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新生儿动脉缺血性卒中的影像诊断方法

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摘　要

目的：对动脉缺血性卒中(NAIS)的各种影像检查技术进行综述。方法：查阅国内外用于诊断NAIS的影像检查技术，包括磁共振(MRI)、颅脑超声(CUS)、计算机断层扫描(CT)、数字减影血管造影(DSA)，以及他们相关新技术的文献。对病变的各种影像检查技术及其影像表现进行介绍。结果：不同的影像学方法对于疾病的诊断具有不同的优势，扩散加权成像(DWI)对急性期检测NAIS最敏感；而新的成像技术包括弥散张量成像(DTI)和动脉自旋标记(ASL)帮助我们全面诊断该疾病。结论：磁共振成像是诊断NAIS的金标准；新的成像技术可以为临床提供更多的影像学信息。

关键词

新生儿动脉缺血性卒中(NAIS)，磁共振成像(MRI)，扩散加权成像(DWI)

Imaging Diagnostic Methods for Neonatal Arterial Ischemic Stroke

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Abstract

Objective: To provide a comprehensive review of various imaging techniques for neonatal arterial ischemic stroke (NAIS). Methods: We conducted a review of domestic and international imaging techniques used for the diagnosis of neonatal arterial ischemic stroke (NAIS), including magnetic resonance imaging (MRI), cranial ultrasound (CUS), computed tomography (CT), and digital subtraction angiography (DSA), along with literature on their related advanced technologies. We provide an overview of various imaging techniques and their corresponding imaging manifestations for

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NAIS lesions. Results: Different imaging modalities offer distinct advantages in disease diagnosis. Diffusion-weighted imaging (DWI) is the most sensitive for detecting acute-stage NAIS, while advanced imaging techniques such as diffusion tensor imaging (DTI) and arterial spin labeling (ASL) provide comprehensive diagnostic capabilities for this condition. Conclusions: Magnetic resonance imaging is the gold standard for diagnosing NAIS; novel imaging techniques can provide additional radiological information for clinical practice.

Keywords

Neonatal Arterial Ischemic Stroke (NAIS), Magnetic Resonance Imaging (MRI), Diffusion-Weighted Imaging (DWI)

1. 引言

动脉缺血性卒中其定义为出生 28 d 内经颅脑影像学证实的动脉供血区域急性局灶性血流中断事件[1]。NAIS 的危险因素尚不完全清楚，脑膜炎、脑静脉血栓形成、红细胞增多症、遗传性和散发性凝血障碍、创伤性颅内出血都可能与新生儿脑梗死有关[2]。与动脉粥样硬化或高血压引起的成人中风相比，NAIS 的病因与出生前或出生时的病情有关。虽然尚不清楚，但有几种假说可以解释 NAIS 的病因，包括胎盘血栓栓塞、母胎炎症以及分娩时颅内或颈动脉损伤[3]-[7]。大多数患有 NAIS 的新生儿无症状或表现出非典型症状。癫痫发作、呼吸暂停、意识改变和喂养困难是常见的临床表现[8] [9]。一项对 30 多年研究的总结性回顾发现，新生儿卒中的死亡率为 3% [10]。NAIS 的诊断取决于临床和放射学证据[11]。扩散加权成像(DW-MRI)的使用使我们能够在发病后数小时内识别病变[12]。超过一半的 NCI 发生在大脑中动脉(MCA)区域，左侧 MCA 区域的发病率是右侧的三到四倍，一些梗死明显对应于大脑大动脉的血管分布，通常是大脑中动脉，但并非总是如此[2]。

2. 影像诊断方法

2.1. 计算机断层扫描(CT)

计算机断层扫描(CT)扫描需要几分钟，通常不需要镇静。它在 NAIS 的早期阶段显示出一个局灶性低密度阴影。然而，CT 很少用于 NAIS 的诊断。CT 对小面积梗死和后颅窝梗死的敏感性较低。它还存在辐射风险，目前不作为新生儿脑梗死影像学诊断的首选方法[13]。CT 血管成像(CTA)通过连续扫描和计算机三维图像重建，即可获得脑血管的三维立体影像。扫描时间短，不足 1 分钟，图像处理时间也不长，平均约 30 分钟，被认为是脑血管病诊断及术前评估的一种快速、简单、无创和可靠的影像学技术。另外，CTA 可显示动脉阻塞和侧支循环情况。但由于 CTA 需要做造影增强，从而增加了药物过敏和血管痉挛的风险，三维立体影像处理中，也可能造成人为伪差，使其在急诊中的应用受到一定限制。

2.2. 磁共振成像(MRI)

磁共振成像(magnetic resonance imaging, MRI)是诊断 NAIS 的金标准，因为 MRI 的敏感性高，即使

对于小梗死也是如此[14]-[17]。此外，MRI 是无创的，不使用辐射。传统类型的 MRI 包括弥散加权成像(DWI)、T1 加权成像和 T2 加权成像以及磁共振血管造影(MRA)。DWI 对急性期检测 NAIS 最敏感，尤其是损伤后 2~4 天[17]-[19]。研究表明，DWI 检测 NAIS 的敏感性可达 91% [20]，尽管在受伤后一周内显着降低[21]。DWI 上 NAIS 的典型发现是弥散受限，其病理基础主要是缺血缺氧引发的细胞毒性水肿。在 NAIS 后 6 天内，缺血区的 T1 加权成像显示低信号，T2 加权成像显示高信号。并且 6 天后在 T1 和 T2 加权成像上信号强度反转。NAIS 后 6 天内 T1WI 低信号、T2WI 高信号反映了急性期细胞毒性水肿；6 天后的信号反转(T1WI 高信号、T2WI 低信号)与亚急性期蛋白质释放、微小出血或胶质增生相关[22]。此外，MRA 用于检测血管，无需使用静脉造影剂，这有助于确定中风的原因并预测预后。然而，MRA 对检测涉及微血管结构的病变的敏感性较低，并且不显示低速度的血管。新的 MRI 方法也正在出现，这些方法也适用于中风。弥散张量成像(DTI)基于 DWI，可以追踪白质纤维并显示急性网络损伤[23]。它还可以帮助临床医生预测长期后遗症，包括 NAIS 后的运动障碍和视力障碍[24]。有研究报道基于 DTI 的追踪成像在患儿 3 个月时可用于预测 NAIS 后的神经发育结果。它在新生儿期具有与 DWI 类似的预测价值，特别是在新生儿 DWI 不确定或早期运动发育异常的情况下，具有额外的价值[19]。最近，开发了一种称为动脉自旋标记(ASL)的新型 MRI 技术来量化脑灌注。动脉自旋标记是一种无创非对比灌注成像技术，它使用血液中的内源水作为灌注示踪剂。它基于在流入的动脉血质子进入感兴趣区域之前对其进行磁性标记(施加射频脉冲)的原理。在标记和流入期之后，使用快速采集技术获取一对图像：标记图像，其中血水磁化反转，以及控制图像，其中血水磁化未反转。它们之间的信号差异与脑血流量(CBF)成正比[25]。ASL 通过血液的“磁性标记”而不是示踪剂来估计脑灌注。它可以可靠地检测 NAIS 患者的低灌注和高灌注，但信噪比较低，可用作 NAIS 后的灌注监测仪[26] [27]。有研究表明，ASLMRI 可用于评估梗死区域，并且未来 ASLMRI 可用于评估奢侈灌注和动脉通过伪影在梗死区域演变中的作用。此外，它可能用于评估未来神经保护性治疗(如红细胞生成素、低温)对最终梗死大小的效果[28]。此外，最近开发的功能磁共振成像(fMRI)和磁共振波谱成像可以帮助临床医生了解中风后的大脑功能和代谢变化[29]。然而，这些技术尚未广泛用于新生儿。

2.3. 数字减影血管造影(DSA)

DSA 是通过电子计算机进行辅助成像的血管造影方法，是 20 世纪 70 年代以来应用于临床的一种 X 线检查新技术，可同时观察动脉、静脉、毛细血管狭窄、闭塞和灌注情况。但由于 DSA 是一种有创性检查，对脑血管病不应作为首选或常规检查方法[29]。

2.4. 颅脑超声(CUS)

颅脑超声检查(CUS)广泛用于诊断 NAIS。CUS 在 NAIS 早期在梗死区域显示强烈的回声反射，而在晚期由于梗死区域的坏死和液化而显示低回声或无回声。早期研究表明，CUS 检测 NAIS 的敏感性仅为 30.5% [30]。然而，随着超声设备的发展，灵敏度显著提高，从 72%到 87%不等，尤其是在 NAIS 后 48 小时[31]。然而，CUS 对大脑后动脉和小动脉梗死不敏感[32]。基于其无创性能、实时成像和床旁检测的便利性，CUS 在临床上被用作 NAIS 的初步筛查工具。

3. 总结

目前 NAIS 的诊断主要取决于神经影像学检查结果，有多种影像学检查方法可以辅助诊断该疾病。传统成像主要针对结构，只能显示受损区域的位置。近年来，先进的成像技术，包括弥散张量成像(DTI)和动脉自旋标记(ASL) [33]，已经证明了缺血性卒中后新生儿脑的急性网络损伤或灌注，为全面了解 NAIS

提供了可能性。

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