TURUN YLIOPISTO

Akseli Ruohola

DIAGNOSTIC YIELD OF CERVICAL MAGNETIC RESONANCE ANGIOGRAPHY IN STROKE IMAGING – A RETROSPECTIVE ANALYSIS

Syventävien opintojen kirjallinen työ

Kevätlukukausi 2026

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Kliininen laitos

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Vastuuohjaaja: Jussi Hirvonen

TURUN YLIOPISTO
Lääketieteellinen tiedekunta

RUOHOLA, AKSELI: Diagnostic yield of cervical magnetic resonance angiography in stroke imaging – a retrospective analysis

Syventävien opintojen kirjallinen työ, 19 s.
Diagnostinen radiologia
Maaliskuu 2026

Cervical vascular imaging is widely used in modern stroke imaging to define the stroke etiology and to plan surgical vascular interventions. Cervical magnetic resonance angiography (cMRA) has high sensitivity for detecting structural changes in the cervical arterial wall and is a radiation-free alternative to computed tomography angiography (CTA). We aimed to determine the diagnostic yield of emergency cMRA in patients with stroke symptoms.

We retrospectively analyzed patients (n=385) who underwent a cMRA and a brain MRI imaging at the comprehensive stroke center hospital between 2013 and 2021 due to the suspicion of recent stroke or dissection. We analyzed the findings from cMRA and brain MRI studies and recorded cardiovascular risk factors and symptoms from the MRI referrals.

We found an abnormal finding related to the acute symptoms in 7.3% (28/385) of all cMRA scans, with significantly higher rates among patients with acute brain MRI findings (21.1%) vs. those without (2.8%, OR 3.2, $p<0.001$). Patients with coronary artery disease had 4-fold increased odds of abnormal cMRA findings (OR 3.95, $p=0.005$). Patients with two or more cardiovascular risk factors had 3-fold increased odds of abnormal cMRA findings (OR 3.18, $p=0.024$).

Emergency cMRA combined with brain MRI for stroke has a modest overall positivity. Patients with acute findings in brain MRI had more findings in cMRA, underscoring the need for selective use to optimize resource allocation.

Avainsanat: kaulasuonten magneettiangiografia, aivoinfarktikuvantaminen, diagnostinen hyöty

Diagnostic yield of cervical magnetic resonance angiography in stroke imaging – a retrospective analysis

Akseli Ruohola[1], Mikko Nyman[1], Tatu Happonen[1], Pauli Ylikotila[2], Jussi Hirvonen[1,3], Aapo Sirén[1]

[1]Department of Radiology, University of Turku and Turku University Hospital, Turku, Finland

[2]Neurocenter, Turku University Hospital, Turku, Finland

[3]Medical Imaging Center, Department of Radiology, Tampere University and Tampere University Hospital, Tampere, Finland

Corresponding author: Jussi Hirvonen (jussi.hirvonen@tyks.fi)

ABSTRACT

Purpose: Cervical vascular imaging is widely used in modern stroke imaging to define the stroke etiology and to plan surgical vascular interventions. Cervical magnetic resonance angiography (cMRA) has high sensitivity for detecting structural changes in the cervical arterial wall and is a radiation-free alternative to computed tomography angiography (CTA). We aimed to determine the diagnostic yield of emergency cMRA in patients with stroke symptoms.

Methods: We retrospectively analyzed patients (n=385) who underwent a cMRA and a brain MRI imaging at the comprehensive stroke center hospital between 2013 and 2021 due to the suspicion of recent stroke or dissection. We analyzed the findings from cMRA and brain MRI studies and recorded cardiovascular risk factors and symptoms from the MRI referrals.

Results: We identified an abnormality related to acute symptoms in 7.3% (28/385) of all cMRA scans, with significantly higher rates among patients with acute brain MRI findings (21.1%) than among those without (2.8%; OR 3.2, $p<0.001$). Patients with coronary artery disease had 4-fold increased odds of abnormal cMRA findings (OR 3.95, $p=0.005$). Patients with two or more cardiovascular risk factors had a 3-fold increase in the odds of abnormal cMRA findings (OR 3.18, $p=0.024$).

Conclusion: Emergency cMRA combined with brain MRI for stroke has a modest overall positivity. Patients with acute brain MRI abnormalities had more findings on cMRA, underscoring the need for selective use to optimize resource allocation.

Keywords: cervical magnetic resonance angiography; stroke imaging; brain infarction; cervical artery dissection

INTRODUCTION

Cervical vascular imaging is an inseparable part of modern stroke imaging, as it is necessary to determine stroke etiology and plan interventions. In addition to intracranial and cardiac etiologies, pathologies of cervical vessels are common causes of acute ischemic stroke, both thrombotic and embolic (1–3). Atherosclerotic plaque causing stenosis in cervical vessels is one of the most common etiologies of embolic acute ischemic stroke (3). Among young patients, cervical artery dissection is an important cause of acute ischemic stroke, accounting for 18-20% of strokes in people aged 15 to 45 years (4–7).

Computed tomography angiography (CTA) and magnetic resonance angiography (MRA) are used to detect pathologies of the head and neck vessels that may be the underlying cause of a stroke or transient ischemic attack (TIA) (2,3). Although CTA is the most common initial modality of vessel imaging in emergency settings due to its availability, rapid image acquisition, and limited motion artifacts, MRA is the modality of choice for patients who are allergic to CT contrast medium, have renal failure, or are especially vulnerable to the effects of ionizing radiation (2,3,8). Generally, neck CTA is superior to neck MRA for detecting occlusions and stenoses due to its superior visualization of the vessel lumen; however, for detecting dissection, both are comparable, each with its own strengths and limitations (2,8,9). The major strength of MRA over CTA, due to its high soft-tissue contrast, is its high sensitivity for detecting changes in vessel wall structure, such as intramural hematoma in dissections and vessel wall thickening in vasculitides (2,10).

Stroke imaging protocols typically recommend performing CTA and MRA in conjunction with the respective brain imaging and, in some cases, also include perfusion imaging. Harris et al. found in their cohort that only 3% of patients imaged with a triple examination, including brain MRI, head MRA, and neck MRA, underwent a subsequent surgical intervention, suggesting that these examinations should not be ordered simultaneously without individual assessment (11). Regarding CTA, Rigney et al. reported that the use of CTA among patients presenting to the ED for headache or dizziness increased by 67%, whereas the positivity rate decreased by 38% over four years (12). Consequently, tools to more effectively allocate MRA imaging resources are needed.

Expectations regarding MRIs' and MRAs' ability to solve clinical problems are often high, from both patients' and physicians' perspectives. However, current knowledge of the use of MRA as a primary vascular imaging modality in the stroke workup is limited. This study aimed to explore potential correlations between cervical MRA (cMRA) findings and brain MRI findings in patients with suspicion of stroke who underwent emergency imaging, utilizing the higher sensitivity of MRI compared to CT imaging. We also aimed to identify clinical factors that predict significant findings in cMRA, thereby helping clinicians allocate imaging more precisely in the emergency setting. We hypothesized that the diagnostic yield of cervical MRA among patients without acute stroke on brain MRI is low.

MATERIALS AND METHODS

The study population consisted of patients who underwent cervical MRA at the emergency radiology department of our institution between April 1, 2013, and August 31, 2021 (n = 508). Our hospital is an academic tertiary care referral center serving a population of approximately 480,000. Inclusion criteria for the primary outcome analysis were (1) cMRA ordered because of suspected recent stroke or acute dissection, (2) age 18 years or more, and (3) no preceding cervical vascular imaging (CTA or US) during the same admission. The final sample included 385 patients. The *code stroke* patients are invariably scanned with CT and CTA and are therefore not included in this sample.

The cMRA scans were referred by a responsible on-call physician, usually a neurologist. Our institution has an MRI scanner dedicated to emergency imaging. Therefore, cMRA is often used as an alternative to CTA, especially in young patients and/or when a brain MRI is also warranted. The MRI scans were performed on a Philips Ingenia 3 Tesla system using a dS HeadNeckSpine coil configuration and a gadolinium-based intravenous contrast agent (Dotarem; Guerbet, Villepinte, France). A routine cMRA protocol included non-enhanced 3D T1-weighted fat-saturated gradient-echo imaging to assess, e.g., intramural hematomas, and contrast-enhanced 3D T1-weighted spoiled gradient-echo imaging. A brain MRI protocol included the following sequences at minimum: axial diffusion-weighted, axial T2-weighted, coronal fluid-attenuation inversion recovery, susceptibility-weighted imaging, 3D T1-weighted, and intracranial time-of-flight angiography (TOF). If contrast medium could not be administered, cMRA was performed with TOF.

We reviewed the patient charts and the radiology information system (RIS) to extract relevant information (clinical symptoms and findings, patient history with cardiovascular risk factors, acute and chronic cMRA findings, brain MRI findings, and findings of previous cervical vascular imaging studies). To mitigate underreporting in radiology referrals, cardiovascular risk factors were cross-checked against patient records. The study is a retrospective chart review; a retrospective image review was not conducted.

When assessing the primary imaging outcomes, the cMRA findings were classified into three categories: *abnormal findings likely related to acute symptoms (acute)*, *abnormal findings unlikely related to acute symptoms (chronic)*, and *no abnormalities (no findings).* Findings were independently classified by a medical student (AR) and verified by a board-certified radiologist (AS), with ambiguous cases adjudicated by a board-certified stroke neurologist (PY). *An abnormal finding likely related to acute symptoms* was defined as (1) an acute stroke-related finding in brain MRI corresponding to cMRA pathology or (2) a TIA episode corresponding to cMRA pathology.

The results are presented as the number of cases (n), percentages, means, and ranges for normally distributed variables, and medians and interquartile ranges (IQR) for non-normally distributed variables. Normality assumptions were evaluated visually and parameter-wise (using skewness and kurtosis) and with the Shapiro-Wilk test. Nominal variables were compared with the *$\chi 2$ test*, and continuous variables with a *Student's t-test*. The *Wilcoxon rank sum test* was used as a nonparametric test for continuous variables. A multivariate analysis was performed using binary logistic regression, including factors that were statistically significant in the univariate analysis. Receiver operating characteristic (ROC) and area under the curve (AUC) were used to evaluate the diagnostic power of our model. Optimal cut-off values for continuous variables were determined from the ROC curve by Youden's index. *P* values less than 0.05 were considered statistically significant in all analyses.

The requirement for patient consent was waived due to the retrospective nature of the study. Study permission was obtained from the hospital district board. Statistical analyses were performed using IBM SPSS Statistics for Mac (version 28, copyright IBM Corporation 2021).

RESULTS

In our sample of 385 patients, 195 (50.6%) were female and 190 (49.4%) were male (Table 1). The mean age of the sample was 50.7 years (range, 18-86), with males slightly older than females (54 vs. 48 years). The majority of cMRA scans were performed with a gadolinium contrast agent (N=373, 97%), and only 12 (3.1%) patients were imaged without contrast medium, including pregnant women. The median time from symptom onset to cMRA imaging was two days, and the median number of neurological symptoms was two. The most common cardiovascular risk factor in our sample was hypertension, 44% (N=169) of the whole sample having it.

In total, 59 (15.3%) of all cMRA (385) scans included in this study had abnormal findings, of which 28 (7.3% of all patients) were considered acute and 31 (8.1%) chronic. All findings were classified into eight different categories (Table 2). The most common finding among all patients was non-obstructive atherosclerosis.

Of patients with an acute finding on brain MRI (N=95), 21.1% had an acute and 7.4% had a non-relevant finding on cMRA, whereas the corresponding percentages were 2.8% and 8.3% for patients with non-acute findings on brain MRI (n=290). The difference between these two groups was statistically significant ($P < 0.001$) in a univariate test (OR = 3.2). Interestingly, only 1 out of 7 patients with ICA dissection had acute findings on brain MRI, whereas the corresponding proportion was 4 out of 6 patients with vertebral dissection. In univariate testing comparing acute and non-acute brain MRI groups, ICA stenosis, vertebral occlusion, and vertebral dissection were statistically significantly more often present in the group with acute findings on brain MRI.

In a univariate analysis, hypertension, hypercholesterolemia, coronary artery disease, and prior stroke were statistically significant ($p<0.05$) risk factors for a cMRA abnormality (Table 1). Among cardiovascular risk factors, coronary artery disease had the most significant association with an abnormal cMRA finding (OR = 7.31). Patients with acute or chronic findings in cMRA had statistically significantly ($p < 0.001$) more cardiovascular risk factors in total and were also statistically significantly ($p < 0.001$) older compared to patients with no findings in cMRA. Symptom duration before cMRA imaging and the number of reported neurological symptoms did not reach statistical significance in univariate testing between the two groups (with cMRA findings vs. no findings).

Table 1. Patients' clinical characteristics categorised according to cMRA findings.

	All patients (N=385)	**Finding in cMRA, acute/chronic (N=59)**	**No findings in cMRA (N=326)**	**P-value**	**OR**
Sex, N (%)				<0.803*	0.93
Male	190 (49)	14 (24) / 16 (27)	160 (49)		
Female	195 (51)	14 (24) / 15 (25)	166 (51)		
Age, mean (range)					
Male	54 (20-86)	62 (42-79) / 61 (37-86)	52 (20-85)	0.002**	
Female	48 (18-83)	50 (25-81) / 60 (44-73)	47 (18-83)	0.012**	
Total	51 (18-86)	56 (25-81) / 60 (37-86)	49 (18-85)	<0.001**	

Risk factor, N (%)					
Smoking	80 (21)	6 (10) / 11 (19)	63 (19)	0.098*	1.69
Hypertension	169 (44)	18 (31) / 20 (34)	131 (40)	<0.001*	2.69
Hypercholesterolemia	126 (33)	13 (22) / 17 (29)	96 (29)	0.001*	2.48
Diabetes	46 (12)	8 (14) / 3 (5.1)	35 (11)	0.085*	1.91
Coronary artery disease	23 (6.0)	6 (10) / 6 (10)	11 (3.4)	<0.001*	7.31
Prior stroke	71 (19)	8 (14) / 13 (22)	50 (19)	<0.001*	3.04
Number of CV risk factors, median (IQR)	1 (0-2)	2 (0-4) / 2 (1-4)	1 (0-2)	<0.001 ***	
Symptom duration before cMRA, median (IQR)	2 (1-4)	4 (1-10) / 1 (1-5)	2 (1-4)	0.270 ***	
Number of reported symptoms, median (IQR)	2 (1-3)	2 (1-4) / 2 (1-2)	2.0 (1-3)	0.590***	

*Chi-Squared test (factor*cMRA dichotomous) for categorical variables

** Independent samples T-test for continuous variables (age* cMRA dichotomous)

***Wilcoxon rank sum test as a non-parametric test for continuous variables

Of all patients, 7 (1.8%) underwent a vascular operation within an average of five days (range 1-14), including six patients with acute cMRA findings and one patient with an ICA stenosis on the contralateral side in relation to the acute symptoms. Six of the patients underwent ICA endarterectomy, and one underwent vertebral artery stenting.

Table 2. Frequencies of cMRA findings within different groups sorted by frequency.

Finding in cMRA	All patients (N=385)	Patients with acute findings in cMRA (N=28)	Patients with acute findings on the brain MRI (N=95)	Patients with non-acute findings on the brain MRI	P-value*
Normal finding	326 (84.7)	0 (0)	68 (72)	258 (89)	<0.001

Non-obstructive atherosclerosis	19 (4.9)	2 (7)	4 (4.2)	15 (5.2)	1.000**
ICA stenosis	11 (2.9)	10 (36)	8 (8.4)	3 (1.0)	<0.001
ICA dissection	7 (1.8)	4 (14)	1 (1.1)	6 (2.1)	1.000**
Vertebral occlusion	7 (1.8)	3 (11)	5 (5.3)	2 (0.7)	0.011**
Vertebralis dissection	6 (1.6)	6 (21)	4 (4.2)	2 (0.7)	0.035**
Vertebral stenosis	5 (1.3)	3 (11)	3 (3.2)	2 (0.7)	0.099**
ICA occlusion	3 (0.8)	0 (0)	1 (1.1)	2 (0.7)	0.574**
Congenital anomaly	1 (0.3)	0 (0)	1 (1.1)	0 (0)	0.274**

ICA = internal carotid artery

*Chi-Squared test between acute and non-acute brain MRI groups

**Fisher's exact test

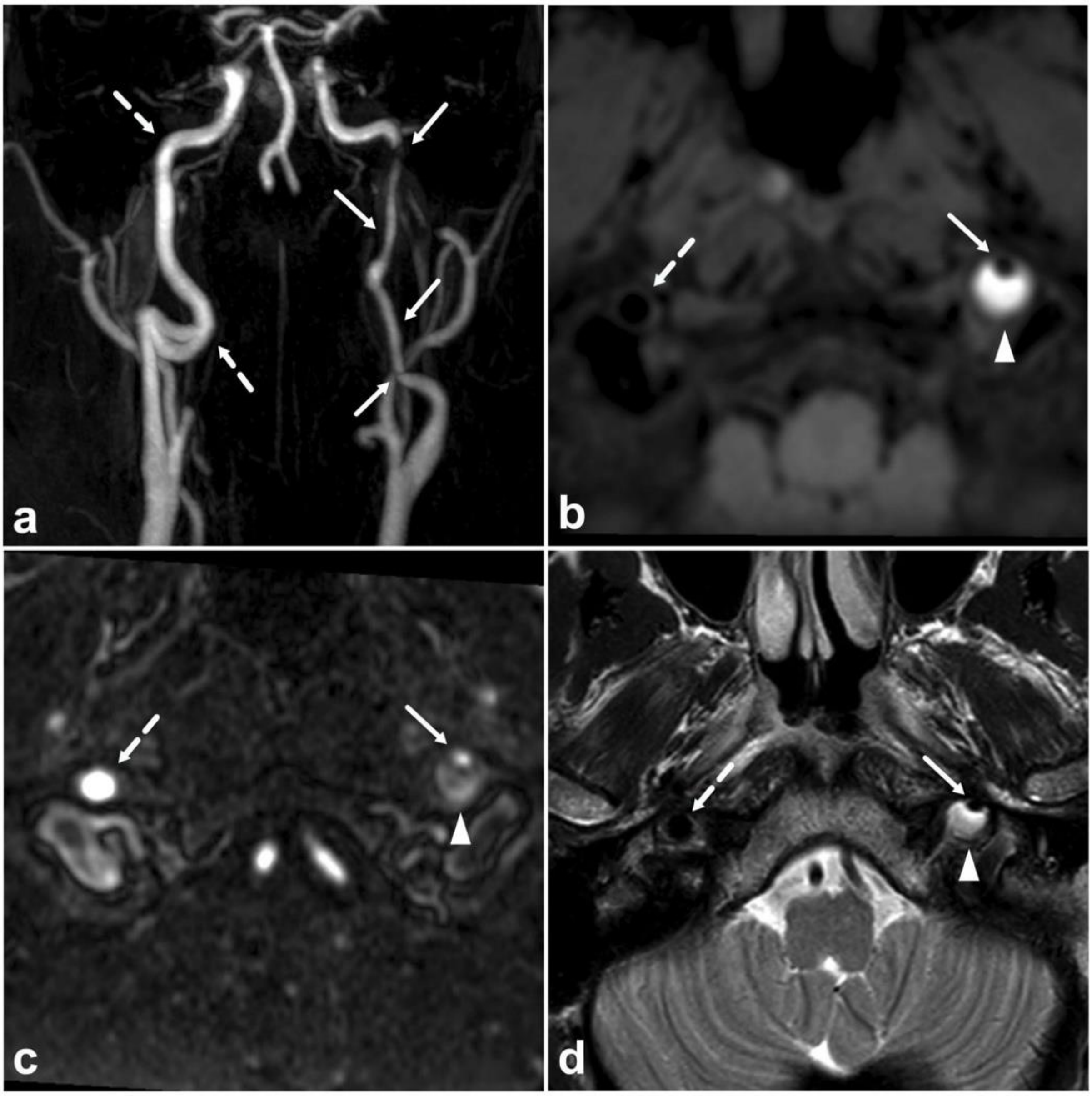

Figure 1 a. Gadolinium-enhanced magnetic resonance angiography, maximum intensity projection in a coronal plane **b.** Fat-saturated T1-weighted MRI, axial plane **c.** Gadolinium-enhanced magnetic resonance angiography, axial plane **d.** T2-weighted MRI, axial plane. A male patient in his late forties was admitted to the emergency department with a left-sided headache and Horner syndrome. A dissection was seen in the left internal carotid artery (white arrows). The dissection caused lumen narrowing in a six-centimeter-long segment (a normal right internal carotid artery lumen indicated by broken arrows for comparison). A T1-hyperintense intramural hematoma (indicated by white arrowheads) is best demonstrated in the T1-weighted sequence with fat saturation **(b)**. Brain MRI was unremarkable.

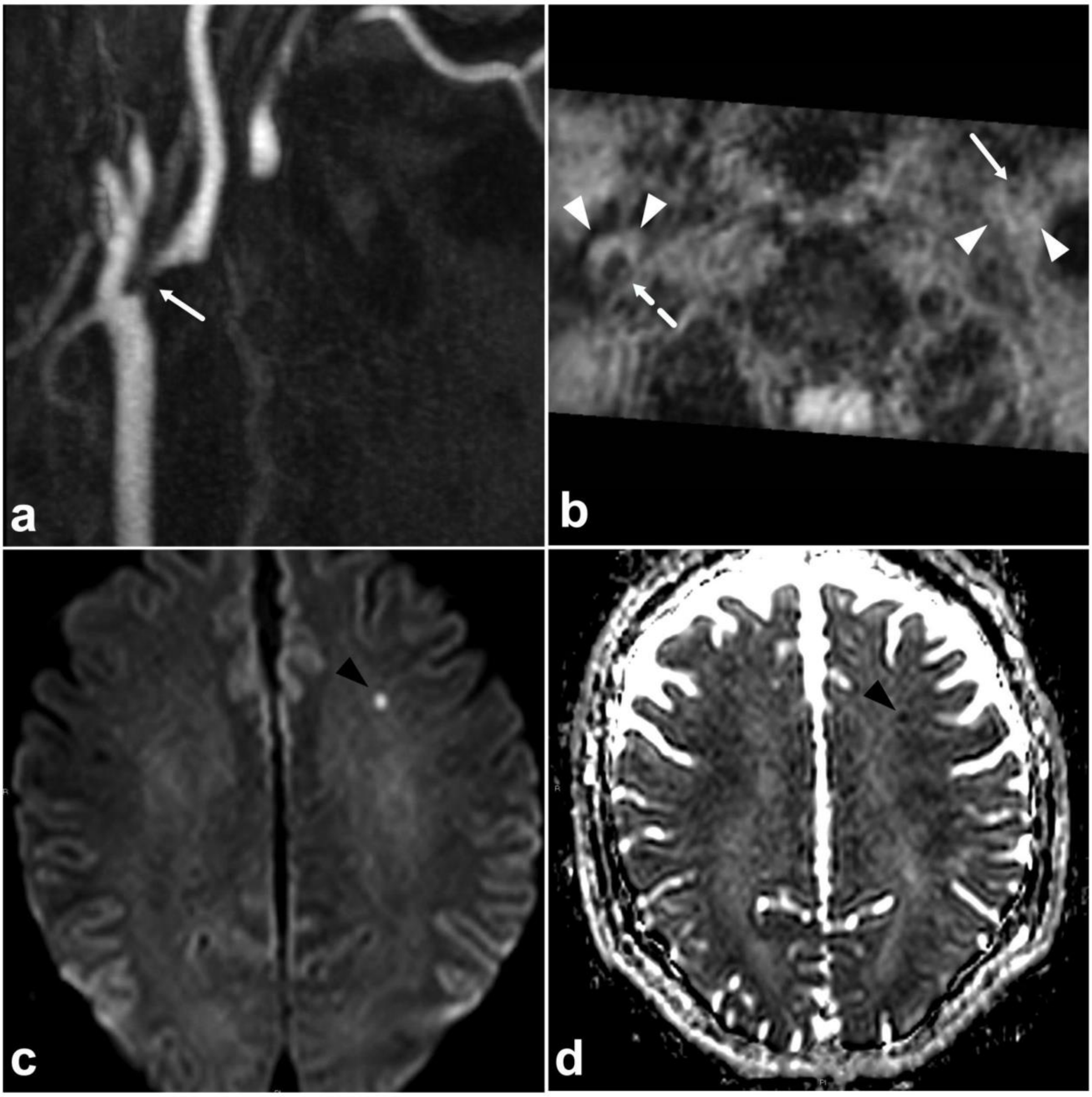

Figure 2 a. Gadolinium-enhanced magnetic resonance angiography, maximum intensity projection in a sagittal plane **b.** Fat-saturated T1-weighted MRI, axial plane **c**. Diffusion-weighted brain MRI, axial plane **d.** Apparent diffusion coefficient, axial plane. A male patient in his late fifties with nausea and right-sided ataxia. Brain MRI depicted an acute lacunar infarction in the left frontal white matter (**c**, **d**, black arrowheads). Magnetic resonance angiography revealed a subtotal stenosis of the left internal carotid artery (white arrows). In contrast to Figure 1, the T1-weighted fat-saturated MRI (**b**) does not demonstrate an intramural hematoma, but a slightly T1-hyperintense atherosclerotic plaque (white arrowheads). Atherosclerosis can be seen bilaterally, but the lumen of the right internal carotid artery is only slightly narrowed (broken white arrow).

The three most common neurological symptoms among all patients in our sample were visual impairment (N=137, 36%), headache (N=112, 29%), and paresthesia (N=95, 24%). In a univariate analysis (Table 3), none of the neurological symptoms were statistically significant.

Table 3. Frequencies of patients' neurological symptoms sorted by ascending P-value.

Symptom, N (%)	**All patients (N=385)**	**Findings in cMRA, acute/chronic (N=59)**	**No findings in cMRA (N=326)**	**P-value ****	**OR**
Dysphagia	8 (2.1)	1 (1.7) / 2 (3.4)	5 (1.5)	0.078	3.439
Paresthesia	95 (25)	6 (10) / 4 (6.8)	85 (26)	0.135	0.579
Aphasia	50 (13)	7 (12) / 4 (6.8)	39 (12)	0.160	1.686
Facial paresis	27 (7.0)	2 (3.4) / 4 (6.8)	21 (6.4)	0.302	1.644
Nystagmus	40 (10)	2 (3.4) / 2 (3.4)	36 (11)	0.323	0.586
Vertigo	34 (8.8)	3 (5.1) / 1 (1.7)	30 (9.2)	0.546	0.718
Horner's syndrome	5 (1.3)	1 (1.7) / 0 (0)	4 (1.2)	0.567	1.388
Visual impairment*	137 (36)	7 (12) / 11 (19)	119 (37)	0.376	0.764
Nausea or vomiting	82 (21)	12 (20) / 2 (3.4)	68 (21)	0.620	1.180
Hemiparesis	70 (18)	6 (10) / 6 (10)	58 (17.8)	0.641	1.180
Auditory symptom	10 (2.6)	1 (1.7) / 1(1.7)	8 (2.5)	0.655	1.395
Dysarthria	38 (9.9)	4 (6.8) / 1 (1.7)	33 (10)	0.696	0.822
Ataxia	59 (15)	7 (12) / 3 (5.1)	49 (15)	0.707	1.154
Headache	112 (29)	9 (15) / 8 (14)	95 (29)	0.959	0.984
Neck pain	53 (14)	3 (5.1) / 5 (8.5)	45 (14)	0.960	0.980

*Diplopia or any visual disturbance

**Chi-Squared test (symptom*cMRA dichtomic)

In a multivariate analysis (Table 4) with a cutoff value of 0.50, multiple cardiovascular risk factors and coronary artery disease remained statistically significantly associated with abnormal cMRA findings. Patients with two or more cardiovascular risk factors had a significantly higher risk of an abnormal finding on cMRA (p-value 0.024, OR 3.18) than patients with one or no cardiovascular risk factors. Also, patients with coronary artery disease had a significantly higher risk (p-value 0.005, OR 3.95) of an abnormal finding in cMRA than patients without coronary artery disease. This model had an ROC AUC of 0.733 ($p<0.001$, 95% CI 0.66-0.80), and it correctly classified 86% of patients overall. The classification was correct in 99% of patients without cMRA abnormalities, but in only 12% of patients with cMRA abnormalities.

Table 4. Multivariate analysis of predisposing factors for abnormal findings in cMRA.

Risk Factor	***P-value***	***OR***	***95% CI (lower-upper)***
Age over 58 years*	0.173	1.61	0.8 - 3.2
Two or more CV risk factors*	0.024	3.18	1.2 - 8.7

Hypertension	0.770	0.88	0.4 - 2.0
Hypercholesterolemia	0.369	0.70	0.3 - 1.5
Coronary artery disease	0.005	3.95	1.5 - 10
Previous stroke	0.207	1.59	0.8 - 3.3

CV = cardiovascular

*Cut-off point determined by Youden's index.

The original study sample included 72 patients with cMRA performed after cervical CTA due to clinical or radiological diagnostic uncertainties, considering carotid or vertebral dissection. Of these cases, 42 had the same acute findings on MRA and CTA (true positives), 24 had no findings on either study (true negatives), and 6 had a suspicion of dissection on CTA, but MRA was unremarkable (false positives). None had pathological findings on MRA alone (no false negatives). As a secondary analysis within our study, using MRA as a reference test, the sensitivity of CTA was 100%, the specificity was 80%, the accuracy was 91.7%, the PPV was 87.5%, and the NPV was 100%.

DISCUSSION

In this study, we aimed to evaluate the diagnostic yield of emergency cMRA in patients with recent stroke by exploring the correlation between cMRA and brain MRI findings. We also aimed to identify predisposing and protective factors for abnormal cMRA findings. Our analysis of 385 patients revealed a modest overall diagnostic yield, with abnormal cMRA findings in only 15.3% of cases (7.3% acute and 8.1% chronic). We found that patients with acute brain MRI findings were more than three times as likely to have an acute cMRA finding (probably related to the current neurological symptom) on cMRA than patients without acute brain MRI findings, underscoring the value of integrating brain parenchymal imaging to contextualize vascular pathology.

Patients with two or more cardiovascular risk factors (hypertension, hypercholesterolemia, diabetes, coronary artery disease, diabetes and previous stroke) were more likely to have abnormal findings in cMRA than those with fewer than two risk factors. As an individual risk factor, patients with coronary artery disease were more likely to have abnormal findings in cMRA than those without. None of the heterogeneous group of neurological symptoms predicted an abnormal finding on cMRA. Therapeutic impact was limited, with only 1.8% of patients proceeding to vascular intervention, aligning with concerns about routine vascular imaging overuse in the workup of neurological symptoms (13). Thus, these results indicate that the overall diagnostic yield of cervical MRA is relatively low among patients with recent stroke.

The overall abnormality rate of 15.3% in cMRA studies compares to previous results of 20-46% using CTA as an imaging modality for neck vessels (14–16). Deipolyi et al. (2015) found a relevant vascular pathology in the neck CTA in 31% of the patients imaged according to emergency stroke protocol. The majority of findings were stenosis of the carotid or vertebral arteries, and only 4% were dissections. In our study, 44% of the abnormal cases considered relevant to the acute symptoms involved carotid or vertebral stenosis or occlusion, and 22% involved carotid or vertebral dissection. These differences between the results of CTA studies and our study may be explained, in particular, by the greater use of cMRA in cases of suspected dissection in our institution. In addition, cMRA was used in patients who presented to the hospital late after symptom onset. The median time from symptom onset to cMRA imaging in our study was 2 days, regardless of whether abnormalities were detected on cMRA. Our cohort did not include hyperacute patients imaged according to the *code stroke* protocol.

We found only one previous study in the medical literature that explores the yield of cMRA combined with brain MRI in the diagnosis of acute stroke. Our results are consistent with those of the previous study. Harris et al. reported that 2.5% of patients in their cohort underwent a subsequent vascular intervention, whereas the corresponding proportion in our cohort was 1.8%. They found a significant (>50%) cervical artery stenosis in 27.1% of patients with stroke depicted in brain MRI and 10.2% of patients without stroke in brain MRI. In our cohort, the proportion of relevant cMRA findings was 21.1% among those with acute stroke on brain MRI and 2.8% among those without. The significantly lower rate of stenoses in patients without acute brain MRI findings is likely due to a lower threshold of emergency brain MRI at our institution.

In this study, we identified no neurological symptoms predictive of an abnormal MRA finding. This may be due to overreporting of irrelevant symptoms. Horner's syndrome (partial) has been found to represent the third most common clinical manifestation of cervical artery dissection (25% of cases) (17). In our sample, one out of 13 patients with cervical artery dissection had Horner's syndrome. Even hemiparesis was more common among patients without cMRA findings than among those with acute cMRA findings. This lack of significant correlation between cMRA findings and neurological symptoms underscores the heterogeneity of symptoms in neurological patients in the emergency department and the difficulty of precisely allocating advanced imaging in the emergency setting.

As a secondary analysis in our study, we found that the sensitivity of CTA was 100%, the specificity was 80%, the accuracy was 91.7%, the PPV was 87.5%, and the NPV was 100% when

MRA served as the reference. Six of all the CTA's had a suspicion of dissection, but MRA was unremarkable (false positives). Regarding the diagnosis of cervical artery dissections, Provenzale et al. found that the sensitivity and specificity of CTA and MRA were similar to those of DSA. The sensitivity of CTA ranged between 51% and 100%, the specificity between 67% and 100%, the PPV between 65% and 100%, and the NPV between 70% and 100% (9). Thus, a benefit of emergency cMRA is the resolution of ambiguous findings on CTA.

The concurrent use of brain MRI and cMRA is a significant strength of our study. We were able to better differentiate whether the cMRA finding is likely related to an acute disease presentation. For example, we could determine whether a stenosis in a cervical vessel accounts for the stroke observed on brain MRI by assessing the correspondence between the stroke location and the affected vessel. From MRI images, we could also identify, for example, brainstem strokes that are difficult to depict with CT. Our study is limited by its retrospective design. We obtained the symptoms only from the MRI referrals. Thus, the recorded neurological symptoms were highly heterogeneous, and we cannot determine which symptom was the primary driver of the imaging referral. Also, we did not perform a retrospective image analysis. Despite the limitations, our findings reflect the clinical practice in an emergency department managing patients with suspected acute stroke.

In conclusion, when combined with brain MRI for stroke workup, emergency cMRA has a modest rate of relevant positive findings (7.3% of all patients), with these findings more common in patients with concomitant acute brain MRI findings (21.1%) than in those without (2.8%). Routine cMRA does not seem to offer added value over CTA. The modest diagnostic and therapeutic yield of unselected emergency cervical MRA does not justify its routine inclusion in all stroke protocols; selective application guided by brain MRI findings and cardiovascular risk profile is recommended.

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