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## 高分辨率磁共振成像对颅内动脉粥样硬化斑块的诊断价值\*

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**摘要 目的:**探讨高分辨率磁共振成像(magnetic resonance imaging, MRI)对颅内动脉粥样硬化斑块的诊断价值。**方法:**选择 2016 年 1 月至 2018 年 6 月在我院诊治的缺血性脑卒中患者 134 例作为研究对象, 所有患者都给予数字减影血管造影(Digital subtraction angiography, DSA)与高分辨率 MRI 检查, 记录颅内动脉粥样硬化斑块特征与分型, 以 DSA 诊断为金标准, 判断 MRI 的诊断价值(阳性预测值、特异度、灵敏度、阴性预测值)。**结果:**在 134 例患者中, 高分辨率 MRI 显示未见斑块 62 例, I 型 5 例、II 型 26 例、III 型 26 例、IV 型 15 例, 与 DSA 诊结果一致 124 例, 占比 92.5%。高分辨率 MRI 与 DSA 诊断颅内动脉粥样硬化斑块的 Kappa 值为 0.89, MRI 对各分型的颅内动脉粥样硬化斑块的阳性预测值、特异度、灵敏度、阴性预测值分别为: I 型 87.0%、99.2%、95.8%和 99.2%, II 型 81.0%、98.5%、83.4%和 98.5%, III 型 82.7%、82.7%、84.0%和 95.7%, IV 型 100.0%、100.0%、100.0%和 100.0%。**结论:**高分辨率 MRI 用于诊断颅内动脉粥样硬化斑块的价值与 DSA 检查有很好的一致性, 可反映硬化斑块的分型。

**关键词:**高分辨率磁共振成像; 颅内动脉粥样硬化斑块; 数字减影血管造影; 诊断价值

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## Diagnostic values of High Resolution Magnetic Resonance Imaging for the Diagnosis of Intracranial Atherosclerotic Plaque\*

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**ABSTRACT Objective:** To investigate the values of high-resolution magnetic resonance imaging (MRI) in the diagnosis of intracranial atherosclerotic plaque. **Methods:** 134 cases of patients with ischemic stroke were selected from January 2016 to June 2018 in our hospital as subjects. All patients were given digital subtraction angiography(DSA) and high-resolution MRI examination, recorded the characteristics and classification of intracranial atherosclerotic plaque. The diagnostic value of MRI (positive predictive value, specificity, sensitivity, negative predictive value) was determined by taking DSA diagnosis as the gold standard. **Results:** In the 134 patients, high-resolution MRI showed there were no plaque in 62 cases, type I in 5 cases, type II in 26 cases, type III in 26 cases, and type IV in 15 cases, which were consistent with DSA diagnosis results in 124 cases that the rates were 92.5%, The Kappa value of high-resolution MRI and DSA in the diagnosis of intracranial atherosclerotic plaque were 0.89. The positive predictive value, Specificity, sensitivity and negative predictive value of MRI for each type were: I Type 87.0%, 99.2%, 95.8% and 99.2%, II type 81.0%, 98.5%, 83.4% and 98.5%, III type 82.7%, 82.7%, 84.0% and 95.7%, IV type 100.0%, 100.0%, 100.0% and 100.0%. **Conclusion:** The value of high-resolution MRI in the diagnosis of intracranial atherosclerotic plaque is consistent with that of DSA, which can reflect the classification of atherosclerotic plaque.

**Key words:** High-resolution magnetic resonance imaging; Intracranial atherosclerotic plaque; Digital subtraction angiography; Diagnostic value

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### 前言

颅内动脉粥样硬化斑块是缺血性脑卒中的常见病因的重要危险因素之一, 现代研究表明该病是由多种病因导致的脑血管疾病。由于其发病的部位不同, 导致临床表现复杂多变, 容易漏诊与误诊<sup>[1]</sup>。特别是该病易合并脑出血, 可使疾病的诊断和治疗更加复杂, 也会增加患者的死亡率<sup>[2]</sup>。大脑中动脉是颅

内动脉最粗的一支, 也为颅内血管中最易发生动脉粥样硬化斑块的部位<sup>[3,4]</sup>。

近年来, 随着超声、数字减影血管造影(Digital subtraction angiography, DSA)、电子计算机断层扫描(CT, Computed Tomography)、核磁共振成像(magnetic resonance imaging, MRI)等医学影像技术的成熟和发展, 当前对颅内动脉粥样硬化斑块的早期诊断率有了显著提高<sup>[5-7]</sup>。DSA 一直以来被认为是颅内

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动脉粥样硬化斑块最可靠的诊断和鉴别诊断方法,但是属于侵入性检查<sup>[8]</sup>。CT与超声虽然是一种简便、无创,临床上便于重复的脑血管疾病诊断方法,但是诊断的准确性、特异性不高<sup>[9]</sup>。高分辨率MRI具有非侵袭性、高分辨率图像质量以及多参数成像等等优势,可以清晰显示颅内动脉管壁及粥样硬化斑块的成分和性质,具有很高的敏感性和灵敏度<sup>[10,11]</sup>。高分辨率MRI具有三维成像、任意切面等优点,也可提供清晰可靠的解剖形态图像,对颅内动脉的整体和局部功能进行准确的计算与测定,从而提高诊断效果<sup>[12]</sup>。并且MRI技术能识别出更多的解剖和组织学细节,有可能全面和准确地诊断颅内动脉粥样硬化斑块<sup>[13,14]</sup>。本研究具体探讨了高分辨率磁共振成像对颅内动脉粥样硬化斑块的诊断价值,以期提高颅内动脉粥样硬化斑块的诊断准确性,现将研究结果做如下报道。

## 1 资料与方法

### 1.1 研究对象

采用回顾性研究方法,选择在我院诊治的缺血性脑卒中患者134例为研究对象。纳入标准:患者及家属对本研究知情同意;符合缺血性脑卒中的诊断标准;医院伦理委员会批准了此次研究;年龄40-70岁;临床资料完整;具有MRI检查指征与适应症。排除标准:出血性脑卒中患者;临床资料缺乏者;存在潜在的心源性脑栓塞可能性的患者;有MRI检查禁忌症的患者;处于妊娠期及哺乳期妇女;检查不依从的患者。

其中,男68例,女66例;43-69岁,平均年龄 $61.33 \pm 2.84$ 岁;平均体重指数 $22.19 \pm 3.13$  kg/m<sup>2</sup>;平均受教育年限 $13.99 \pm 2.44$ 年;平均病程 $4.21 \pm 1.28$ 年;合并疾病:高血压23例,糖尿病18例,高脂血症43例。

### 1.2 诊断方法

所有患者都给予高分辨率MRI与DSA检查,扫描时嘱入选者平卧闭目,平静呼吸,使用橡皮耳塞降低噪音,减少头部及其他部位的主动和被动运动。MRI检查采用西门子Skyra 3.0T磁共振扫描仪,配套头部八通道相控阵线圈。常规轴位T1WI(TR/TE=500/11ms),T2WI(CTR/TE=3400/98ms),

FastFLAIR(TR/TE/TI9000/56/200ms),层间距0mm,视野256mm×256mm,矩阵256×256,层厚1.0mm,回波时间3.0ms,扫描时间4min5s。在高分辨率中成像,通过高压注射器射对比剂钆喷替酸葡甲胺(北京北陆药业股份有限公司,Gd-DTPA)25-35mL,流速3mL/s。扫描完毕后,把数据图像上传到西门子图像后处理工作站进行处理。DSA检查选择西门子数字减影血管造影机,实施股动脉穿刺术,行主动脉弓从而开展全脑血管造影,其中造影剂为非离子型对比剂优维显370,经颅内动脉团注速度为3-4mL/s,其总量为6-9mL。在检查时,扫描参数:矩阵1024×1024,视野22cm,像素0.2×0.2,进行前后位、斜位及侧位像采集。

DSA检查与MRI检查诊断意见由两名资深放射科医生(副高级职称及其以上,工作年限≥5年)通过评估图像经协商达成一致。

### 1.3 观察指标

颅内动脉粥样硬化斑块性质分型:I型:管壁无钙化,管壁厚度接近正常;II型:内膜弥漫增厚的无钙化偏心性斑块;III型:覆盖有纤维帽的斑块,含有较大的坏死脂核,可伴有少量钙化;IV型:钙化斑块。

### 1.4 统计学分析

本研究所获得的计量数据和计数数据均采用SPSS22软件进行分析,计量数据采用均数±标准差表示,计数数据采用构成比、率、百分比等表示,相关性分析采用kappa相关性分析(0.0-0.20极低一致性、0.21-0.40一般一致性、0.41-0.60中等一致性(moderate)、0.61-0.80高度一致性、0.81-1几乎完全一致),检验水准为 $\alpha=0.05$ 。

## 2 结果

### 2.1 颅内动脉粥样硬化斑块的情况

134例患者中,DSA显示为未见斑块62例,I型4例,II型22例,III型21例,IV型15例。高分辨率MRI显示未见斑块62例,I型5例,II型26例,III型26例,IV型15例。详细情况见表1。

表1 颅内动脉粥样硬化斑块的高分辨率MRI与DSA检出情况(n)

Table 1 High-resolution MRI and DSA detection of intracranial atherosclerotic plaques (n)

MRI	DSA				Total	
	No plaques	I	II	III		IV
No plaques	62	0	0	0	0	62
I	0	4	1	0	0	5
II	0	0	22	4	0	26
III	0	1	4	21	0	26
IV	0	0	0	0	15	15
Total	62	5	27	25	15	134

### 2.2 高分辨率MRI诊断颅内动脉粥样硬化斑块与DSA的一致性分析

134例患者中,高分辨率MRI与DSA诊断颅内动脉粥样硬化斑块结果一致124例,占比92.5%,MRI诊断分型增加与

减低都有5例,各占比3.4%。详细情况见表2。

### 2.3 诊断效果

134例患者中,高分辨率MRI与DSA诊断颅内动脉粥样硬化斑块的一致性非常好,Kappa值为0.89。MRI对各分型的

颅内动脉粥样硬化斑块的阳性预测值、特异度、灵敏度、阴性预测值等都超过 80%,详细情况见表 3。

表 2 高分辨率 MRI 诊断颅内动脉粥样硬化斑块与 DSA 的一致性分析(n)

Table 2 Consistency analysis of High-resolution MRI and DSA in the diagnosis of intracranial atherosclerotic plaque (n)

DSA	MRI Meet	Increase	Decrease	Total
No plaques	62	0	0	62
I	4	1	0	5
II	22	4	1	27
III	21	0	4	25
IV	15	0	0	15
Total	124	5	5	134

表 3 高分辨率 MRI 诊断颅内动脉粥样硬化斑块的灵敏度、特异度、阳性预测值与阴性预测值(n)

Table 3 The sensitivity, specificity, positive predictive value, and negative predictive value of high-resolution MRI in the diagnosis of intracranial atherosclerotic plaque (n)

Diagnosis effect	I	II	III	IV
Sensitivity	95.8%	83.4	84.0%	100.0%
Specificity	99.2%	98.5%	98.2%	100.0%
Positive predictive value	87.0%	81.0%	82.7%	100.0%
Negative predictive value	99.2%	98.5%	95.7%	100.0%

### 3 讨论

缺血性脑卒中为一种全身性疾病,颅内动脉粥样硬化斑块与该病的发生密切相关。目前,我国缺血性脑卒中缓和趋于年轻化,中年人群的脑血管状况越来越受到重视<sup>[15]</sup>。由于该病患者的临床表现变异性大,对患者进行病情判断与预后预测显得尤为重要<sup>[16]</sup>。研究显示在颅内动脉粥样硬化斑块患者中, I 型的硬化斑块亦可以导致缺血性脑卒中,同时动脉粥样硬化斑块的不稳定性与卒中的发生密切相关<sup>[17]</sup>。

颅内动脉粥样硬化斑块常用的诊断方法有超声、CT、DSA 和 MRI 等, DSA 一直被认为是评价颅内血管病变的 "金标准",其能够实时显示患者血流动力学改变,可以对病变血管狭窄程度进行直接评价,准确发现并定位血管病变部位,特别是血管变异、动脉瘤、脑血管狭窄和闭塞等方面的诊断价值较高<sup>[18]</sup>。DSA 检查为有创性检查,在临床上的应用有一定的限制<sup>[19]</sup>。超声与 CT 具备快速、成本低等优势,但是诊断的效果有待提高。高分辨率 MRI 具有非侵袭性、高分辨率等优势,可同时观察多个颅内动脉,对动脉闭塞的检出与常规 DSA 检查高度一致<sup>[20]</sup>。本研究显示高分辨率 MRI 对颅内动脉粥样硬化斑块的检出率与一致性都比较好。在假阳性与假阴性方面, MRI 对颅内动脉粥样硬化斑块的诊断略有有一定的个别误差,最主要在于大脑中动脉的血管对磁场梯度较敏感,易产生认为狭窄;并且免疫、炎症等因素也会造成局部脑血管痉挛,导致高分辨率 MRI 成像时显示出假阴性<sup>[21,22]</sup>。

研究报道显示约 70% 的年龄  $\geq 60$  岁的缺血性脑梗死患者存在颅内动脉粥样硬化斑块,即便其他患者未发现明显颅内动脉粥样硬化斑块,但是在三年内发生缺血性脑梗死的危险性为

5.0%左右<sup>[23]</sup>。颅内动脉粥样硬化斑块可通过多种机制导致缺血性脑卒中,其中粥样硬化斑块生长导致的血管堵塞、斑块脱落导致远端血管堵塞为主要原因,因此通过影像学方法识别斑块尤其是硬化斑块成为亟待解决的问题<sup>[24]</sup>。传统血管成像技术往往局限于通过测量动脉管腔狭窄程度来判断病变的严重性,不过由于颅内动脉存在正性重构效应,导致诊断误差比较大<sup>[25]</sup>。而高分辨率 MRI 既能检查管腔的狭窄程度,更加准确地多平面识别斑块成分,可以无创、无辐射地对软组织、血管外壁及管腔进行高清成像。特别是借助西门子公司专用线圈和扫描序列,可以更好的帮助粥样硬化斑块患者进行风险预测和早期干预治疗<sup>[26,27]</sup>。本研究显示 kappa 相关性显示高分辨率 MRI 与 DSA 诊断颅内动脉粥样硬化斑块的 Kappa 值为 0.89, 对各分型的颅内动脉粥样硬化斑块的阳性预测值、特异度、灵敏度、阴性预测值等都超过 80%。而随着很多高新企业 3.0T 高分辨率 MRI 扫描设备的研制成功, 3.0T MRI 图像的像素大小可以达到  $0.24 \text{ mm} \times 0.24 \text{ mm} \times 0.5 \text{ mm}$ , 特别是有效像素容积可达  $0.029 \text{ mm}^3$ , 提高显示分辨率,能有效显示细小分支血管,促进提高诊断价值<sup>[28]</sup>。高分辨并且 MRI 能不受血流流速缓慢的影响,更有效抑制流动伪影的影响,也是目前唯一适合在活体内进行颅内动脉管壁成像的影像学方法<sup>[29]</sup>。不过 MRI 对颅内动脉粥样硬化斑块进行成像也存在一定的制约性,特定的扫描序列是斑块成像的重要条件,同时成像分辨率、信噪比和扫描时间三因素存在矛盾性,导致可能存在诊断误差<sup>[30]</sup>。同时本研究的样本数量较少,将在下一步将扩大样本进行明确分析。

总之,高分辨率 MRI 用于颅内动脉粥样硬化斑块具有很高的诊断价值,与 DSA 检查有很好的 consistency,可反映硬化斑块的类型。

## 参考文献(References)

- [1] Al Said S, Bode C, Duerschmied D. Anticoagulation in Atherosclerotic Disease[J]. *Hamostaseologie*, 2018, 38(4): 240-246
- [2] Del Brutto O H, Mera R M, Espinosa V, et al. Distribution of Cervicocephalic Atherosclerotic Lesions and Their Correlation with Cardiovascular Risk Factors in a Population of Amerindians. The Atahualpa Project[J]. *J Stroke Cerebrovasc Dis*, 2018, 27(11): 3356-3364
- [3] Guo R, Zhang X, Zhu X, et al. Morphologic characteristics of severe basilar artery atherosclerotic stenosis on 3D high-resolution MRI[J]. *BMC Neurol*, 2018, 18(1): 206
- [4] Li D, Dai W, Cai Y, et al. Atherosclerosis in stroke-related vascular beds and stroke risk: A 3-D MR vessel wall imaging study [J]. *Ann Clin Transl Neurol*, 2018, 5(12): 1599-1610
- [5] Lu S S, Ge S, Su C Q, et al. Plaque Distribution and Characteristics in Low-Grade Middle Cerebral Artery Stenosis and Its Clinical Relevance: A 3-Dimensional High-Resolution Magnetic Resonance Imaging Study[J]. *J Stroke Cerebrovasc Dis*, 2018, 27(8): 2243-2249
- [6] Lu S S, Xie J, Su C Q, et al. Plasma homocysteine levels and intracranial plaque characteristics: association and clinical relevance in ischemic stroke[J]. *BMC Neurol*, 2018, 18(1): 200
- [7] Shi Z, Zhu C, Degnan A J, et al. Identification of high-risk plaque features in intracranial atherosclerosis: initial experience using a radiomic approach[J]. *Eur Radiol*, 2018, 28(9): 3912-3921
- [8] Shin J, Chung J W, Park M S, et al. Outcomes after ischemic stroke caused by intracranial atherosclerosis vs dissection [J]. *Neurology*, 2018, 91(19): e1751-e1759
- [9] Tsigoulis G, Safouris A, Kim D E, et al. Recent Advances in Primary and Secondary Prevention of Atherosclerotic Stroke [J]. *J Stroke*, 2018, 20(2): 145-166
- [10] Wang M, Wu F, Yang Y, et al. Quantitative assessment of symptomatic intracranial atherosclerosis and lenticulostriate arteries in recent stroke patients using whole-brain high-resolution cardiovascular magnetic resonance imaging [J]. *J Cardiovasc Magn Reson*, 2018, 20(1): 35
- [11] Yang P S, Pak H N, Park D H, et al. Non-cardioembolic risk factors in atrial fibrillation-associated ischemic stroke [J]. *PLoS One*, 2018, 13(7): e0201062
- [12] Yang W J, Zheng L, Wu X H, et al. Postmortem Study Exploring Distribution and Patterns of Intracranial Artery Calcification [J]. *Stroke*, 2018, 49(11): 2767-2769
- [13] Yu J, Zhang S, Li M L, et al. Relationship between the geometry patterns of vertebrobasilar artery and atherosclerosis[J]. *BMC Neurol*, 2018, 18(1): 83
- [14] Zhang N, Zhang F, Deng Z, et al. 3D whole-brain vessel wall cardiovascular magnetic resonance imaging: a study on the reliability in the quantification of intracranial vessel dimensions[J]. *J Cardiovasc Magn Reson*, 2018, 20(1): 39
- [15] Abe A, Sekine T, Sakamoto Y, et al. Contrast-Enhanced High-Resolution MRI for Evaluating Time Course Changes in Middle Cerebral Artery Plaques[J]. *J Nippon Med Sch*, 2018, 85(1): 28-33
- [16] Chen Z, Liu A F, Chen H, et al. Evaluation of basilar artery atherosclerotic plaque distribution by 3D MR vessel wall imaging[J]. *J Magn Reson Imaging*, 2016, 44(6): 1592-1599
- [17] Chueh J Y, Van Der Marel K, Gounis M J, et al. Development of a high resolution MRI intracranial atherosclerosis imaging phantom[J]. *J Neurointerv Surg*, 2018, 10(2): 143-149
- [18] Chung G H, Jeong J Y, Kwak H S, et al. Associations between Cerebral Embolism and Carotid Intraplaque Hemorrhage during Protected Carotid Artery Stenting[J]. *AJNR Am J Neuroradiol*, 2016, 37(4): 686-91
- [19] Chung G H, Kwak H S, Hwang S B, et al. Magnetic resonance imaging of intracranial atherosclerosis: Comparison of ex vivo 3T MRI and histologic findings[J]. *Eur J Radiol*, 2017, 97: 110-114
- [20] Hartevelde A A, Denswil N P, Siero J C, et al. Quantitative Intracranial Atherosclerotic Plaque Characterization at 7T MRI: An Ex Vivo Study with Histologic Validation [J]. *AJNR Am J Neuroradiol*, 2016, 37(5): 802-810
- [21] Jiang Y, Peng W, Tian B, et al. Identification and Quantitative Assessment of Different Components of Intracranial Atherosclerotic Plaque by Ex Vivo 3T High-Resolution Multicontrast MRI [J]. *AJNR Am J Neuroradiol*, 2017, 38(9): 1716-1722
- [22] Lee H N, Ryu C W, Yun S J. Vessel-Wall Magnetic Resonance Imaging of Intracranial Atherosclerotic Plaque and Ischemic Stroke: A Systematic Review and Meta-Analysis [J]. *Front Neurol*, 2018, 9: 1032
- [23] Li D, Dai W, Cai Y, et al. Atherosclerosis in stroke-related vascular beds and stroke risk: A 3-D MR vessel wall imaging study [J]. *Ann Clin Transl Neurol*, 2018, 5(12): 1599-1610
- [24] Perren F, Vargas M I, Kargiotis O. Etiology of Intracranial Arterial Stenosis: Are Transcranial Color-Coded Duplex Ultrasound and 3T Black Blood MR Imaging Complementary? [J]. *J Neuroimaging*, 2016, 26(4): 426-430
- [25] Qiao Y, Guallar E, Suri F K, et al. MR Imaging Measures of Intracranial Atherosclerosis in a Population-based Study [J]. *Radiology*, 2016, 280(3): 860-868
- [26] Sun B, Li X, Liu X, et al. Association between carotid plaque characteristics and acute cerebral infarction determined by MRI in patients with type 2 diabetes mellitus [J]. *Cardiovasc Diabetol*, 2017, 16(1): 111
- [27] Vakil P, Elmokadem A H, Syed F H, et al. Quantifying Intracranial Plaque Permeability with Dynamic Contrast-Enhanced MRI: A Pilot Study[J]. *AJNR Am J Neuroradiol*, 2017, 38(2): 243-249
- [28] Wu F, Song H, Ma Q, et al. Hyperintense Plaque on Intracranial Vessel Wall Magnetic Resonance Imaging as a Predictor of Artery-to-Artery Embolic Infarction[J]. *Stroke*, 2018, 49(4): 905-911
- [29] Xu Y, Yuan C, Zhou Z, et al. Co-existing intracranial and extracranial carotid artery atherosclerotic plaques and recurrent stroke risk: a three-dimensional multicontrast cardiovascular magnetic resonance study[J]. *J Cardiovasc Magn Reson*, 2016, 18(1): 90
- [30] Zheng L, Yang W J, Niu C B, et al. Correlation of Adventitial Vasa Vasorum with Intracranial Atherosclerosis: A Postmortem Study[J]. *J Stroke*, 2018, 20(3): 342-349