

Superior Sagittal Sinus Thrombosis: Subtle Signs on Neuroimaging

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Abstract

Introduction: The aim of this study was to review the clinical, computed tomography (CT) and magnetic resonance imaging (MRI) diagnosis and the frequency of positive neuroimaging findings in patients with cerebral venous thrombosis (CVT) involving the superior sagittal sinus. **Materials and Methods:** A clinical and radiological database of patients with final diagnosis of CVT was compiled from the inpatient hospital information service of a tertiary neurological hospital over 5 years. CT and MRI studies in 22 patients were retrospectively examined for direct signs of venous sinus thrombosis and for complications of CVT. The diagnosis of CVT before and after CT and MRI was reviewed. **Results:** Clinical diagnosis of possible CVT was suspected in only 1 patient. When the diagnosis was not suspected, CT diagnosis was difficult and there was a high false negative rate of 52.6%. MRI fared better, but the false negative rate was still 11%. Direct signs of venous sinus thrombosis such as the triangle sign, empty delta sign on CT and loss of the normal flow voids on MRI, could be retrospectively detected in 57.9%, 100% and 100% of patients respectively. Although 4 patients presented with subarachnoid haemorrhage, these direct signs were present in 3 patients. **Conclusion:** Clinical diagnosis of CVT is rarely suspected before CT and MRI, and although subtle positive signs are often present, these may not be appreciated unless there is a high index of suspicion or image review at multidisciplinary team meetings.

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Key words: Cerebrovascular disorders, Cerebral venous thrombosis, Magnetic resonance imaging, Venous infarction

Introduction

Cerebral venous thrombosis (CVT) is an infrequent but potentially deadly disease. The mortality rate of CVT is 10% to 20%, and surviving patients may suffer significant morbidity such as seizures or neurological deficits.¹⁻³ Although anticoagulation and thrombolytic therapy are available and can improve clinical outcome,^{4,5} a timely and accurate diagnosis of CVT by computed tomography (CT), magnetic resonance imaging (MRI) or digital subtraction angiography (DSA) is necessary in order to commence early treatment. Unfortunately, the clinical presentation of CVT is not specific, and patients may have a wide spectrum of signs and symptoms mimicking conditions as diverse as arterial stroke, brain tumours, encephalitis and benign intracranial hypertension.⁶

Diagnostic neuroimaging is essential in patients with CVT. Although MR venography is an accurate and non-

invasive method for the diagnosis of CVT,⁷ at our institute and in most hospitals, this pulse sequence is not routinely performed unless the diagnosis of CVT is clinically suspected or positive signs for CVT are recognised. Therefore, a high index of suspicion and knowledge of the subtle signs of CVT on CT and MRI are necessary to make the correct diagnosis.⁸ Recognition of these signs should prompt the addition of appropriate confirmatory tests such as MR venography, CT venography or DSA in order to prevent delay in diagnosis and treatment.^{9,10} In this study, we retrospectively reviewed CT and MRI findings in patients with CVT to determine the accuracy of diagnosis of CVT and the frequency of radiological signs of CVT that may alert radiologists to the correct diagnosis.

Materials and Methods

We compiled a clinical and radiological database of

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patients with a final diagnosis of CVT from the hospital information service based on the discharge summary of all inpatients in a tertiary neurological hospital from 1999 to 2003.¹¹ All patients with a final diagnosis of CVT involving the superior sagittal sinus were included in our study, but patients who did not have radiological images and reports, had CVT from local neoplasms or CVT involving only the cavernous sinuses were subsequently excluded from analysis.

All CT and MRI studies were reviewed by consensus reading by 2 radiologists (PHT & CCTL) who were blinded to the radiological request forms and reports. Signs of CVT assessed included direct visualisation of the thrombosed venous sinus as well as indirect signs of venous congestion, infarction and haemorrhage. Direct evidence of sinus thrombosis included the hyperdense “triangle sign” on unenhanced CT,¹² “empty delta” filling defect on contrast-enhanced CT,^{13,14} and loss of the normal flow voids (that is, hyperintense or isointense thrombus replacing the normal low signal of flowing blood in venous sinuses) on MRI (Fig. 1).¹⁵ Indirect signs of venous thrombosis and hypertension include cerebral oedema (hypodensity on CT or hyperintensity on T2-weighted/FLAIR images), cerebral haematoma (hyperdensity on CT and inhomogeneous signal abnormality on MRI),⁶ subarachnoid haemorrhage (SAH) (hyperdensity on CT or hyperintensity on FLAIR) and prominent vascular or dural enhancement after contrast injection. If there was disagreement between the readers, the sign was marked not present.

CT studies comprised 5 or 7 mm thick sections performed on a helical CT scanner before and after intravenous injection of 50 mL of iodinated contrast medium. MRI examination comprised at least axial T1-weighted spin-echo (TR/TE 400–560/8–14 ms) and T2-weighted (TR/TE 3500–4000/95–105 ms effective) fast spin-echo sequences with coronal fluid attenuated inversion recovery (FLAIR TR/TE/IR 10,000/125/2200 ms inversion time) sequences performed in some patients. Either phase contrast (TR/TE/26/7 ms flip angle 20, velocity encoding 10 cm/s, 2.4 mm thickness) or 2D time of flight (TR/TE 23/4.7 ms, 1.5–2 mm sections) MR venography or biplane DSA studies were performed in all cases for confirmation of diagnosis.

The CT and MRI radiology reports and clinical charts were subsequently reviewed for the clinical diagnosis, “reason for request” and the radiological impression. We monitored if the key phrase “venous thrombosis” or “sinus thrombosis” was documented. The diagnosis of CVT before and after CT or MRI was recorded.

Results

Twenty-two patients (9 male, 13 female; age, 23 to 81 years) who had CVT confirmed on either MR venography

(n = 17) or DSA (n = 5) were enrolled in this study. All had superior sagittal sinus thrombosis with or without transverse sinus thrombosis; none had isolated straight sinus or cortical vein thrombosis. Nineteen CT studies (13 with intravenous contrast) and 18 MRI studies (5 with intravenous contrast) were performed; 15 patients had both CT and MRI examinations. Table 1 shows the diagnosis before and after CT and MRI as well as the neuroimaging findings of patients with CVT in our database.

A review of CT request forms showed that in only one (5.3%) patient (Patient 1) was the clinical diagnosis of CVT suspected (and subsequently confirmed) before the CT study. In the remaining 18 studies, CVT was not explicitly mentioned in the reason for CT request. Of these patients, 8 had a CT diagnosis of possible CVT and the correct diagnosis of CVT was not mentioned in 10 patients, giving a false negative CT rate of 52.6% [95% confidence interval (CI), 28.9 to 75.6].

There were 18 requests for MRI. Ten were for clinical suspicion of CVT, of which 6 were performed for confirmation after positive CT diagnosis, and 4 had negative CT reports but MRI was ordered to “rule out CVT” after multidisciplinary team meetings and CT image review. Of the remaining 8 MRI requests that did not mention possible CVT, 3 had no prior CT, 4 had negative CT studies and the last patient (Patient 9) had both CT and MRI performed on the same day, but MRI was reported independently of a positive CT diagnosis; CVT was not suspected before neuroimaging.

The correct diagnosis of CVT was made on 16 MRI studies (confirmed in all 10 with clinical suspicion and detected in 6 more unsuspected patients), but missed in 2 cases (false negative MRI rate 11.1%; 95% CI, 1.4 to 34.7). In both instances, the diagnosis had not been suspected clinically and MR venography was not performed. One patient (Patient 16) was subsequently recalled 4 days later for confirmatory MR venography, after multidisciplinary team meetings and review of CT and MRI suggested the correct diagnosis. In the other patient (Patient 17) who presented with seizures, CT and MRI showed cerebral oedema suspicious of neoplasm, but no enhancing lesion was detected (Fig. 2). During follow-up, it emerged that she had suffered an episode of superior sagittal sinus thrombosis 10 years ago, and a subsequent DSA study confirmed the diagnosis of recurrent CVT. In retrospect, direct signs of sinus thrombosis were visible on CT and MRI in both patients but were not appreciated during initial reporting.

On CT, the “triangle sign” and “empty delta sign” were present in 57.9% and 100% of unenhanced and contrast-enhanced studies respectively. On MRI, the normal venous flow void was replaced by thrombus in all patients on T1-weighted images (10 with hyperintense and 8 with isointense

signal) and in 15 of 18 patients on T2-weighted images (9 with hyperintense signal and 6 with isointense signal). In all 7 patients who underwent coronal FLAIR sequences, hyperintense thrombus was detected.

Signs of intracranial complications of CVT were seen in the brain parenchyma in 14 patients (63.6%; 95% CI, 40.4 to 82.8). Six patients (27.3%) had cerebral haematomas in the parasagittal frontal cortex (2 patients had parenchymal haematomas with SAH), and 4 patients (18.2%) had SAH without parenchymal haematoma. Four patients only had signs of cerebral oedema on neuroimaging.

A retrospective review of images in the 4 patients who had SAH without parenchymal haematoma showed that in 3 patients, direct signs of sinus thrombosis (either the “triangle sign”, “empty delta sign” or replacement of MRI flow void) were present. In the fourth patient, who underwent unenhanced CT but not MRI examination (Patient 19),

there were no other signs of CVT except subtle frontal lobe oedema. Correct diagnosis of CVT was established only on the venous phase of DSA performed to rule out aneurysm.

Discussion

In the majority of patients reviewed, the clinical diagnosis of CVT was not suspected or mentioned on the request form for CT or MRI. As a result, the imaging protocol was not directed towards diagnosing or excluding CVT. On retrospective review, direct signs of CVT involving the superior sagittal sinus were present on unenhanced CT as the “triangle sign” in 57.9% of the patients in our series, compared with 20% to 55% of cases in previous reports.^{13,14} On contrast-enhanced CT, the “empty delta sign” could be detected in all patients compared to 70% as previously reported.^{16,17}

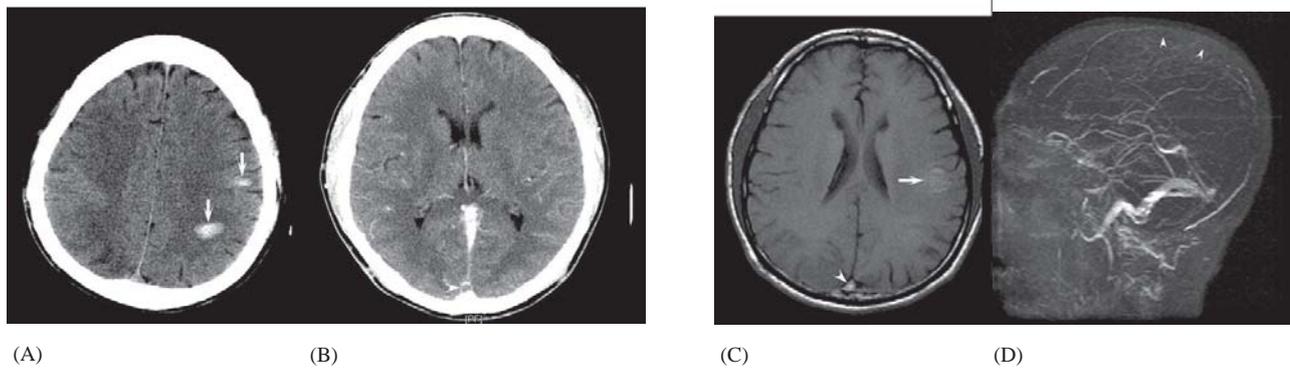


Fig. 1. Patient 7: A 62-year-old man with CVT diagnosed on CT and MRI.

Unenhanced CT. (A) shows focal cerebral haemorrhage in the left frontal lobe (arrows) and contrast-enhanced CT. (B) shows the superior sagittal sinus thrombus as a filling defect: the empty delta sign (arrowhead). T1-weighted MR image. (C) shows a corresponding presence of hyperintense blood (arrow) and thrombus (arrowhead) in the superior sagittal sinus. MR venography. (D) confirms the absence of blood flow in the superior sagittal sinus (arrowheads) due to extensive CVT.

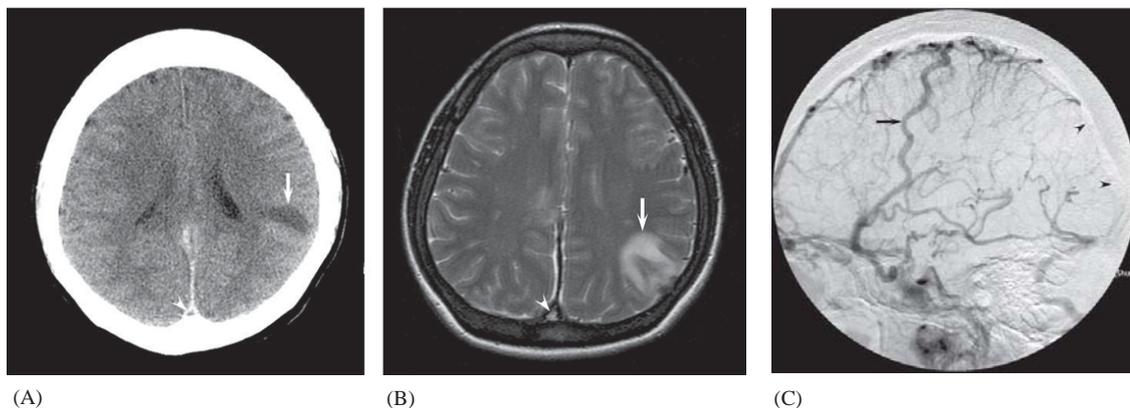


Fig. 2. Patient 17: A 34-year-old woman with CVT misdiagnosed on CT and MRI.

Contrast-enhanced CT. (A) showing focal left frontal lobe cerebral oedema (arrow). The empty delta sign (arrowhead) was not appreciated and a diagnosis of neoplasm was entertained. T2-weighted MR image. (B) shows left frontal lobe cerebral oedema (arrow), and the hyperintense thrombus in the superior sagittal sinus (arrowhead). Delayed venous phase of digital subtraction angiography study. (C) performed 3 months later shows extensive CVT involving the posterior third of the superior sagittal (arrowhead), straight, both transverse sinuses, as well as the vein of Galen and internal cerebral veins. Enlarged collateral cortical veins such as the Vein of Trolard are noted (arrow).

Table 1. Diagnosis and Neuroimaging Findings in Patients with CVT

Patient/Age/Sex	Diagnosis before CT	CT findings	MRI findings
1/43/F	Seizure, CVT	Triangle sign, oedema, haemorrhage, SAH	NP
2/81/F	Hemiparesis	Triangle sign	NP
3/32/F	Headache	Triangle sign, haemorrhage	Sinus thrombosis, oedema, haemorrhage
4/24/M	Headache	Triangle sign, empty delta sign	Sinus thrombosis
5/28/M	Headache	Triangle sign, empty delta sign	Sinus thrombosis
6/39/F	Headache	Triangle sign, empty delta sign	Sinus thrombosis
7/62/M	Hemiparesis	Empty delta sign, haemorrhage	Sinus thrombosis, oedema, haemorrhage
8/42/M	Headache	Empty delta sign	Sinus thrombosis, oedema
9/49/M	Seizure	Empty delta sign	Sinus thrombosis
10/25/F	Headache	Normal (*Empty delta sign)	Sinus thrombosis
11/41/F	Headache	Normal (*Triangle sign, empty delta sign)	Sinus thrombosis
12/37/F	Seizure	SAH (*Empty delta sign)	Sinus thrombosis, oedema, SAH
13/46/F	Seizure	Haemorrhage, SAH (*Triangle sign)	Sinus thrombosis, oedema, haemorrhage, SAH
14/48/M	Headache	Normal (*Empty delta sign)	Sinus thrombosis, SAH
15/46/F	Hemiparesis	Haemorrhage, oedema (*Triangle sign, empty delta sign)	Sinus thrombosis, oedema, haemorrhage
16/78/F	Seizure	Oedema (*Triangle sign, empty delta sign)	Oedema (*sinus thrombosis)
17/34/F	Seizure	Oedema (*Empty delta sign)	Oedema (*sinus thrombosis)
18/30/M	Seizure	SAH (*Triangle sign)	NP
19/23/M	Seizure	SAH, oedema	NP
20/68/M	NP	NP	Sinus thrombosis, oedema, haemorrhage
21/58/F	NP	NP	Sinus thrombosis, oedema
22/30/F	NP	NP	Sinus thrombosis

CT: computed tomography; CVT: cerebral venous thrombosis; MRI: magnetic resonance imaging; NP: not performed; SAH: subarachnoid haemorrhage
* denotes that the findings were present on retrospective review but were not reported

These signs were recognised in 9 of 19 CT studies and the correct diagnosis of CVT was made. However, the diagnosis was missed (i.e. false negative) in 52.6% of patients who underwent CT, all of whom were investigated for headache, seizure or hemiparesis but without clinical suspicion of CVT. Although previous reports have stated that up to 80% of CT studies are abnormal in CVT,¹² many of the findings such as haemorrhage or cerebral oedema are non-specific. Unless clinical suspicion is high and direct signs of the thrombosed sinus are actively sought, the diagnosis may be missed on CT.¹⁸ In our retrospective review of patients with false negative CT, we found that positive signs of venous thrombosis and parenchymal complications were present, but were not appreciated in all but 1 patient. Fortunately, in 4 of these patients, the CT images were reviewed during multidisciplinary team meetings and the significance of the positive signs was appreciated, illustrating the clinical utility and importance of multidisciplinary team meetings.¹⁹

On the other hand, only 11.1% of MRI examinations were false negatives. Subtle signs of CVT were appreciated

in the majority of these cases, including 6 of 8 patients in whom the diagnosis was not suspected. In these cases, abnormal signal replacing the hypointense signal void of flowing blood could be recognised on a combination of T1, T2-weighted and FLAIR images. Subacute thrombus (5 days to 2 weeks old) is hyperintense on both T1 and T2-weighted images, and is more readily detected than acute thrombus (less than 5 days old), which is isointense on T1-weighted image and hypointense on T2-weighted images, thus mimicking the normal flow void.²⁰ We also found high sensitivity for FLAIR images, particularly as the thrombus filling defect in the coronal plane complemented the axial T1 and T2-weighted images.¹⁴ Other investigators have also found FLAIR, diffusion-weighted imaging and gradient-recalled susceptibility-weighted images to be useful in the diagnosis of CVT.²¹

We found 4 patients who presented with SAH without cerebral haematoma (Patients 12, 14, 18, 19). With established CVT, venous distension, interstitial oedema, cytotoxic oedema, venous infarction and haemorrhage

occur progressively.^{22,23} When a large parenchymal haemorrhagic infarction dominates with only a small amount of SAH, the diagnosis of CVT is easier to make if it is suspected (Patient 1) than when it is not. On the other hand, in SAH without parenchymal haemorrhage, subtle signs of sinus thrombosis were present on retrospective review of CT and MRI in 3 of 4 patients. However, these signs were recognised on 2 MRI studies but missed on 2 CT studies. In the last patient (Patient 19), SAH was the sole abnormality on CT, and DSA was performed to rule out ruptured aneurysm. SAH as the only manifestation of CVT is a rare but recognised phenomenon,²⁴ and this case illustrates the importance of obtaining the venous phase of DSA, particularly when no aneurysm is found, so as not to miss the diagnosis of CVT.

Our study is hampered by several limitations that may prevent the generalisation of our findings. Case selection was difficult as CVT is a rare condition and it is difficult to perform prospective studies on these patients. Our retrospective study is prone to selection bias and we assessed only the sensitivity of the imaging signs without any control population. There is also bias towards positive signs, especially the “triangle sign” on unenhanced CT, which can be prone to subjective interpretation.²⁵ Future studies would benefit from a comparison with control groups of patients with suspected CVT, but which were true negative, in order to test the specificity and negative predictive value of these signs.

Conclusions

Despite advanced imaging modalities, CVT is a difficult diagnosis to make when it is not clinically suspected. Although direct imaging evidence of the thrombosed venous sinus such as the triangle sign, empty delta sign and loss of flow void on MRI are frequently present, these may not be appreciated unless there is a high index of suspicion or images are reviewed at multidisciplinary team meetings. Radiologists should be aware of the subtle signs of CVT, and direct such patients with clinical or radiological suspicion to appropriate confirmatory investigations.

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REFERENCES

- Boussier MG, Chiras J, Bories J, Castaigne P. Cerebral venous thrombosis – a review of 38 cases. *Stroke* 1985;16:199-213.
- Preter M, Tzourio C, Ameri A, Boussier MG. Long-term prognosis in cerebral venous thrombosis. Follow-up of 77 patients. *Stroke* 1996;27:243-6.
- Hinman JM, Provenzale JM. Hypointense thrombus on T2-weighted MR imaging: a potential pitfall in the diagnosis of dural sinus thrombosis. *Eur J Radiol* 2002;41:147-52.
- Einhaupl K, Boussier MG, de Bruijn SFTM, Ferro JM, Martinelli I, Masuhr F, et al. EFNS guideline on the treatment of cerebral venous and sinus thrombosis. *Eur J Neurol* 2006;13:553-9.
- Masuhr F, Mehraein S, Einhaupl K. Cerebral venous and sinus thrombosis. *J Neurol* 2004;251:11-23.
- Renowden S. Cerebral venous sinus thrombosis. *Eur Radiol* 2004;14:215-26.
- Fink JN, McAuley DL. Cerebral venous sinus thrombosis: a diagnostic challenge. *Intern Med J* 2001;31:384-90.
- Fellner FA, Fellner C, Aichner FT, Molzer G. Importance of T2*-weighted gradient-echo MRI for diagnosis of cortical vein thrombosis. *Eur J Radiol* 2005;56:235-9.
- Casey SO, Alberico RA, Patel M, Jimenez JM, Ozsvath RR, Maquire WM, et al. Cerebral CT venography. *Radiology* 1996;198:163-70.
- Ozsvath RR, Casey SO, Lustrin ES, Alberico RA, Hassankhani A, Patel M. Cerebral venography: comparison of CT and MR projection venography. *AJR Am J Roentgenol* 1997;169:1699-707.
- Yang GL, Tan YF, Loh SC, Lim CC. Neuroradiology imaging database: using picture archive and communication systems for brain tumour research. *Singapore Med J* 2007;48:342-6.
- Boussier MG. Cerebral venous thrombosis: diagnosis and management. *J Neurol* 2000;247:252-8.
- Virapongse C, Cazenave C, Quisling R, Sarwar M, Hunter S. The empty delta sign: frequency and significance in 76 cases of dural sinus thrombosis. *Radiology* 1987;162:779-85.
- Connor SE, Jarosz JM. Magnetic resonance imaging of cerebral venous sinus thrombosis. *Clin Radiol* 2002;57:449-61.
- Vogl TJ, Bergman C, Villringer A, Einhaupl K, Lissner J, Felix R. Dural sinus thrombosis: value of venous MR angiography for diagnosis and follow-up. *AJR Am J Roentgenol* 1994;162:1191-8.
- Keiper MD, Ng SE, Atlas SW, Grossman RI. Subcortical hemorrhage: marker for radiographically occult cerebral vein thrombosis on CT. *J Comput Assist Tomogr* 1995;19:527-31.
- Thron A, Wessel K, Linden D, Schroth G, Dichgans J. Superior sagittal sinus thrombosis: neuroradiological evaluation and clinical findings. *J Neurol* 1986;233:283-8.
- Daif A, Awada A, al-Rajeh S, Abduljabbar M, al Tahan AR, Obeid T, et al. Cerebral venous thrombosis in adults. A study of 40 cases from Saudi Arabia. *Stroke* 1995;26:1193-5.
- Back MF, Ang EL, Ng WH, See SJ, Lim CC, Chan SP, et al. Improved median survival for glioblastoma multiform following introduction of adjuvant temozolomide chemotherapy. *Ann Acad Med Singapore* 2007;36:338-42.
- Isensee C, Reul J, Thron A. Magnetic resonance imaging of thrombosed dural sinuses. *Stroke* 1994;25:29-34.
- Idbaih A, Boukobza M, Crassard I, Porcher R, Boussier MG, Chabriat H. MRI of clot in cerebral venous thrombosis: high diagnostic value of susceptibility-weighted images. *Stroke* 2006;37:991-5.
- Villringer A, Mehraein S, Einhaupl KM. Pathophysiological aspects of cerebral sinus venous thrombosis (SVT). *J Neuroradiol* 1994;21:72-80.
- Forbes KP, Pipe JG, Heiserman JE. Evidence for cytotoxic edema in the pathogenesis of cerebral venous infarction. *AJNR Am J Neuroradiol* 2001;22:450-5.
- Oppenheim C, Domingo V, Gauvrit JY, Lamy C, Mackowiak-Cordoliani MA, Pruvo JP, et al. Subarachnoid hemorrhage as the initial presentation of dural sinus thrombosis. *AJNR Am J Neuroradiol* 2005;26:614-7.
- Provenzale JM, Joseph GJ, Barboriak DP. Dural sinus thrombosis: findings on CT and MR imaging and diagnostic pitfalls. *AJR Am J Roentgenol* 1998;170:777-83.