml), scanning is started from the calf and ending at the pelvis to demonstrate the deep veins.

After the 1\textsuperscript{st} run (Fig. 7 on page 13) to show the deep veins, the tourniquet is released and a 2\textsuperscript{nd} run (Fig. 8 on page 13) is obtained to demonstrate the superficial veins. Up to a maximum of 120 ml of dilute contrast is injected.

We have found that there is sufficient residual contrast in the veins of the foot after release of the tourniquet to opacify the normal great saphenous vein. However, the small saphenous vein did not opacify unless there was reflux or an abnormal communication (Fig. 9 on page 13). We are looking into how to ensure better opacification of the small saphenous vein while minimizing use of IV contrast.

Post processing the images and PACS archival

Each data set has multiple coronal slices. The mask is subtracted from the contrast enhanced run to show the opacified vessels with as much tissue suppression as possible. Some residual moiré artifact is often noted at the periphery of the FOV.
Slices from the data sets may be stitched together in post processing to provide an overview of the entire venous system. The overlap mentioned earlier helps to reduce artifacts (Fig. 10 on page 14).

The non-subtracted coronal slices are sent to PACS. The subtracted coronal slices are used to generate a rotating MIP image with 19 steps over 360 degrees. These images are sent to PACS. During interpretation, a thin client workstation (GE Advantage Workstation) available on the PACS systems (GE Centricity) is used for axial and sagittal reconstructions. This minimizes data storage.

Normal Anatomy

The nomenclature used follows the statements by the International Interdisciplinary Consensus Committee on Venous Anatomical Terminology\cite{4,5}. A few pointers regarding normal anatomy are illustrated.

1. At the saphenofemoral junction, the great saphenous vein is usually not opacified in the 1 st run (Fig. 11 on page 15).
2. Extrinsic compression at the popliteal fossa can result in loss of signal (Fig. 12 on page 16). This can be a normal finding and may be avoided by ensuring adequate space between the skin and couch.
3. The ankle tourniquet causes loss of signal at the ankle due to compression of the veins. This should be seen in the 1 st run (Fig. 13 on page 17).

Variant Anatomy

Variation in venous anatomy of the lower limbs is common. Some examples are illustrated:

1. Duplication of the femoral vein (Fig. 14 on page 18)
2. Sciatic vein (Fig. 15 on page 19)

Pathology

The main indication for the MRV is varicose veins. In addition, extrinsic compression (Fig. 16 on page 20 and Fig. 17 on page 21) and collaterals may be demonstrated. In complex cases, the full length view of the veins is helpful in appreciating the changes in anatomy.
Unusual sites of drainage may be demonstrated (Fig. 18 on page 22). These can be difficult to demonstrate with other techniques, including direct venography (Fig. 19 on page 23).

The use of a tourniquet in the first run is helpful in determining that opacification of the superficial system is due to a short saphenous vein (Fig. 20 on page 24) or incompetent perforators (Fig. 21 on page 25).

Multiple draining veins do not pose a problem in delineation as rotation of the MIP images allows multiple points of view (Fig. 22 on page 26).
Images for this section:

1. The patient is seated on an examination couch or trolley with the foot hanging over the edge. A trolley that can be elevated is helpful. A tourniquet is applied to distend the leg veins.

2. The vein over the 1st metacarpophalangeal joint is the preferred site. The aim is to fill the deep venous system via the dorsal venous arch. If a more lateral or proximal vein is used, the cannula is sited in an antegrade direction i.e. pointing towards the toes. If both legs are to be imaged, separate cannulas are needed.

**Fig. 1:** The patient is positioned in the above manner for the venepuncture

© Diagnostic Radiology, Tan Tock Seng Hospital - Singapore/SG
Fig. 2: The MRV shows a posterior positioned popliteal vein (upper block arrow) that is not compressed. However, the venous malformation in the subcutaneous tissue (lower block arrow) is slightly compressed by the calf pressing against the couch.

© Diagnostic Radiology, Tan Tock Seng Hospital - Singapore/SG
**Fig. 3:** The coverage and important points to note when positioning are illustrated above.

© Diagnostic Radiology, Tan Tock Seng Hospital - Singapore/SG

**Fig. 4:** The phased array coils are illustrated in green. The cushions are illustrated in plum. A support cushion is illustrated in blue.

© Diagnostic Radiology, Tan Tock Seng Hospital - Singapore/SG
Fig. 5: Moire artifacts at the periphery of the field of view.

© Diagnostic Radiology, Tan Tock Seng Hospital - Singapore/SG
**Fig. 6:** The sagittal view of the MRV demonstrates the extent of travel of the thigh veins as they pass from posterior to anterior.

© Diagnostic Radiology, Tan Tock Seng Hospital - Singapore/SG

**Fig. 7:** 1st run

© Diagnostic Radiology, Tan Tock Seng Hospital - Singapore/SG

**Fig. 8:** 2nd run.

© Diagnostic Radiology, Tan Tock Seng Hospital - Singapore/SG
Fig. 9: The 2nd run shows small collaterals that do not appear with the 1st run is shown in the MRV. Also, there is opacification of the medial gastrocnemius vein.

© Diagnostic Radiology, Tan Tock Seng Hospital - Singapore/SG
**Fig. 10:** The subtracted images from the three stations can be stitched to provide an overview of the entire leg vein system.

© Diagnostic Radiology, Tan Tock Seng Hospital - Singapore/SG
Fig. 11: The great saphenous vein is not opacified in this image obtained in the 1st run.

© Diagnostic Radiology, Tan Tock Seng Hospital - Singapore/SG
Fig. 12: There is loss of signal at the popliteal fossa due to extrinsic compression.

© Diagnostic Radiology, Tan Tock Seng Hospital - Singapore/SG
**Fig. 13:** There is loss of signal at the ankle due to application of the tourniquet causing compression of the veins. This is a normal finding.

© Diagnostic Radiology, Tan Tock Seng Hospital - Singapore/SG
**Fig. 14:** Duplication of the femoral vein (Block arrow). Duplication can occur at other sites and is seen as an extra vessel that parallels the named vein.

© Diagnostic Radiology, Tan Tock Seng Hospital - Singapore/SG
Fig. 15: Sciatic vein (Block arrow). This is an embryologic remnant that follows the sciatic nerve. A separate femoral vein duplication (not arrowed) is also noted.

© Diagnostic Radiology, Tan Tock Seng Hospital - Singapore/SG
**Fig. 16:** Oblique view of the bifurcation. Partial compression of the left common iliac vein by the left common iliac artery.

© Diagnostic Radiology, Tan Tock Seng Hospital - Singapore/SG
Fig. 17: Compression of the left iliac vein by the left external iliac artery.

© Diagnostic Radiology, Tan Tock Seng Hospital - Singapore/SG
Fig. 18: Varicose veins with reflux into the medial gastrocnemius vein.

© Diagnostic Radiology, Tan Tock Seng Hospital - Singapore/SG
**Fig. 19:** Correlation between descending venography and MRV. Note that the dilated medial gastrocnemius vein is not opacified.

© Diagnostic Radiology, Tan Tock Seng Hospital - Singapore/SG
Fig. 20: Reflux into the short saphenous vein which supplies the varicose veins in the calf.

© Diagnostic Radiology, Tan Tock Seng Hospital - Singapore/SG
**Fig. 21:** Incompetent perforators supplying the GSV.

© Diagnostic Radiology, Tan Tock Seng Hospital - Singapore/SG
Fig. 22: Two views of the same calf. Multiple collateral vessels are seen supplying a venous malformation.

© Diagnostic Radiology, Tan Tock Seng Hospital - Singapore/SG
Conclusion

Direct contrast MRV has the advantages of avoiding ionising radiation, accurately depicting the venous anatomy of the leg veins and guiding treatment (Fig. 23 on page 29, Fig. 24 on page 29, Fig. 25 on page 30, Fig. 26 on page 31). This educational exhibit helps equip new comers to the technique with tips and tricks that make it easier to perform and interpret such examinations.
Fig. 23: Note the coaxial transformation of the profunda ven. This is considered diagnostic of femoral vein aplasia/occlusion.

© Diagnostic Radiology, Tan Tock Seng Hospital - Singapore/SG
Fig. 24: In the same patient as Figure 23, there is a 2nd collateral that lies in the vastus lateralis muscle.

© Diagnostic Radiology, Tan Tock Seng Hospital - Singapore/SG
**Fig. 25:** In the same patient as Figure 23, there is a perforator of the thigh that communicates between the deep and superficial system.

© Diagnostic Radiology, Tan Tock Seng Hospital - Singapore/SG
**Fig. 26:** In the same patient as Figure 23, medial calf perforators are demonstrated.

© Diagnostic Radiology, Tan Tock Seng Hospital - Singapore/SG
Personal Information

G. K. L. Wansaicheong
Senior Consultant

S. Punamiya
Senior Consultant

E. Quah
Radiographer

M. R. Ortiz
Radiographer

M. Saw
Radiographer

S. Narayanan*
Consultant

All authors are employed by Tan Tock Seng Hospital.

All authors are from the Department of Radiology except * who is from the Department of Surgery.
References

1. Diagnosis of chronic venous disease of the lower extremities: the "CEAP" classification.

Kistner RL, Eklof B, Masuda EM.


Sidhu PS, Alikhan R, Ammar T, Quinlan DJ.


3. Recurrent lower-limb varicose veins: effect of direct contrast-enhanced three-dimensional MR venographic findings on diagnostic thinking and therapeutic decisions.

Müller MA, Mayer D, Seifert B, Marincek B, Willmann JK.


5. Nomenclature of the veins of the lower limb: extensions, refinements, and clinical application.
