HAYDARPAŞA NUMUNE MEDICAL JOURNAL

DOI: 10.14744/hnhj.2022.15483
Haydarpasa Numune Med J 2023;63(1):53–57

ORIGINAL ARTICLE

Evaluation of Magnetic Resonance Venography Techniques on the Detection of Dural Sinus Variations, Flow Gaps, and Thrombosis

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Abstract

Introduction: The aim of the study was to examine the role of the contrast-enhanced gadolinium-enhanced three-dimensional magnetic resonance venography (GE 3D MRV) technique in the detection of dural sinus pathologies by comparing the two-dimensional (2D TOF MRV).

Methods: One hundred and eighty patients who underwent MRV due to dural sinus pathology in the radiology department of Haydarpaşa Numune Training and Research Hospital between January 2019 and July 2019 were included in the study. Images of 21 patients in the study group who had both 2D TOF MRV or GE 3D MRV were evaluated retrospectively.

Results: About 33.3% of cases were male and 66.7% (n=14) were female. The mean age of the patients was 29.7±4.64 years (18–64 years). In 2D TOF MRV series, complete signal loss was observed in the unilateral transverse sinus (TS) of four patients (2.2%/180–1.6%) and in the sinus rectus of 1 patient (1/180–0.55%). Of these, 2 (1.1%) located in the TS and GE (2.1%) located in the sinus rectus were confirmed in the 3D MRV. Two patients' imaging showed a jugular vein and ipsilateral sigmoid sinus flow defect on 2D TOF MRV, but no findings on GE 3D MRV. There were four arachnoid granulations observed in the transverse sinuses in 4% of cases on two-dimensional venography, all of them confirmed on contrast-enhanced examinations. Six of the flow gaps observed in the transverse sinuses of 12 patients in 2D TOF MRV, disappeared completely in GE 3D MRV. When the diameters of the transverse sinuses were determined using the two techniques, the ratio of inconsistencies in Grade 0 and Grade 3 was higher than the others.

Discussion and Conclusion: GE 3D MRV, a contrast imaging method, can be used effectively when there is a diagnostic challenge to exclude sinus thrombosis on 2D TOF imaging.

Keywords: Gadolinium; lateral sinus thrombosis; magnetic resonance imaging; transverse sinuses.

Dural sinus thrombosis (DST) remains as one of the most common diagnostic challenges in daily neuroradiology practice. Less than two individuals per 100,000 are affected with DST each year[1]. Young and middle-aged adults, especially females, are 3 times more commonly affected[2]. Dural sinuses responsible for brain parenchyma drainage are initially evaluated using a two-dimensional time-of-flight magnetic resonance venography (2D TOF MRV) array. In 2D TOF MRV, the assessment of venous structures, especially in where the flow is slow, can sometimes

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Submitted Date (Başvuru Tarihi): 06.08.2022 **Revised Date (Revize Tarihi):** 06.08.2022 **Accepted Date (Kabul Tarihi):** 11.08.2022

be limited by saturation effects. In this technique, anatomical variations and flow gaps in transverse sinuses, which are the main channels of cerebral venous drainage, often mimic sinus thrombosis imposing a diagnostic difficulty[3]. In this regard, gadolinium-enhanced three-dimensional (GE 3D MRV) is preferred to 2D TOF MRV in the determination of thrombotic disease, and other possibilities such as venous stenosis or atresia[4,5].

In addition to its role in the exclusion of thrombus diagnosis, the necessity of contrast-enhanced imaging is still open to debate due to the risks as nephrogenic systemic fibrosis and the cost-effectiveness. Although GE 3D MRV allows better evaluation of the venous system, 2D TOF MRV sequences are more frequently preferred at some centers, because it does not require contrast agent. In the light of recent improvements, in our study, the necessity of the using of contrast-enhanced MRV technique in the detection of dural sinus pathologies as DST was investigated by comparing these two methods.

Materials and Methods

This retrospective study was approved by the Ethics Committee of the Institute (Date: August 07, 2019, KAEK-KK/2019/65). Signed informed consent forms were waived due to the retrospective and cross-sectional design of the study. There was no financial support for this study.

Patients

One hundred and eighty patients who underwent MRV imaging at our radiology clinic were enrolled. Among these patients, 26 were examined with both 2D TOF MRV and GE 3D MRV. Five patients with history of DST, arteriovenous malformation, history of cranial surgery were excluded from the study. Finally, 21 patients (14 females) were included in the study.

Imaging Technique

MRIs were performed in a 1.5 T MRI scanner (General Electric-Optima 450w-1.5 Tesla) using a standard 16-channel head coil. 2D TOF MRV images were acquired in the sagittal plane using following parameters, Slice thickness,1.4 mm; TR, 50ms; TE, 10 ms; Flip angle, 60, Matrix, 128×128; Field of view, 240 mm; Imaging time: 4 min). Gadolinium-enhanced 3D gradient-echo techniques were obtained with using Gadoterate meglumine (Dotarem®; Guerbet, Italy), it was used 0.2 milliliters (mL) per kilogram of body weight. When feasible, the contrast agent was injected with a power injector at a rate of 2 mL/sec. A 10 mL flush of normal saline followed the contrast agent injection. After the sagittal 3D gradient-echo sequence was initiated with the following parameters: Slice thickness,1.4 mm TR, 12 ms; TE, 6 ms; flip angle, 10°; matrix, 320×512; field of view, 240 mm; and Imaging time: 4 min).

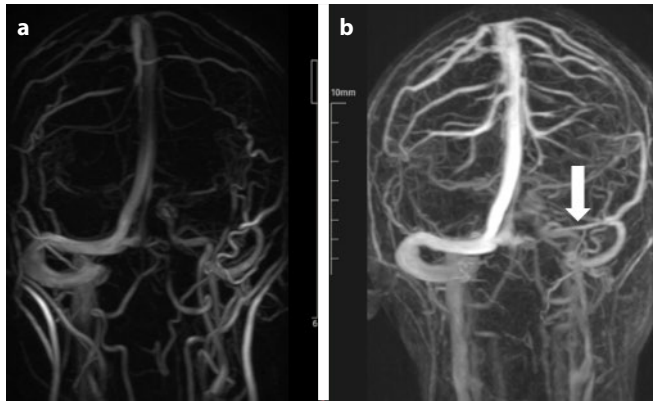

Figure 1. The grading was performed on the visibility of the dural sinuses: **(a)** 2D TOF MRV shows that the left lateral sinus was not viewed over its whole course visualized and evaluated Grade D. **(b)** GE 3D MRV shows the left lateral sinus partially visible (arrow).

All data obtained in this way were processed using the maximum intensity projection technique.

The dural sinuses were classified at each two techniques according to their visibility by the grading system proposed by Haroun et al.:[6] Grade A: When the sinus was entirely and intensely visualized; Grade B: When the sinus was entirely visualized but weak; Grade C: When the sinus was partially visible, Grade D indicates that the sinus was not viewed over its whole course (Fig. 1). Furthermore, transverse sinus (TS) diameters were measured in cm at the mid-lateral portion of the TS to all cases for each MRV technique. According to this, Grade 0 is TS symmetry or TS asymmetry ≤10% compared with the contralateral TS; Grade 1 is TS asymmetry >10% and ≤50% compared with the contralateral TS; Grade 2is TS asymmetry >50% compared with the contralateral TS; and Grade 3 is aplasia, or TS signal absent[7].

Two radiologists compared the visibility of the dural sinuses on images obtained for each technique with consensus.

Statistical Analysis

Statistical Package for the Social Sciences for Windows 22.0 IBM Corp, USA (SPSS 22) program was used for the statistical analysis. Descriptive statistical methods (mean, standard deviation, median, first quarter, third quarter, frequency, percentage, minimum, and maximum) were used to evaluate the study data.

Results

Of the 21 cases included in the study, 33.3% (n=7) were male and 66.7% (n=14) were female. The mean age of the patients was 29.7±4.64 years (18–64 years).

Four unilateral transverse sinuses (2.2/180–1.6%) and one straight sinus (1/180–0.55%) showed complete signal loss on 2D MRV series. Three of the sinus filling defects (two of the transverse sinuses (1.1%) and one straight sinus; total 2.1%) confirmed on GE 3D MRV. Findings were evaluated as compatible with acute sinus thrombus with the presence of additional data such as additional T1 hyperintensity. Two patients had jugular vein and ipsilateral sigmoid sinus flow defect on 2D TOF MRV but they appeared normal on GE 3D MRV. The comparative data of the two methods are presented in Table 1.

When the diameters of the transverse sinuses were determined according to two techniques, the frequency of inconsistency in Grades 0 and Grade 3 was higher than the others (Table 2).

Table 1. Grading of dural sinus visibility according to 2D Time-of-Flight MR Venography and Gadolinium-enhanced 3D MR Venography of 21 patients

	2D TOF MRV				GE 3D MRV			
	A	B	C	D	A	B	C	D
Superior sagittal sinus	21	-	-	-	21	-	-	-
Right transverse sinus	18	1	1	2	20	1	-	1
Left transverse sinus	17	3	-	2	20	1	-	1
Straight sinus	20	-	-	1	20	-	-	1
Right sigmoid sinus	17	2	1	1	19	2	-	-
Left sigmoid sinus	16	2	2	1	20	1	-	-

2D TOF MRV: 2D Time-of-Flight MR Venography; GE 3D MRV: Gadolinium-enhanced three-dimensional magnetic resonance venography; Grade A: Sinus is entirely and intensely visualized; Grade B: Sinus is entirely visualized but weak; Grade C: Partially visible Grade D: Sinus is not viewed.

Table 2. Grading of transverse sinus diameters on 2D Time-of-Flight MR Venography and Gadolinium-enhanced 3D MR Venography

	Grades of According to Diameters of Transverse Sinuses			
	0	1	2	3
2D TOF MRV	14	1	2	4
GE 3D MRV	16	2	1	2

Grade 0: TS symmetry or TS asymmetry ≤ 10% compared with the contralateral TS; grade 1 is TS asymmetry >10% and ≤ 50% compared with the contralateral TS; grade 2 is TS asymmetry > 50% compared with the contralateral TS; grade 3 is aplasia, or TS signal absent.

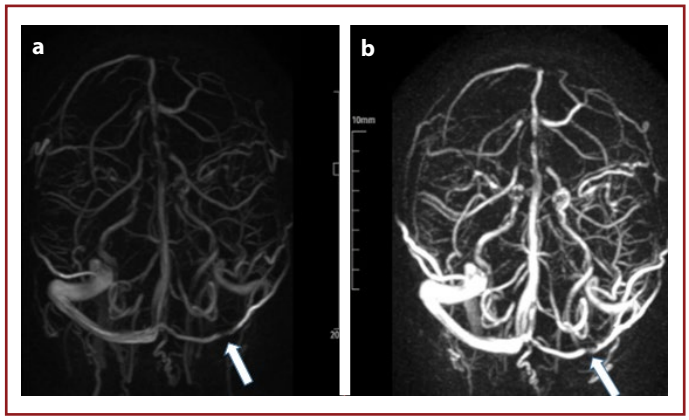

Figure 2. (a) 2D TOF MRV shows a left dominant TS. There is a flow gap (arrow) within the left non-dominant TS. **(b)** GE 3D MRV shows the persistence of the flow gap (arrow) within the left TS .

There were four arachnoid granulations observed in the transverse sinuses on 2D TOF MRV (4/180–2.2%) and all of them confirmed on GE 3D MRV.

Flow gaps observed on 2D TOF MRV in non-dominant transverse sinuses of 12 patients (12/180–6%) (Fig. 2). Six of the flow gaps (6/12–50%) were completely disappeared on GE 3D MRV.

All of the patients who had bilateral TS compression (Grade 0) were females with intracranial hypertension (2/180–1.1%) and they demonstrated similar shape and similar calibration in both techniques.

Discussion

In this study, we retrospectively evaluated MRV imaging of 180 adult patients. Acute life-threatening DST accounted for 2.1% of the study population. Since the majority of the patients in the study group were examined for suspected sinus thrombus, this rate is expected to be higher than the incidence of the general population (<2 persons per 100.000). The 2/3 of suspect of thrombosis in the dural sinuses were observed at the unilateral transverse sinuses. The other sinuses were not affected except for sinus recti. In addition, all flow gaps on 2D TOF MRV were located in the transverse sinuses, and only half of them were confirmed on the GE 3D MRV. Sinus thrombosis is seen more common 3 times in females. Consistently, 2/3 of the patients with thrombosis in the study population were female.

GE 3D MRV eliminates artifacts that emerge due to slow or turbulent flow seen in 2D TOF MRV,[8] it also reveals the sinus caliber more accurately[5]. However, Boddu et al.[9] reported that GE 3D MRV can exaggerate the width of transverse sinuses since the dural lining also improves

the image. In our study, the number of Grade 1 cases with 10% or less difference in the grading showing the diameter difference between the transverse sinuses (Table 2) was observed in 14 cases in TOF, while it reached 16 cases in GE 3D MRV. However, four cases had Grade 3 findings with unilateral signal loss in the transverse sinuses and aplasia on 2D TOF were confirmed only two of them at the GE 3D MRV examination. According to these results, GE 3D MRV may be preferred to 2D TOF MRV in the assessment of diameters of transverse sinuses, which are more affected by flow artifacts, in detecting differences as small as 10% and in detecting aplasia.

Farb et al.[5] demonstrated that the flow gaps found in non-dominant transverse sinuses on 2D MR venography often disappear entirely following contrast application in their research including 2D and 3D MR venography. In our study, all flow gaps were located in the non-dominant TS and half of them disappeared on GE 3D MRV.

Arachnoid granulations are herniation of the arachnoid tissue through the venous sinus's dura wall. On 13% of contrast-enhanced MR images of the brain, isolated filling deficiencies within the dural venous sinuses, consistent with arachnoid granulations, are seen. They are usually seen around venous entry sites within the transverse sinuses[3]. The prevalence of apparent arachnoid granulations on imaging examinations varies from 0.3 to one in 100 adults[10]. They were detected at 2.2% in our study population and it was a higher rate compared to the literature. However, the two imaging methods showed similar performance in detecting arachnoid granulations in the study.

MRV technology is often preferred in the evaluation of TS morphology used in the determination of idiopathic intracranial hypertension[8,11-13] and migraine[14]. Farb et al.[15] showed that in their GE 3D MRV study, TS stenosis is seen consistently in more than 90% of patients with idiopathic intracranial hypertension. Our experiments are in line with this study's results.

Our study involves certain limitations. The first limitation is the limited number of study population. Second, other MR sequences used to evaluate dural sinus pathologies, such as diffusion-weighted imaging, were not included in the study because of its retrospective nature.

We suggest that GE 3D MRV is useful for confirmation of sinus thrombus cases previously suspected on 2D TOF MRV. However, contrast-enhanced imaging is not necessary for evaluation of arachnoid granulations or TS compression.

Ethics Committee Approval: This retrospective study was approved by the Ethics Committee of the Institute (Date: August 07, 2019, KAEK-KK/2019/65).

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: A.Ö.B.; Design: A.Ö.B.; Data Collection or Processing: A.Ö.B., T.Ö.; Analysis or Interpretation: A.Ö.B., T.Ö.; Literature Search: A.Ö.B.; Writing: A.Ö.B., T.Ö.

Conflict of Interest: None declared.

Financial Disclosure: The authors declared that this study received no financial support.

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