Diagnostic yield of emergency brain MRI among patients with suspected cerebral venous sinus thrombosis – a retrospective cohort study

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Abstract

Background Cerebral venous sinus thrombosis (CVST) is a rare neurological emergency condition with non-specific symptoms. Imaging options to rule out CVST are computed tomography (CT) and magnetic resonance imaging (MRI). The purpose of this study was to determine the diagnostic yield of emergency brain MRI as a first-line imaging method among patients with suspected CVST.

Material and methods In this retrospective cohort study, we analyzed emergency brain MRI referrals from a five-year period in a tertiary hospital for suspicion of CVST. We recorded patient characteristics, risk factors mentioned in the referrals, and imaging outcomes.

Results Altogether 327 patients underwent emergency brain MRI on the grounds of suspected CVST. MRI showed evidence of CVST among five patients (1.5%). Imaging showed other clinically significant pathology among 15% of the patients, and incidental findings among 5% of the patients.

Conclusion Despite clinical suspicion, diagnostic yield of emergency MRI for CVST is low, and similar to that previously reported for CT. MRI is an alternative imaging method devoid of ionizing radiation in patients with suspected CVST.

Keywords

Magnetic resonance imaging, Emergency imaging, Headache, Thrombosis, Cerebral venous sinus thrombosis (CVST)

Background

Cerebral venous sinus thrombosis (CVST) is a potentially life-threatening neurological emergency condition defined as a blood clot in the major venous outlets of the brain. CVST is a subset of cerebral venous thrombosis, referring to the presence of a blood clot specifically in the dural venous sinuses. The incidence of CVST in the general population has previously been reported as 0.2 to 0.5 cases per 100 000 individuals per year, but a recent study has reported a higher incidence of 1.3 to 1.6 per 100 000 per year (1). Yet CVST is much more often suspected in the emergency department on clinical grounds, because its symptoms and risk factors are very non-specific: A stereotypical patient is a young adult female with a history of smoking and hormonal oral contraceptive use, presenting with headache (2,3).

Imaging options to rule out CVST are computed tomography (CT) and magnetic resonance imaging (MRI) (4–6). A fairly recent meta-analysis from 2018 indicates that both CT and MRI have a high level of diagnostic accuracy in differential diagnosis of cerebral venous thrombosis and CVST (7). Non-enhanced CT and contrast-enhanced CT venography are widely available and cost-effective imaging options in an emergency setting, although they expose the patient to ionizing radiation.

Various MRI techniques, such as contrast-enhanced MRI and magnetic resonance venography (MRV), are also useful techniques for ruling out CVST. The major advantage of MRI over CT is that MRI offers better soft tissue discrimination and thereby higher sensitivity than CT for subtle brain pathology. MRI does not involve the use of ionizing radiation, which is beneficial in cases of pregnancy and young patients, although CT scans of the maternal head and neck cause minimal fetal dose, much below the teratogenic threshold (8). Disadvantages of MRI are also its poorer availability in the emergency department and its higher cost. A previous study reported CT findings in patients with suspected CVST (4), but the additional value of MRI in terms of prevalence of clinically significant findings in these patients is unknown.

The primary aim of the present study was to assess the diagnostic yield of emergency brain MRI among patients presented with clinically suspected CVST, and to characterize these patients in terms of demographics, history, and specific signs and symptoms. We specifically focused on primary screening for CVST with MRI because of its high accuracy in emergency brain imaging. The secondary aim was to explore intracranial pathology other than CVST encountered in emergency brain MRI among patients with a clinical suspicion of CVST.

Material and methods

For this retrospective cohort study, we obtained permission from The Hospital District of Southwest Finland. Waiver for written patient consent was not sought from the institutional review board (IRB, called the Ethics Committee of The Hospital District of Southwest Finland), because it is not required by the national legislature for retrospective studies of existing data. The study was conducted in accordance with the Declaration of Helsinki. We first identified 8772 unique emergency brain MRI scans conducted between 4/2014 and 1/2019 from picture archiving and communication systems (PACS) and radiological information systems using standard brain MRI codes, carried out at an academic tertiary care referral center, performed on a Philips Ingenia 3 Tesla system. The MRI protocol included routine sequences such as T1- and T2-weighted imaging, fluid-attenuated inversion recovery (FLAIR), diffusion-weighted imaging (DWI), susceptibility-weighted imaging (SWI), 3D time-of-flight (TOF) arterial angiography, 2D TOF venography (MRV) (selected patients), and contrast-enhanced (CE) MRV (selected patients). Imaging data were cross-referenced with those from electronic medical records (EMR).

To identify clinical suspicion of CVST, we queried referrals with the words “sinus thrombosis” and “(dural) venous sinus/es”. We excluded cases referred to MRI with previously diagnosed CVST, either at an outside institution, or with another imaging modality, such as CT

angiography. This search identified 327 MRI referrals for suspected CVST. We recorded whether known risk factors for CVST were mentioned in the referrals, and the pertinent findings in the MRI reports. Whether an MRI finding was considered potentially causally related to the symptoms and thus clinically significant was evaluated by a consensus procedure by a board-certified neurologist (P.Y.) and a neuroradiologist (M.N.). From the EMR, we recorded relevant clinical information, such as patient history, duration of headache, laboratory results, length of hospital stay and final discharge diagnosis.

Results are typically expressed as percentages, medians and interquartile ranges (IQR). We used Pearson T-tests and Wilcoxon rank sum test to compare continuous variables and the Chi square (X^2) test to compare ordinal data. The data were analyzed using JMP for Mac (Version 16.1 Pro. SAS Institute Inc., Cary, NC, 1989-2019) and SAS version 9.4 (SAS Institute, Cary, NC, USA). P-values less than 0.05 were considered statistically significant.

Results

In total, 327 patients underwent emergency MRI under clinical suspicion of CVST. Of these, 274 (84%) were female and the median age was 30 (IQR: 23–38) years (Table 1). Medical risk factors for CVST were mentioned in 50% of the referrals, including smoking, oral contraception, pregnancy, puerperium, and thrombophilia. Twenty-three (7%) patients had two of these risk factors. The most prevalent clinical symptom at presentation was headache (91%), commonly accompanied with other symptoms as nausea/vomiting or visual impairment. Nineteen patients (6%) had a previous diagnosis of a significant brain disease, such as brain tumor, hydrocephalus, Moyamoya disease, or previous cerebral infarction/hemorrhage.

Among the emergency MRI referrals to rule out CVST, we found five positive cases out of 327 (1.5%) (Figure 1). That is, 98.5% did not show CVST. Positive cases were confirmed by follow-

up MRI six months after initial diagnosis, which showed partial or complete resolution of thrombosis. All but one of these patients were young females. All had thrombosis in the transverse sinus, and 4/5 had superior sagittal sinus involvement. These thrombi were variably shown by routine MRI sequences: on T2-weighted images in 1/5 patients, on FLAIR images in 2/5 patients, and on T1-weighted images in 4/5 patients (Figure 2). Only one patient had parenchymal changes (edema, no hemorrhage). Regarding laboratory results of patients with confirmed CVST, D-dimer was the only statistically significantly different from non-CVST patients (median 0.8 *vs.* 0.3 mg/L, p=0.04, Wilcoxon rank sum test) (Table 1).

Imaging was deemed completely unremarkable for 77%, whereas clinically significant intracranial pathology other than CVST was found in 48 (15%) cases: *e.g.,* intracerebral hemorrhage, cerebral infarction, brain tumor and sinusitis (Table 2). That is, 16% of patients had significant findings in MRI, including CVST. In addition, incidental findings were discovered in 17 (5%) cases, such as developmental venous anomalies and non-specific white matter lesions.

In a univariate analysis, male sex, high body mass index (BMI), high C-reactive protein (CRP) levels and a previously diagnosed brain disease in history were found to predict clinically significant intracranial pathology in emergency MRI (Table 1). In contrast, patient age, duration of headache prior to MRI, or presence of any of the individual symptoms had no statistically significant impact on whether or not significant findings were discovered.

Among patients in this study, only 61 (19%) underwent CT scanning prior to MRI, and 49 (80%) of these scans were considered unremarkable. That is, six (10%) patients showed significant findings in CT, and for the other six, CVST could not be definitively ruled out. Prevalence of significant findings in MRI was similar in patients that had a previous unremarkable CT and in those who did not have CT at all (18% *vs.* 14%, p=0.46, X^2 test).

The most prevalent discharge diagnosis was non-specified headache (30%), followed by migraine headache (21%) and tension headache (9%) (Table 3). The rest of the discharge diagnoses

included a wide spectrum of different categories, including various types of nervous diseases, circulatory diseases, infections, and malignancies. Most (70%) patients were discharged from the hospital within the following 24 hours.

Discussion

Diagnosing CVST is challenging, considering that the diagnostic yield of imaging for suspected CVST is relatively low in terms of how often it is suspected on clinical grounds. We found that emergency MRI showed signs of CVST in only 1.5% of all cases, and other clinically significant intracranial pathology in 15% of cases. Most prevalent findings among these patients included sinusitis, intracerebral hemorrhage, cerebral infarction, and signs of intracranial hypertension. These novel results add to previous knowledge by showing that the diagnostic yield of MRI is not remarkably higher that than of CT among these patients.

The clinical presentation of CVST is often vague and non-specific. Our findings regarding patient demographics, history, and specific signs and symptoms that have induced clinical suspicion for CVST are similar to those that are reported in literature (9–12). In our data, a typical patient was a young woman with headache accompanied with nausea and focal neurological deficits, such as numbness or visual impairment. Imaging deemed unremarkable with no clinically significant findings for 84% of patients, and with no CVST for 98% of patients. This demonstrates the high index of clinical suspicion, and the low diagnostic yield that MRI seems to have among these patients.

Regarding the small sample of patients with CVST, we did not attempt to create an algorithm to predict a positive imaging outcome based on risk factors, symptoms and laboratory results. We did not consider it reasonable to draw further conclusions from these factors in this study.

We found that the yield of imaging suspected CVST cases using emergency MRI was greater among patients that were male, had high BMI or CRP, or had a known brain disease. Females,

especially those who were pregnant, underwent MRI more often with no detected intracranial pathology, which further underlines the high alert for suspicion of CVST among these patients. Patient age, duration of headache prior to MRI, or presence of individual symptoms had no impact on whether or not clinically significant findings were discovered in emergency MRI. From the clinical perspective, this indicates that medical imaging plays a considerable role in ruling out CVST regardless of these factors.

The prevalence of other significant findings in emergency MRI (15%) is only slightly higher than that previously reported for nonenhanced CT (11%) (4). These relatively small differences in results might well be attributed to differences in patient management, demographical characteristics, or referral patterns between institutions. In retrospect, many of our significant findings could likely have been visible on CT (*e.g.*, intracerebral hemorrhage, infarction), which in most circumstances might be sufficient in the emergency environment with shorter scan time and lower cost. On the other hand, MRI could show more subtle, but potentially significant findings among these patients (*e.g.*, small infarcts, signs of intracranial hypertension), but this ability of MRI did not translate into a considerably higher overall incidence on significant pathology compared with CT.

Dedicated emergency MRI is a feasible first-line imaging method for various acute pathology (13). At our institution, this has become a routine modality especially among young patients, because of its excellent soft tissue contrast and lack of ionizing radiation. Therefore, we sought to characterize MRI findings in suspected CVST among these patients in particular, and to not include patients who might have undergone only CT for similar clinical suspicion. We found that the prevalence of significant findings was similar in patients that had previous unremarkable CT and in those who did not have CT at all. This analysis further confirms the role of MRI as a first-line imaging method at our emergency department for these patients. However, some sampling bias toward MRI cannot be excluded. Our patients were slightly younger than those previously reported as having undergone CT based on suspected CVST (4). In addition, the availability of emergency MRI in our institution might

lower the threshold to ask for imaging for young, mildly symptomatic patients compared to when only CT is available.

Regarding imaging methodology, CE-MRV has the highest diagnostic accuracy to detect CVST (14), whereas TOF-MRV has similar sensitivity but slightly lower specificity (15). Routine MRI sequences have variable accuracies, but generally perform less well than MRV methods (14,16). At our institution, patients with suspected CVST receive MRV, mostly CE-MRV. We did not find any cases with isolated cortical venous thrombosis, which is a rare subtype of cerebral venous thrombosis, presenting with headaches, neurological deficits, and seizures (17,18). Isolated cortical venous thrombosis would likely be visible using our protocol on SWI images (17), and probably on 3D-CE-MRV as well.

One of the major strengths of this study was the routine use of MRI in the emergency radiology department. Furthermore, this study reflects a true clinical situation, due to its several patients with clinical suspicion of CVST at the same center over a time period of almost five years, investigated under similar conditions. Due to practical routine in the use of emergency MRI and a large sample size, we believe that these results are well generalizable to the whole population of patients with suspected CVST.

Yet, this study is limited by its retrospective, single-center design. In addition, guidelines for the clinical suspicion of CVST may vary from one hospital to another. Most importantly, emergency MRI is not routinely available in all institutions, limiting the generalizability of our findings. MRI with MRV is a highly reliable method for diagnosing CVST, but conventional CT will remain as the first imaging modality for most acute situations, simply due to wide-spread availability, fast scanning times, and ability to suggest most acute conditions, such as tumors, hemorrhages, and abscesses, although many of these conditions will eventually require MRI for an accurate diagnosis. Added value for MRI over CT as a primary screening tool stems mainly from its superior soft tissue discrimination and lack of ionizing radiation.

Conclusions

In conclusion, we found that the diagnostic yield of emergency imaging suspected CVST using MRI was low, and similar to that has been reported for CT. In our data, significant findings were most likely found among patients that were male, had high BMI or CRP, or had a known brain disease. Although diagnostic yield was approximately similar to that reported for CT, lack of ionizing radiation might favor the use of MRI as an alternative screening tool for intracranial pathology among emergency patients suspected of having CVST.

List of abbreviations

CVST = Cerebral venous sinus thrombosis

CT = Computed tomography

MRI = Magnetic resonance imaging

PACS = Picture archiving and communication systems

FLAIR = Fluid-attenuated inversion recovery

DWI = Diffusion-weighted imaging

SWI = Susceptibility-weighted imaging

TOF = Time-of-flight

MRV = Magnetic resonance venography

CE = Contrast-enhanced

EMR = Electronic medical records

IQR = Interquartile range

BMI = Body mass index

CRP = C-reactive protein

Declarations

Ethics approval and consent to participate

We obtained permission from The Hospital District of Southwest Finland. The study was conducted in accordance with the Declaration of Helsinki. Waiver for written patient consent was not sought from the institutional review board (IRB, called the Ethics Committee of The Hospital District of Southwest Finland), because it is not required by the national legislature for retrospective studies of existing data (*e.g.* registry data). Institutional review board review (approval or waiver) was not sought, because it is not required by the national legislature for retrospective studies of existing data.

Registry studies in Finland are exempted from ethical approval by law, and are only subject to hospital district permission. This is based on the following legislature: Law on the secondary use of social and health data (552/2019), Data protection act (1050/2018), Act on the publicity of the activities of authorities (621/1999), and the EU GDPR (2016/679). Legislature is publicly available at www.finlex.fi (most laws and decrees are only available in Finnish and Swedish). For any additional inquiries, please contact Turku Research Services at www.turkucrc.fi/en/contact.

Consent for publication

Not applicable.

Availability of data and materials Image data cannot be publicly shared because of the national legislature on patient data. Otherwise all relevant data are within the manuscript. Further inquiries should be addressed to Jussi Hirvonen (jussi.hirvonen@utu.fi).

Competing interests The Authors declare that there are no competing interests.

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References

1. Ruuskanen JO, Kytö V, Posti JP, Rautava P, Sipilä JOT. Cerebral Venous Thrombosis: Finnish Nationwide Trends. Stroke. 2021;52(1):335–8.

2. Mehta A, Danesh J, Kuruvilla D. Cerebral Venous Thrombosis Headache. Curr Pain Headache Rep. 2019;23(7):47.

3. Ortega-Gutierrez S, Holcombe A, Aksan N, Dai B, Shaban A, Lazarre L, et al. Association of admission clinical predictors and functional outcome in patients with Cerebral Venous and Dural Sinus Thrombosis. Clin Neurol Neurosurg. 2020;188:105563.

4. Almqvist H, Mazya M, Falk Delgado A, Falk Delgado A. Radiological evaluation in patients with clinical suspicion of cerebral venous sinus thrombosis presenting with nontraumatic headache - a retrospective observational study with a validation cohort. BMC Med Imaging. 2020;20(1):24.

5. Ghoneim A, Straiton J, Pollard C, Macdonald K, Jampana R. Imaging of cerebral venous thrombosis. Clin Radiol. 2020;75(4):254–64.

6. Dmytriw AA, Song JSA, Yu E, Poon CS. Cerebral venous thrombosis: state of the art diagnosis and management. Neuroradiology. 2018;60(7):669–85.

7. Xu W, Gao L, Li T, Ramdoyal N, Zhang J, Shao A. The Performance of CT versus MRI in the Differential Diagnosis of Cerebral Venous Thrombosis. Thromb Haemost. 2018;118(06):1067–77.

8. Proença F, Guerreiro C, Sá G, Reimão S. Neuroimaging safety during pregnancy and lactation: a review. Neuroradiology. 2021;63(6):837–45.

9. Ropper AH, Klein JP. Cerebral Venous Thrombosis. N Engl J Med. 2021;385(1):59-64.

10. Behrouzi R, Punter M. Diagnosis and management of cerebral venous thrombosis. Clin Med (Lond) 2018;18(1):75-79.

11. Capecchi M, Abbattista M, Martinelli I. Cerebral venous sinus thrombosis. J Thromb Haemost. 2018;16(10):1918–31.

12. Kalita J, Singh VK, Jain N, Misra UK, Kumar S. Cerebral Venous Sinus Thrombosis Score and its Correlation with Clinical and MRI Findings. J Stroke Cerebrovasc Dis. 2019;28(11):104324.

13. Nurminen J, Velhonoja J, Heikkinen J, Happonen T, Nyman M, Irjala H, et al. Emergency neck MRI: feasibility and diagnostic accuracy in cases of neck infection. Acta Radiol. 2021;62(6):735–42.

14. van Dam LF, van Walderveen MAA, Kroft LJM, Kruyt ND, Wermer MJH, van Osch MJP, et al. Current imaging modalities for diagnosing cerebral vein thrombosis – A critical review. Thromb Res. 2020;189:132–9.

15. Gao L, Xu W, Li T, Yu X, Cao S, Xu H, et al. Accuracy of magnetic resonance venography in diagnosing cerebral venous sinus thrombosis. Thromb Res. 2018;167:64–73.

16. Sadigh G, Mullins ME, Saindane AM. Diagnostic Performance of MRI Sequences for Evaluation of Dural Venous Sinus Thrombosis. Am J Roentgenol. 2016;206(6):1298–306.

17. Singh R, Cope WP, Zhou Z, De Witt ME, Boockvar JA, Tsiouris AJ. Isolated cortical vein thrombosis: case series. J Neurosurg. 2015;123(2):427–33.

18. Boukobza M, Crassard I, Bousser MG, Chabriat H. MR Imaging Features of Isolated Cortical Vein Thrombosis: Diagnosis and Follow-Up. Am J Neuroradiol. 2009;30(2):344–8.

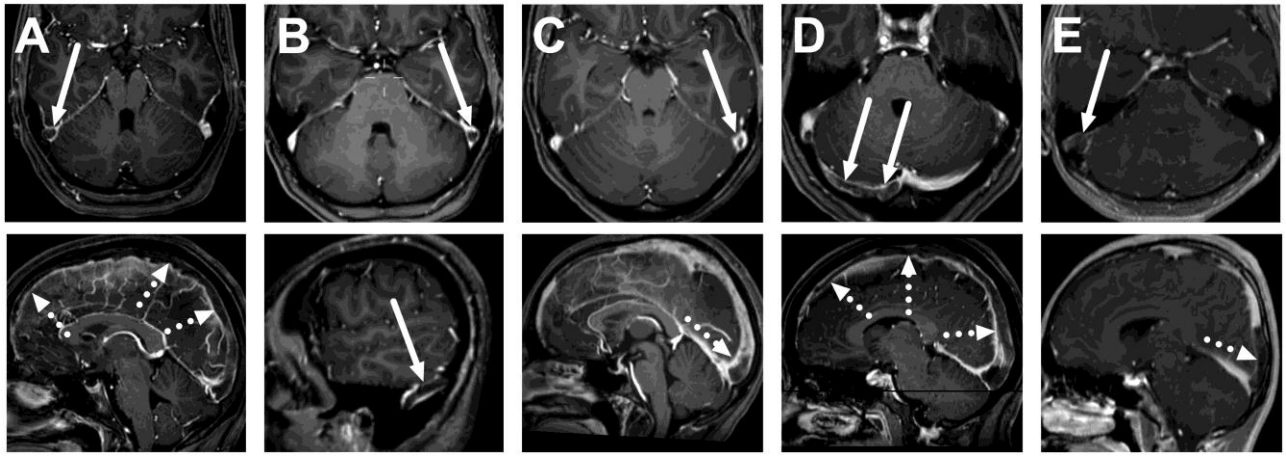

Figure 1. True positive cases of cerebral venous sinus thrombosis. Axial (top row) and sagittal (bottom row) images of post-gadolinium T1-weighted 3D MRI images of five patients: a 26-year-old female (A), a 33-year-old female (B), a 21-year-old female (C), a 27-year-old female (D), and a 16-year-old male (E). Thrombosis is seen as a hypointense filling defect against the high signal from the gadolinium-based contrast agent in the venous sinuses, usually in the transverse sinuses (arrows) and the superior sagittal sinus (dotted arrows).

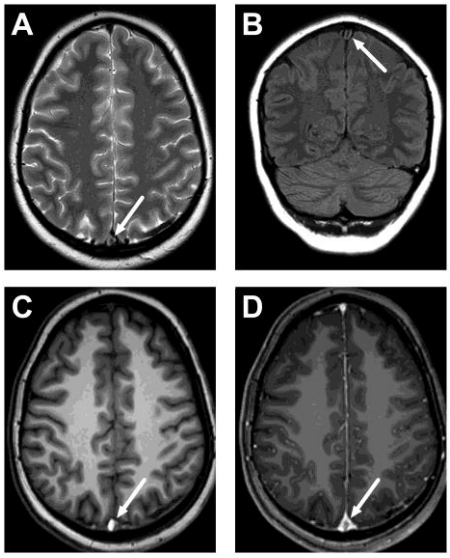

Figure 2. An example of cerebral venous sinus thrombosis on routine pre-contrast images. Images show lack of normal flow void on T2-weighted (A) and fluid-attenuated inversion recovery (FLAIR) (B) images, as well as high signal on the pre-contrast T1-weighted image (C), in the superior sagittal

sinus (arrows). Post-contrast T1-weighted image is provided for reference (D), showing the non-enhancing thrombus (arrow). Most patients did not show thrombosis on all routine sequences, however.

Table 1. Clinical characteristics of patients with clinically suspected CVST who underwent emergency MRI.

	All patients N = 327	**Positive for CVST N = 5**	**Clinically significant MRI finding[1] N = 53**	**No significant MRI finding N = 274**	**P-value[2]**
Sex	**N (%)**				
Female	274 (84)	4 (80)	39 (74)	235 (86)	0.027
Male	53 (16)	1 (20)	14 (26)	39 (14)	
Age	**Median (IQR)**				
Total [years]	30 (23–38)	26 (19–30)	28 (21–42)	30 (23–38)	0.957
Female [years]	29 (23–37)	27 (22–32)	29 (24–42)	29 (23–37)	0.585
Male [years]	31 (22–46)	16 (16)	24 (16–61)	33 (22–45)	0.545
Body mass index	**Data available [N]: Median (IQR)**				
BMI [kg/m^2]	222: 26 (22–31)	2: 33 (32–34)	41: 28 (24–36)	181: 25 (22–30)	0.018
Medical risk factors	**N (%)**				
Smoking	68 (21)	1 (20)	14 (26)	54 (20)	0.271
Thrombophilia	7 (2)	0 (0)	1 (2)	6 (2)	0.889
Oral contraception	51 (16)	3 (60)	7 (13)	44 (16)	0.601
Pregnancy	40 (12)	0 (0)	1 (2)	39 (14)	0.012
Puerperium	11 (3)	0 (0)	0 (0)	11 (4)	0.138
Previously diagnosed brain disease	19 (6)	0 (0)	8 (15)	11 (4)	0.002
Symptoms	**N (%)**				
Headache	297 (91)	5 (100)	47 (89)	250 (91)	0.554
Nausea/vomiting	145 (44)	5 (100)	23 (43)	122 (45)	0.880
Visual impairment	108 (33)	2 (40)	17 (32)	91 (33)	0.872
Numbness	97 (30)	2 (40)	15 (28)	82 (30)	0.813
Vertigo	85 (26)	2 (40)	13 (25)	72 (26)	0.790
Photophobia	78 (24)	4 (80)	17 (32)	61 (22)	0.125

	Neck muscle tension	71 (22)	2 (40)	14 (26)	57 (21)	0.364
	Dysphasia	41 (13)	0 (0)	7 (13)	34 (12)	0.872
	Seizure	8 (2)	0 (0)	2 (4)	6 (2)	0.495
	No other symptoms than headache	26 (8)	0 (0)	2 (4)	24 (9)	0.219
Laboratory results		**Data available [N]: Median (IQR)**				
	Hemoglobin [g/L]	312: 133 (125–142)	5: 140 (135–147)	53: 135 (125–146)	259: 133 (125–141)	0.602
	C-reactive protein [mg/L]	302: 2 (0–7)	5: 4 (3–30)	52: 4 (1–19)	250: 2 (0–5)	0.001
	D-Dimer [mg/L]	104: 0.3 (0.0–0.7)	3: 0.8 (0.7–2.6)	23: 0.3 (0.0–0.7)	81: 0.2 (0.0–0.8)	0.902
Imaging information		**N (%)**				
	Contrast-enhanced MRI	252 (77)	5 (100)	48 (91)	204 (75)	0.011
Additional clinical information		**Median (IQR)**				
	Duration of headache before MRI [days]	4 (1–10)	5 (5–9)	4 (2–10)	3 (1–10)	0.097
	Length of hospital stay [days]	0 (0–1)	9 (7–11)	5 (0–9)	0 (0–0)	<0.001

MRI = Magnetic resonance imaging, CVST = Cerebral venous sinus thrombosis, IQR = Interquartile range.

[1)] Including CVST.

[2)] P-values are for comparisons between groups "Clinically significant MRI finding" and "No significant MRI finding", and associated with Chi-squared test for categorical variables, and with Wilcoxon rank sum test for continuous variables.

Table 2. Clinically significant MRI findings in patients with clinical suspicion of CVST.

MRI finding	N (%)
Sinusitis*	10 (3.1)
Intracerebral hemorrhage	8 (2.4)
Cerebral infarction	7 (2.1)
Intracranial hypertension*	7 (2.1)
Cerebral venous sinus thrombosis	5 (1.5)
Blood vessel pathology	4 (1.2)
Brain tumor	3 (0.9)
Demyelination	3 (0.9)
Mastoiditis	2 (0.6)
Subarachnoid hemorrhage	1 (0.3)
Subdural hematoma	1 (0.3)
Brain metastases	1 (0.3)
Arteriovenous Fistula	1 (0.3)

Intracranial Hypotension	1 (0.3)
Total	**54* (16)**

*1 patient presenting with both sinusitis and intracranial hypertension.

Table 3. Most frequent discharge diagnoses among patients with clinical suspicion of CVST.

Diagnosis	ICD-10	N (%)
Non-specified headache	R51	98 (30)
Migraine	G43	70 (21)
Tension headache	G44.2	28 (8.6)
Visual disturbances	H53	14 (4.3)
Dizziness and giddiness	R42	13 (4.0)
Paresthesia of skin	R20.2	11 (3.4)
Acute sinusitis	J01	10 (3.1)
Diseases of the ear and mastoid process	H60–H95	10 (3.0)
Idiopathic intracranial hypertension	G93.2	9 (2.8)
Malignant neoplasms	C00–C97	8 (2.4)
Intracerebral hemorrhage	I61	8 (2.4)
Cerebral infarction	I63	7 (2.1)
Convulsion	R56.8	7 (2.1)
Cerebral venous sinus thrombosis	I67.6	5 (1.5)
Viral meningitis	A87	5 (1.5)
Total		**303 (92*)**

*The remaining 8% of the discharge diagnoses were the least frequent, each being represented in only <1% of cases. Note that discharge diagnoses may include chronic diseases, and not only those found on emergency MRI (*e.g.*, malignant neoplasms).