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脊髓损伤扩散峰度成像参数与脊髓型颈椎病患者神经功能评分的相关性研究 *

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摘要 目的:研究扩散峰度成像(DKI)参数与脊髓型颈椎病(CSM)患者神经功能评分的相关性及临床意义。**方法:**选取 2018 年 12 月至 2019 年 6 月本院收治的 CSM 患者 37 例作为研究组及健康志愿者的 30 例作为对照组,采用 GE3.0 磁共振机分别对两组人员行磁共振成像(MRI)及 DKI 扫描,观察其影像学特征及 DKI 参数的变化情况,并分析 DKI 参数值与临床行为评分的相关性。**结果:**所有研究对象的 MRI 图像均符合诊断要求。志愿者颈髓形态完整、信号均匀;不同年龄组颈髓平均弥散各向异性分数(FA)值、平均弥散峰度(MK)值比较差异无统计学意义($P>0.05$)。根据 MRI 的 T2 加权图像上椎管受压程度及脊髓信号改变,将实验组分为 A、B、C 组, 对照组与各实验组的 MK 值、FA 值比较差异有统计学意义 ($P<0.05$)。实验组 FA 值与 mJOA 评分呈显著正相关(r=0.34),与 NDI 评分呈负相关(r=-0.38);MK 值与 mJOA 评分呈正相关(r=0.67),与 NDI 评分呈负相关(r=-0.46)。**结论:**DKI 序列对 CSM 诊断具有参考较高价值,其参数与临床行为评分关系密切,能够评估早期 CSM 患者的脊髓损伤情况,并为诊断和治疗提供参考。

关键词:磁共振扩散峰度成像;脊髓损伤;脊髓型颈椎病;平均弥散峰度

中图分类号:R651.2;R681.55 **文献标识码:**A **文章编号:**1673-6273(2020)02-290-05

Correlation of Diffusion Kurtosis Imaging in the Cervical Spinal Cord with the Clinical Scores of Patients*

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ABSTRACT Objective: To study the correlation between diffusion kurtosis imaging (DKI) parameters and neurological function scores in patients with cervical spinal cord (CSM). **Method (s):** Total 37 cases of patients diagnosed with CSM of our hospital from December 2017 to June 2018 were enrolled as the study group. There were 30 cases of healthy people were randomly selected as the control group. Use GE 3.0 MRI scanning equipment, the two groups underwent conventional magnetic resonance imaging (MRI) and DKI scan. The imaging features and DKI parameters were observed, and the relationship between fractional anisotropy (FA), mean kurtosis (MK) and clinical scores was analyzed. **Result (s):** MRI images of all subjects met the requirements of diagnosis and measurement. The cervical spinal of healthy people were smooth, uniform, and complete structure. There was no significant difference in the mean diffusion anisotropy (FA) and mean diffusion kurtosis (MK) between different age groups ($P > 0.05$). According to the degree of spinal canal compression and the changes of spinal cord signal in MRI T2 weighted image, the study group was divided into group A, B and C. There were statistically significant differences between the MK values of the control group and the study groups ($F=61.34$, $P < 0.05$). There were statistically significant differences in the average FA value between the control and the study groups ($F=26.48$, $P= < 0.05$). FA value of the study group was positively correlated with mJOA score (r=0.34), negatively correlated with NDI score (r=-0.38), and MK was positively correlated with mJOA score (r=0.67) and negatively correlated with NDI score (r=-0.46). **Conclusion(s):** The DKI sequence has a high reference value for CSM diagnosis. Its parameters are closely related to the neurological function scores. It can evaluate the spinal cord injury in early CSM patients and provide reference for diagnosis and judging prognosis.

Key words: Diffusion kurtosis imaging; Cervical spondylotic myelopathy; Spinal cord injury; Mean diffusion kurtosis

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前言

脊髓型颈椎病(cervical spondylotic myelopathy,CSM)是颈椎病中较为严重的一种类型[1,2],常压迫脊髓或伴行血管,造成脊髓损伤,继而出现脊髓的相关功能障碍、甚至截瘫[3,4]。如何改善 CSM 患者的生活质量,做到早期诊断和评估脊髓损害程度,受到越来越广泛的关注[1,3]。

目前,临床普遍使用 MRI 评估 CSM,虽能描述脊髓形态学改变,却不能在分子水平上反映脊髓损伤时的一些变化,常导致低估其脊髓的病变程度 [5-7]。扩散峰度成像(Diffusion Kurtosis Imaging,DKI)是基于扩散加权成像(Diffusion weighted imaging,DWI)发展来的一种新技术,能更准确的描述脊髓病变情况,从而做出更加全面的分析[8,9]。

因此,本研究主要分析了颈髓 DKI 参数与 CSM 患者神经功能评分的相关性, 并探讨了脊髓不同损伤程度时的 DKI 参数的变化,以期为定量诊断脊髓疾病提供参考依据。

1 材料与方法

1.1 一般资料

选取 2018 年 12 月至 2019 年 6 月招募的健康志愿者 30 例作为对照组(年龄 20-70 岁,平均为 45.9 岁),按其年龄分成三组:a(20-40 岁)、b(40-60 岁)、c(60 岁以上)。收集我院确诊为脊髓型颈椎病(CSM)的患者 37 例作为实验组(男性 21 例,女性 16 例;年龄范围与实验组相同,平均为 47.6 岁)。所有受试人员均签署知情同意书。

入选标准:(1)既往身体健康,无中枢神经系统疾患和其他影响中枢神经系统的全身性疾患,(2) 常规颈部脊髓 MRI 图像无异常。

排除标准:(1)存在其他椎管内存在脊髓受压的疾病,如占位等;(2) MRI 图像质量不满意者 (3)颈部有任何原因的手术病史;(4)带有体内植入物者,如心脏起搏器等。

1.2 方法

1.2.1 MRI 扫描 采用 GE 3T 磁共振机 (GE Medical System, Healthcare Discovery MR 750, USA),定位范围为中脑水平至胸 1 椎体。常规扫描:矢状位及横轴位 T_2WI,快速自旋回波技术序列(FRFSE);矢状面 T_1WI,反转恢复(FLAIR) T_1WI 序列。DKI 序列采用平面回波(EPI)序列。根据 T2 矢状位图像显示,将实验组分为三组:A 为单纯硬膜囊受压;B 为脊髓受压,但信号正常;C 为脊髓受压同时,T2WI 图像见高信号。DKI 扫描得到弥散各向异性分数(fractional anisotropy, FA)、平均弥散峰度(mean kurtos is, MK)的参数图和伪彩图,由 2 名影像科医师双盲法测取各参数值,取平均值后进行统计分析。

1.2.2 临床评分 采用双盲法, 由 2 名有 10 年以上临床经验的脊柱外科医生, 分别其使用以下两种评分分别对各组人员进行评估。A. 改良颈椎病疗效评定标准 mJOA 评分(modified Japanese Orthopaedic Association Scores for Assessment of Cervical Myelopathy)[10]:是由 1994 年日本骨科学会(JOA)制定的一项临床评分标准,旨在评定颈椎病患者的脊髓功能。最低分为 0 分,最高分为 4 分,分数越低代表神经功能障碍越严重。B.颈椎功能障碍指数 NDI(Neck Disability Index)评分[11]:即颈椎功能障碍指数量表,包括颈痛及相关症状、日常生活活动能力两部分,共 10 个评分项目。每个项目最低分为 0 分,最高分为 5 分,分数越高表示神经功能障碍越严重。

1.3 统计学分析

所有数据均用 " 均数士标准差 " 表示, 分析采用 SPSS 20.0 软件。各年龄组内之间数据比较,采用独立样本 t 检验;各组之间 MK 值、FA 值比较, 采用单因素方差分析(One-way ANOVA);MK 值、FA 值分别与 mJOA 值、NDI 值之间的关系,分别采用 Pearson 相关性分析;均以 P<0.05 具有统计学意义。

2 结果

2.1 各组 mJOA 与 NDI 评分的比较

所有志愿者和受检者的图像均满足诊断要求。30 名志愿者颈髓形态完整、信号均匀,MRI 图像无异常,mJOA 值均为满分 17 分; 相关症状均无异常,NDI 值均为 0 分。实验各组(A、B、C 组) 名患者均伴不同程度临床症状,mJOA 与 NDI 评分情况见表 1。

表 1 志愿者和实验组的 mJOA 与 NDI 评分($\bar{x}\pm s$)

Table 1 mJOA and NDI scores of healthy people, group A, Group B and group C($\bar{x}\pm s$)

Groups	Amount(n)	mJOA scores	ND scores
healthy people	30	17	0
Group A	12	15.09± 0.04	4.77± 0.43
Group B	17	12.15± 0.56	12.54± 0.17
Group C	8	7.68± 0.31	26.73± 0.36

Note: compared with the group A, Group B and group C. P<0.05.

2.2 不同年龄志愿者组颈髓平均 FA 值、MK 值的比较

本研究中,志愿者组不同年龄组间的颈髓平均 FA 值、MK 值比较差异均无统计学意义(P>0.05),见表 2。

2.3 志愿者组、实验各组(A、B、C)的 FA 值、MK 值比较

志愿者组与实验各组的 MK 值三者之间差异有统计学意义(F=61.34, P<0.05);志愿者组与实验各组平均 FA 值三者之间差异有统计学意义(P=<0.05)。进一步分析组间两两差异:志愿者组与实验 A 组比较,MK 值和 FA 值差异无统计学意义(P>0.05);与 B、C 组及 A、B、C 组间比较,MK 值、FA 值差异均有统计学意义。实验组内比较 MK 值:A>B>C 组;FA 值 A>B>C 组;差异均有统计学意义(P<0.05,表 3)。

表 2 志愿者组内不同年龄间颈髓平均 FA 值、MK 值差异性比较($\bar{x}\pm s$)

Table 2 The comparison of cervical spinal average FA and MK values in healthy people with different age($\bar{x}\pm s$)

	Groups	Amount(n)	Parameter values	F values	*P* values
FA	group a	8	0.62± 0.45	0.35	＞0.05
	group b	12	0.71± 0.18		
	group c	10	0.69± 0.27		
MK	group a	8	0.86± 0.14	0.41	＞0.05
	group b	12	0.87± 0.07		
	group c	10	0.81± 0.47		

2.4 FA 值、MK 值与 mJOA、NDI 评分的相关性分析

实验组脊髓损伤程度与各临床评分具有相关性，且有统计学意义(图 1，P<0.05)。FA 值与 mJOA 评分正相关(r=0.34)，与 NDI 评分负相关 (r=-0.38)；MK 值与 mJOA 评分正相关(r=0.67)，与 NDI 评分负相关(r=-0.46)。

3 讨论

CSM 好发于中老年人群，其发病基础是椎体骨质增生、椎间盘退变及外伤等因素[3, 12-14]。近年来，随着人们生活习惯的改变，CSM 发病呈现出年轻化趋势[2, 15]。MRI 能够较好地显示脊

表 3 志愿者组、实验各组(A、B、C)的 FA 值、MK 值差异性比较

Table 3 The comparison of average FA and MK values among healthy people, group A, B and C

	Groups	Amount(n)	Parameter values	F values	*P* values
FA	healthy people	30	0.63 ± 0.21	61.34*	＜0.05
	group A	12	0.62 ± 0.13		
	group B	17	0.64 ± 0.01		
	group C	8	0.58 ± 0.80		
MK	healthy people	30	0.77 ± 0.29	26.48*	＜0.05
	group A	12	0.62± 0.29		
	group B	17	0.78± 0.32		
	group C	8	0.69 ± 0.19		

Note: healthy people compared with the group A, Group B and group C, P<0.05.

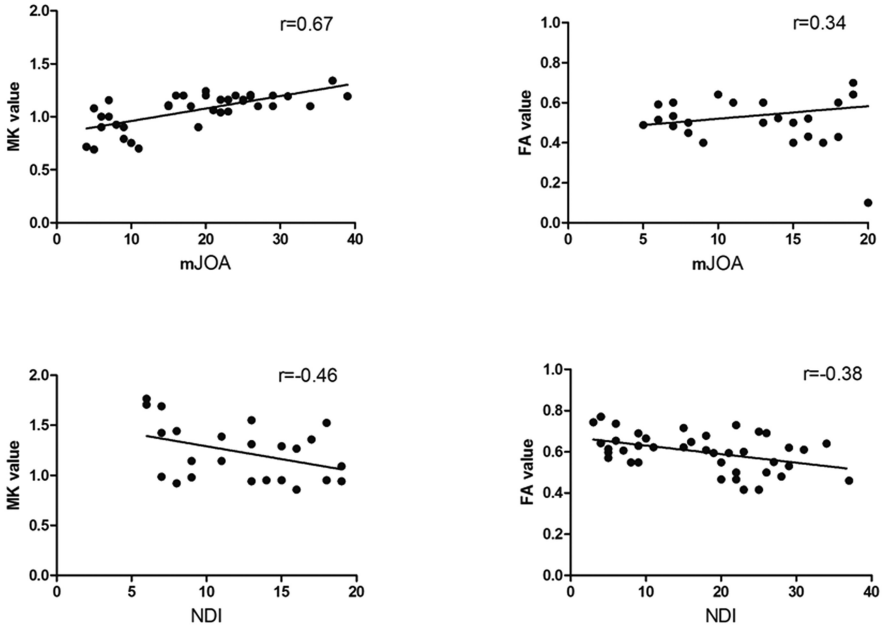

图 1 各实验组 FA 值、MK 值与 mJOA、NDI 评分的相关性分析

Fig.1 The pairwise correlation analysis between MK value, FA value and mJOA, value NDI value

Note: Data were expressed as ($\bar{x}\pm s$).

髓病变的形态学及部分信号改变,但缺乏一定的准确度,不能早期、准确地评估脊髓的损伤程度,且缺乏客观的诊断标准[16-18]。DKI 技术作为一种新的无创、特异性强的检查手段,在疾病的诊断、疗效评估和预后估计等方面起到了重要作用,尤其在脑部各种疾病的应用,受到国内外诸多学者的广泛关注,相关研究报道也较多[19-21]。但在脊髓的应用报道相对较少。Raz 等[22]认为 DKI 能在分子水平反映出轴突和髓鞘的损伤及再修复过程,有利于更准确地了解其特征及发展规律。

本研究中,30 名志愿者的颈髓形态完整、信号均匀,无临床症状。各年龄组间颈髓平均 FA 值、MK 值差异性无统计学意义。实验组患者共 37 名,A 组和 B 组患者在 T_2WI 上显示受压层面颈髓信号无异常;A 组的 FA 值、MK 值均与志愿者组想要参数值差异无统计学意义,说明脊髓结构完整、白质纤维束未破坏[11]。而 B 组的局部脊髓压层面 FA 值、MK 值与对照组差异均有统计学意义;可能是由于脊髓受压后,内部水分子扩散受限后各项异性发生变化,表明 DKI 参数值可以敏感的反映脊髓损伤的早期变化[4, 6]。C 组与对照组及 A 组、B 组各组之间 FA 值、MK 值差异均具有统计学意义,而且 MK 值与 FA 值较 B 组更低,表明颈髓损伤程度严重。本研究所测参数值与以往研究略有不同[22-24],可能与研究样本量大小、DKI 序列参数设置以及 ROI 的选取等因素有关。

有研究显示[25]脊髓损伤时细胞膜破坏会引起血管源性水肿,能导致细胞外水分子极性发生改变,可表现为 FA 值降低。Deo 等[26]建立大鼠脊髓损伤模型,发现随着时间的延长,MK 值逐渐降低,说明 MK 值与脊髓组织损伤及恢复过程相关。另有学者研究发现[24]CSM 患者病变处灰质 MK 值明显降低,可能与非特异性炎性及缺血等因素有关。本研究与上述研究结果相近,表明 DKI 参数能在常规 T_2WI 尚未出现异常信号之前,可检测出颈髓的早期的损伤情况,为临床早期诊断、早期治疗争取时机,从而提高患者预后效果。

本研究结果表明随着 MK 及 FA 值的降低,mJOA 评分呈递减趋势、NDI 评分呈增高趋势,表明颈髓病变程度越高,患者的神经功能障碍越明显。这表明在脊髓损伤程度与相应临床症状严重程度,可以被 FA 值、MK 值敏感反映出来[27-29]。还有学者研究 CSM 患者治疗前后的 FA 值、MK 值情况,以便评估 CSM 患者预后的神经功能及恢复情况[28, 30],结果显示脊髓损伤程度与 FA 值和 MK 值均呈负性相关。尽管 DKI 在脊髓病变研究相对较少,但可在一定程度上判断患者神经功能状况,为早期诊断及预后评估提供一定参考。

本研究中,样本量相对较少,参数测量值可能存在选择偏移,在以后的研究中将增加样本量。由于颈髓周围结构、呼吸运动等因素的影响,图像质量欠佳,并且扫描时间相对较长;以后研究中还需进一步优化 DKI 序列。本研究未能将脊髓灰质和白质区分测量,DKI 参数值未能完全展示脊髓各微观结构的分子状态,以后将进一步细化、深入研究。

综上所述,随着 MK、FA 值的降低,表面颈髓病变程度越高,患者的各项神经功能障碍越明显,预后也会相对较差。DKI 参数能够评估早期 CSM 患者的脊髓损伤情况,可为相关疾病诊断和研究提供参考,并在评估脊髓损伤程度及判断预后方面应用价值,可能是今后的研究热点。

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