The Value of CINE Bright Blood Sequences in the Evaluation of Cryptogenic Stroke

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Introduction

Magnetic Resonance Venography (MRV) of the pelvic venous system is utilized in our institution to evaluate for a source of cryptogenic stroke in patients with acute cerebrovascular accidents (CVA) (1). Patients with echocardiogram evidence of a right to left shunt without evidence of lower extremity deep venous thrombosis (DVT) are further investigated with MRV of the pelvis. Because of the tortuosity of the pelvic veins and the presence of valves, flow artifacts due to turbulence are common and may simulate a clot on standard 2D time-of-flight (2DTOF) sequences. To our knowledge the use of CINE bright blood sequences have not been utilized to differentiate flow artifacts from true venous clots. The goal of this study was to determine if the CINE bright blood techniques are useful adjunctive sequences in the evaluation of the pelvic DVT.

Methods

We retrospectively reviewed pelvic MRV studies from 2004 through 2007. Only patients with presenting with acute CVA, right to left shunt by echocardiogram and negative clinical or Doppler ultrasound evidence of lower extremity DVT were included in the study. The study was performed at 1.5 Tesla magnet utilizing a peripherally pulse triggered CINE balanced Steady State Free Precession (C-bSSFP) pulse sequence (TR = 3.0msec, TE = 1.5 msec, FA = 45 degrees; 8- 10mm thick sections with no gap) in the axial plane or peripherally pulse triggered CINE Fast Gradient-Echo (C-FGRE) pulse sequence (TR = 7.6 msec, TE = 4.6 msec, FA = 15 degrees; 8mm thick sections with no gap) in the axial plane. A conventional 2DTOF was performed utilizing a spoiled gradient-echo (SPGR) sequence (TR = 22.0 - 46.0 msec, TE = 6.9 msec, FA = 70 degrees; 4 -7 mm thick sections with no gap). MRV was performed within 72 hours of onset of symptoms. Each study was evaluated by 3 experienced radiologists and coded by consensus. Clots were identified on the 2DTOF sequence as rounded filling defects seen on two or more contiguous sections when their size and shape matched the CINE bSSFP/FGRE sequence over the cardiac cycle (figure 1) and were termed concordant round filling defects. Linear filling defects were categorized as concordant when their size and shaped matched the CINE bSSFP/FGRE sequences over the cardiac cycle and presumed to represent valves. Flow artifacts were identified on the 2DTOF sequence as rounded filling defects seen on two or more contiguous sections when their size and shape were smaller and varied over the cardiac cycle on the CINE bSSFP/FGRE sequence (figure 1) and were termed discordant round filling defects. The common femoral, external iliac and common iliac veins in addition to lower portion of the inferior vena cava were evaluated for concordant and discordant filling defects.

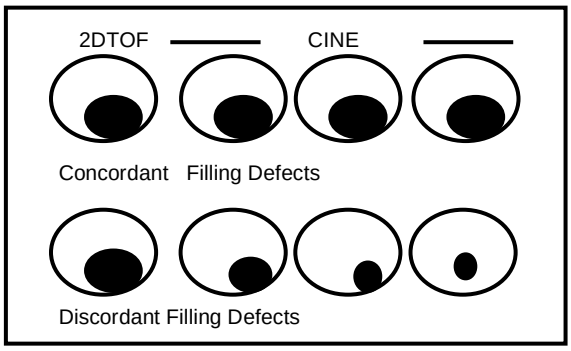

Figure 1

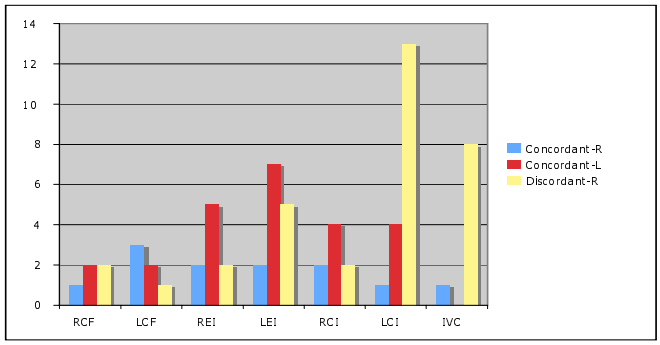

Figure 2

Results

A total 45 patients met inclusion criteria of which 43 patients had negative venous Doppler ultrasound studies. All patients with concordant round filling defects had a negative Doppler ultrasound. A total of 4 patients (9%) had concordant round filling defects including 2 males and 2 females having an age range of 18 – 55 years (ave. = 35 years) compatible with intravenous thrombus. A total of 41 patients (91%) had no concordant round filling defects including 23 females and 18 males having an age range of 25-81 (ave. = 54 years) and thus were negative for clot. 31 of these patients had discordant round filling defects (69%) and a total of 10 patients had studies without filling defects (20%). A total of 11 patients (24%) had concordant linear filling defects compatible with venous valves. None of the patients with linear defects were categorized as discordant. No patients had filling defects on the CINE study, which were not seen on the 2DTOF sequence. The number and distribution of concordant and discordant filling defects is seen in figure 2. Right Common Femoral = RCF; Left Common Femoral = LCF; Right External Iliac = REI; Left External Iliac = LEI; Right Common Iliac = RCI; Inferior Vena Cava = IVC; Concordant Round = Concordant-R; Concordant Linear = Concordant-L; Discordant Round = Discordant=R.

Discussion/Conclusion

MRV is an adjunctive imaging modality to Doppler ultrasound in the evaluation of the venous system. Doppler ultrasound interrogation of the pelvis is however limited and therefore MRV has been increasingly utilized to noninvasively evaluate the venous system of the pelvis. In our institution this is widely utilized in patients with cryptogenic strokes. A positive diagnosis of a DVT will implicate long-term anticoagulation therapy and therefore a study with high sensitivity and specificity is critical to treatment planning.

Although traditional 2DTOF sequences are very sensitive to intraluminal abnormalities, the extensive tortuousity of pelvic veins and the presence of valves result in flow artifacts, which can also simulate clots and occurred in 69% of our studies negative for clot. Flow artifacts are a result of the loss of phase coherence due to turbulence and are minimized by short echo time sequences. The balanced SSFP and FGRE sequences both had lower echo times than 2DTOF sequences resulting in reduced size of the flow dephasing artifacts as was shown in our study. Furthermore, turbulence will vary with velocity of flow and therefore the size and shape of the defect can also vary over the cardiac cycle, which was readily assessed on either of the CINE sequences. Linear defects presumed to represent valves are characterized by concordant linear defects on the CINE sequences and were most common in the external iliac arteries and were readily distinguished from clots and flow artifacts. Similarly, clots are fixed defects and are readily identified by concordant defects on the CINE sequence and were found in all pelvic venous locations studied. Relative low signal intensity in a clot is not related to turbulence and therefore its size is not affected by the low echo times of the CINE sequences. Turbulence is the most common cause of filling defects in our study and could be readily characterized by a discordant filling defect on either CINE sequence.

Positive pelvic MRV exams represented 9% of our cases compared to 20% of cryptogenic stroke cases previously reported (1). This suggests the possibility of an increased false positive rate on the prior study, which only utilized static bright blood sequences. The high prevalence of discordant filling defects related to flow artifacts shown in our study likely increases the chance of misinterpretation. This is especially problematic in the LCI and IVC where flow artifacts are most prevalent and where thrombi can also occur. Our study suggests that CINE bright blood sequences increase specificity in differentiation of flow artifacts from true thrombi when used adjunctively with 2DTOF sequences.

References:

(1). Cramer SC, Rordorf G et al. Increased pelvic vein thrombi in cryptogenic stroke: Results of the Paradoxical Emboli from Large Veins in Ischemic Stroke (PELVIS) study. *Stroke*. 2004 Jan;35(1):46-50.