

· 诊治分析 ·

弥散加权成像和灌注加权成像在超急性期脑梗死诊断及预后评估中的应用价值



扫描二维码
查看原文

王朝刚, 张晓曼, 李兆妍, 徐远杰, 范建江

【摘要】 目的 分析弥散加权成像 (DWI) 和灌注加权成像 (PWI) 在超急性期脑梗死诊断及预后评估中的应用价值。**方法** 选取2020年4月至2021年3月郑州市第一人民医院收治的78例行溶栓治疗的超急性期脑梗死 (脑梗死发病时间 <6 h) 患者作为超急性期组, 45例未行溶栓治疗的急性期脑梗死 (脑梗死发病时间为6 h~3 d) 患者作为急性期组, 33例未行溶栓治疗的亚急性期脑梗死 (脑梗死发病时间为4 d~3周) 患者作为亚急性期组。比较三组患者梗死区DWI、PWI检查指标 [表观弥散系数 (ADC)、局部脑血容量 (rCBV)、局部脑血流量 (rCBF)、平均通过时间 (MTT)、达峰时间 (TTP)] ; 比较超急性期组溶栓治疗前后、不同预后患者梗死区DWI、PWI检查指标; 比较超急性期组DWI-PWI匹配与DWI-PWI不匹配患者溶栓治疗后15 d美国国立卫生研究院卒中量表 (NIHSS) 评分、溶栓治疗后3个月预后。绘制ROC曲线以评价梗死区DWI、PWI检查指标对超急性期脑梗死的诊断价值及对超急性期脑梗死患者预后的预测价值。**结果** 急性期组和亚急性期组患者梗死区ADC、rCBV、rCBF大于超急性期组, 梗死区MTT、TTP短于超急性期组; 亚急性期组患者梗死区ADC、rCBV、rCBF大于急性期组, 梗死区MTT、TTP短于急性期组 ($P<0.05$)。溶栓治疗后, 超急性期组患者梗死区ADC、rCBV、rCBF大于溶栓治疗前, 梗死区MTT、TTP短于溶栓治疗前 ($P<0.05$)。溶栓治疗后3个月, 超急性期组预后良好患者38例, 预后不良患者40例。超急性期组预后良好患者梗死区ADC、rCBV、rCBF大于预后不良患者, MTT、TTP短于预后不良患者 ($P<0.05$)。超急性期组DWI-PWI匹配患者30例, DWI-PWI不匹配患者48例。超急性期组DWI-PWI不匹配患者溶栓治疗后15 d NIHSS评分低于DWI-PWI匹配患者, 预后优于DWI-PWI匹配患者 ($P<0.05$)。梗死区ADC、rCBV、rCBF、MTT、TTP诊断超急性期脑梗死的AUC分别为0.841 [95%CI (0.780, 0.903)]、0.859 [95%CI (0.803, 0.916)]、0.873 [95%CI (0.821, 0.926)]、0.725 [95%CI (0.646, 0.804)]、0.783 [95%CI (0.711, 0.855)]。梗死区ADC、rCBV、rCBF、MTT、TTP预测超急性期脑梗死患者预后的AUC分别为0.860 [95%CI (0.777, 0.943)]、0.815 [95%CI (0.721, 0.909)]、0.826 [95%CI (0.732, 0.920)]、0.673 [95%CI (0.552, 0.795)]、0.677 [95%CI (0.556, 0.798)]。**结论** 梗死区ADC、rCBV、rCBF对超急性期脑梗死具有一定诊断价值, 对超急性期脑梗死患者预后具有一定预测价值; 且DWI-PWI不匹配患者溶栓治疗效果、预后更好。

【关键词】 脑梗死; 灌注加权成像; 弥散加权成像; 诊断; 预后

【中图分类号】 R 743.33 **【文献标识码】** A DOI: 10.12114/j.issn.1008-5971.2022.00.318

王朝刚, 张晓曼, 李兆妍, 等. 弥散加权成像和灌注加权成像在超急性期脑梗死诊断及预后评估中的应用价值 [J]. 实用心脑血管病杂志, 2022, 30 (12): 100-105. [www.syxnf.net]

WANG C G, ZHANG X M, LI Z Y, et al. Application value of diffusion weighted imaging and perfusion weighted imaging in the diagnosis and prognosis evaluation of hyperacute cerebral infarction [J]. Practical Journal of Cardiac Cerebral Pneumal and Vascular Disease, 2022, 30 (12): 100-105.

Application Value of Diffusion Weighted Imaging and Perfusion Weighted Imaging in the Diagnosis and Prognosis Evaluation of Hyperacute Cerebral Infarction WANG Chaogang, ZHANG Xiaoman, LI Zhaoyan, XU Yuanjie, FAN Jianjiang

Department of Neurological, Zhengzhou First People's Hospital, Zhengzhou 450004, China

Corresponding author: ZHANG Xiaoman, E-mail: zhangxiaoman2@163.com

【Abstract】 Objective To analyze the application value of perfusion weighted imaging (PWI) and diffusion weighted imaging (DWI) in the diagnosis and prognosis evaluation of hyperacute cerebral infarction. **Methods** From April 2020 to March 2021, 78 patients with hyperacute cerebral infarction (onset time of cerebral infarction <6 h) who underwent thrombolytic therapy

基金项目: 河南省医学科技攻关计划 (联合共建) 项目 (LHGJ20190985)

450004河南省郑州市第一人民医院神经内科

通信作者: 张晓曼, E-mail: zhangxiaoman2@163.com

in Zhengzhou First People's Hospital were selected as the hyperacute phase group, 45 patients with acute cerebral infarction (onset time of cerebral infarction was 6 h–3 d) who did not receive thrombolytic therapy were selected as the acute phase group, and 33 patients with subacute cerebral infarction (onset time of cerebral infarction was 4 d–3 weeks) who did not receive thrombolytic therapy were selected as the subacute phase group. The examination indexes of DWI and PWI of infarct size [apparent dispersion coefficient (ADC), regional cerebral blood volume (rCBV), regional cerebral blood flow (rCBF), mean transit time (MTT), time to peak (TTP)] were compared among the three groups. In the hyperacute group, DWI and PWI examination indexes of infarct size before and after thrombolytic therapy, DWI and PWI examination indexes in patients with different prognosis were compared. The National Institutes of Health Stroke Scale (NIHSS) score at 15 days after thrombolytic therapy and the prognosis 3 months after thrombolytic therapy were compared between DWI–PWI matched patients and DWI–PWI mismatched patients in the hyperacute phase group. ROC curve was drawn to evaluate the diagnostic value of DWI and PWI examination indexes of infarct size for hyperacute cerebral infarction and the predictive value of DWI and PWI examination indexes of infarct size for prognosis in patients with hyperacute cerebral infarction. **Results** ADC, rCBV and rCBF of infarct size in the acute phase group and the subacute phase group were larger than those in the hyperacute phase group, the MTT and TTP of infarct size were shorter than those in the hyperacute phase group. ADC, rCBV and rCBF of infarct size in the subacute group were higher than those in the acute phase group, MTT and TTP of infarction size were shorter than those in acute phase group ($P < 0.05$). In the hyperacute group, ADC, rCBV and rCBF of infarct size after thrombolytic therapy were larger than those before thrombolytic therapy, and the MTT and TTP of infarct size were shorter than those before thrombolytic therapy ($P < 0.05$). Three months after thrombolytic therapy, there were 38 patients with good prognosis and 40 patients with poor prognosis in the hyperacute group. In hyperacute phase group, ADC, rCBV and rCBF of infarct size in patients with good prognosis were higher than those in patients with poor prognosis, MTT and TTP were shorter than those in patients with poor prognosis ($P < 0.05$). There were 30 DWI–PWI matched patients and 48 DWI–PWI mismatched patients in hyperacute phase group. In hyperacute phase group, the NIHSS score at 15 days after thrombolytic therapy of DWI–PWI mismatched patients was lower than that of DWI–PWI matched patients, and the prognosis was better than that of DWI–PWI matched patients ($P < 0.05$). The AUC of ADC, rCBV, rCBF, MTT and TTP of infarct size for diagnosing hyperacute cerebral infarction was 0.841 [95%CI (0.780, 0.903)], 0.859 [95%CI (0.803, 0.916)], 0.873 [95%CI (0.821, 0.926)], 0.725 [95%CI (0.646, 0.804)], 0.783 [95%CI (0.711, 0.855)], respectively. The AUC of ADC, rCBV, rCBF, MTT and TTP of infarct size in predicting the prognosis of patients with hyperacute cerebral infarction was 0.860 [95%CI (0.777, 0.943)], 0.815 [95%CI (0.721, 0.909)], 0.826 [95%CI (0.732, 0.920)], 0.673 [95%CI (0.552, 0.795)], 0.677 [95%CI (0.556, 0.798)], respectively. **Conclusion** ADC, rCBV and rCBF of infarct size have certain diagnostic value for hyperacute cerebral infarction, and have certain predictive value for the prognosis of patients with hyperacute cerebral infarction. The effect of thrombolytic therapy and prognosis are better in DWI–PWI mismatched patients.

【Key words】 Cerebral infarction; Perfusion weighted imaging; Diffusion weighted imaging; Diagnosis; Prognosis

脑梗死是中老年人群的常见脑血管疾病,其发病率约为110/10万,致残率高达50%以上^[1-2]。目前,溶栓治疗是临床上公认的治疗脑梗死的有效方案,且脑梗死发病3~6 h内给予溶栓治疗可最大限度地改善脑供血,抢救缺血半暗带,从而改善患者神经功能,减少残疾的发生^[3];但发病时间>6 h的脑梗死患者不主张进行溶栓治疗^[4]。因此,脑梗死的早期诊断与治疗直接影响到患者的预后。研究表明,脑梗死发病后6 h内,颅脑CT检查显示脑组织密度无明显变化,脑梗死发病48 h后CT检查才发现边界不清楚的低密度影,此时已经发展为不可逆的脑梗死^[5-6]。目前研究认为,MRI在诊断超急性期脑梗死时更有优势,灌注加权成像(perfusion weighted imaging, PWI)、弥散加权成像(diffusion weighted imaging, DWI)能准确区分大脑软组织和血管^[7],且DWI–PWI不匹配提示患者存在缺血半暗带^[8]。目前,脑梗死不同时期的DWI和PWI定量参数变化尚存在争议。本研究旨在探讨DWI联合PWI在脑梗死早期诊断及溶栓治疗中的应用价值,现报道如下。

1 对象与方法

1.1 纳入与排除标准 纳入标准:(1)符合脑梗死的诊断标准^[9];(2)年龄≤75岁;(3)影像学资料完整。排除标准:(1)有急性出血倾向者;(2)近3个月内有颅内出血、颅脑外伤史者;(3)近3个月内有心肌梗死史者;(4)合并严重肝肾功能不全者;(5)既往有精神疾病史者。

1.2 研究对象 选取2020年4月至2021年3月郑州市第一人民医院收治的78例行溶栓治疗的超急性期脑梗死(脑梗死发病时间<6 h)患者作为超急性期组,45例未行溶栓治疗的急性期脑梗死(脑梗死发病时间为6 h~3 d)患者作为急性期组,33例未行溶栓治疗的亚急性期脑梗死(脑梗死发病时间为4 d~3周)患者作为亚急性期组。三组患者性别、年龄、体质指数及美国国立卫生研究院卒中量表(National Institutes of Health Stroke Scale, NIHSS)评分比较,差异无统计学意义($P > 0.05$),见表1。本研究符合《赫尔辛基宣言》原则,经郑州市第一人民医院伦理委员会审核通过(编号:20200106),所有患者对本研究知情同意并自愿参加。

表1 三组患者一般资料比较

Table 1 Comparison of general information among the three groups

组别	例数	性别 (男/女)	年龄 ($\bar{x} \pm s$, 岁)	体质指数 ($\bar{x} \pm s$, kg/m ²)	NIHSS评分 ($\bar{x} \pm s$, 分)
超急性期组	78	43/35	62.4 ± 6.0	22.9 ± 1.6	12.6 ± 3.1
急性期组	45	24/21	63.4 ± 5.4	22.5 ± 1.5	12.8 ± 3.1
亚急性期组	33	18/15	64.1 ± 6.1	22.7 ± 1.6	12.2 ± 3.1
$F(\chi^2)$ 值		0.037 ^a	0.979	0.684	0.465
P 值		0.982	0.378	0.506	0.629

注：^a表示 χ^2 值；NIHSS=美国国立卫生研究院卒中量表

1.3 检查方法

1.3.1 仪器设备 MAGNETOM Spectra 3.0 T磁共振成像仪购自德国西门子公司，采用16通道相控正交表面线圈。

1.3.2 扫描序列 T1加权像 (T1 weighted image, T1WI) 扫描参数：采用自旋回波序列，TR 547 ms，TE 7.8 ms，层厚3 mm，层距0.3 mm，FOV 160 mm × 249 mm，采集矩阵200 × 240，采集次数2次。T2加权像 (T2 weighted image, T2WI) 扫描参数：采用快速自旋回波序列，TR 3 000 ms，TE 95 ms，层厚3 mm，层距0.3 mm，FOV 160 mm × 249 mm，采集矩阵200 × 240，FS-Fat Saturation压脂技术，采集次数2次。DWI扫描参数：采用自旋回波-回波平面序列，TR 5 200 ms，TE 113 ms，层厚6 mm，层距0.6 mm，FOV 160 mm × 249 mm，采集矩阵200 × 240，采集次数2次。PWI扫描参数：对比剂为钆喷酸葡胺，采用团注法进行肘静脉注射，0.15 ml/kg，注射速度3 ml/s。

1.3.3 图像处理 在德国西门子公司Syngo工作站，将数据导入MRI Viewer软件进行后处理，由2名中级以上职称的影像学医师独立阅片。对DWI数据处理后可得到表观弥散系数 (apparent dispersion coefficient, ADC) 图，计算ADC。PWI数据处理后可得到时间-浓度曲线及局部脑血容量 (regional cerebral blood volume, rCBV) 图，计算rCBV、局部脑血流量 (regional cerebral blood flow, rCBF)、平均通过时间 (mean transit time, MTT)、达峰时间 (time to peak, TTP)。

1.4 观察指标 (1) 观察三组患者梗死区DWI特点，比较其梗死区DWI、PWI检查指标。(2) 比较超急性期组溶栓治疗前后、不同预后患者DWI、PWI检查指标；溶栓治疗后3个月评估患者预后，分为痊愈/康复良好、残疾、死亡，其中痊

愈/康复良好为预后良好、残疾和死亡为预后不良。(3) 比较超急性期组DWI-PWI匹配与DWI-PWI不匹配患者溶栓治疗后15 d NIHSS评分、溶栓治疗后3个月预后。DWI-PWI不匹配定义：DWI显示缺血核心病灶，PWI显示缺血核心病灶+缺血半暗带，DWI病灶容积<70 ml，且PWI病灶容积为DWI病灶容积的1.8倍以上，或PWI病灶容积-DWI病灶容积>15 ml。

1.5 统计学方法 使用SPSS 22.0统计学软件进行数据处理。符合正态分布的计量资料以($\bar{x} \pm s$)表示，多组间比较采用单因素方差分析，组间两两比较采用 q 检验；两组间比较采用成组 t 检验，溶栓治疗前后比较采用配对 t 检验；计数资料以[n(%)]表示，组间比较采用 χ^2 检验。绘制ROC曲线以评价DWI、PWI检查指标对超急性期脑梗死的诊断价值及对超急性期脑梗死患者预后的预测价值。以 $P < 0.05$ 为差异有统计学意义。

2 结果

2.1 三组患者梗死区DWI特点及DWI、PWI检查指标比较 超急性期组梗死区DWI显示豆状核内囊与胼胝体呈显著高信号，ADC图呈显著低信号，见图1A；急性期组梗死区DWI显示放射冠呈椭圆高信号，ADC图呈低信号，见图1B；亚急性期组梗死区DWI显示额颞顶叶呈大片扇形稍低信号，ADC图呈等或高信号，见图1C。三组患者梗死区ADC、rCBV、rCBF、MTT、TTP比较，差异有统计学意义($P < 0.05$)；急性期组和亚急性期组梗死区ADC、rCBV、rCBF大于超急性期组，梗死区MTT、TTP短于超急性期组，差异有统计学意义($P < 0.05$)；亚急性期组梗死区ADC、rCBV、rCBF大于急性期组，梗死区MTT、TTP短于急性期组，差异有统计学意义($P < 0.05$)，见表2。

2.2 超急性期组患者溶栓治疗前后梗死区DWI、PWI检查指标比较 溶栓治疗后，超急性期组患者梗死区ADC、rCBV、rCBF大于溶栓治疗前，梗死区MTT、TTP短于溶栓治疗前，差异有统计学意义($P < 0.05$)，见表3。

2.3 超急性期组不同预后患者梗死区DWI、PWI检查指标比较 溶栓治疗后3个月，超急性期组预后良好患者38例，预后不良患者40例 (其中残疾38例、死亡2例)。超急性期组预后良好患者梗死区ADC、rCBV大于预后不良患者，rCBF快于预后不良患者，MTT、TTP短于预后不良患者，差异有统计学意义($P < 0.05$)，见表4。

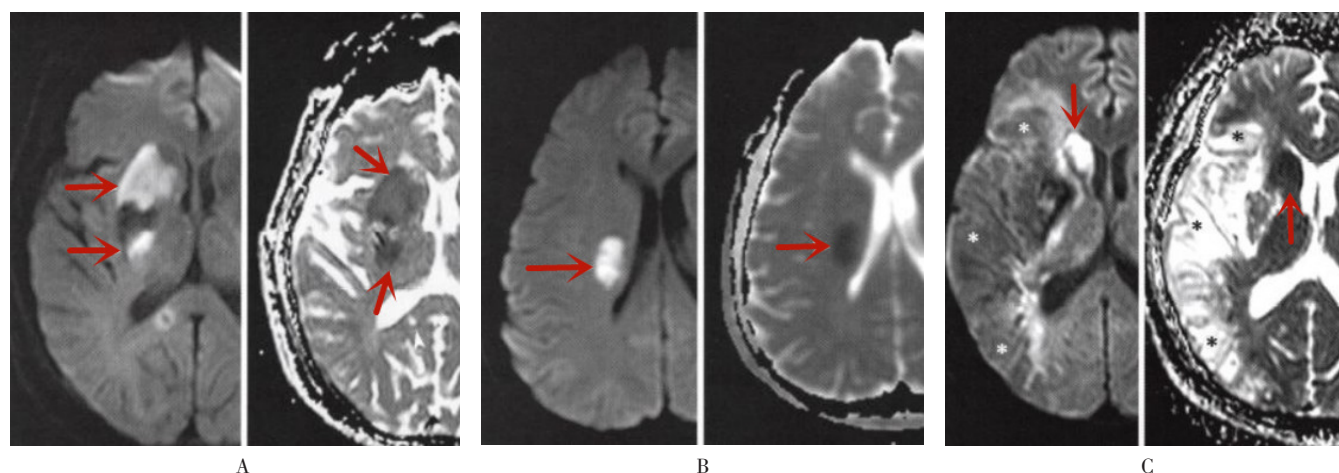
2.4 超急性期组DWI-PWI匹配与DWI-PWI不匹配患者溶栓治

表2 三组患者梗死区DWI、PWI检查指标比较 ($\bar{x} \pm s$)

Table 2 Comparison of examination indicators of DWI and PWI of infarct size among the three groups

组别	例数	ADC	rCBV (ml)	rCBF (ml/min)	MTT (s)	TTP (s)
超急性期组	78	0.38 ± 0.10	27.63 ± 6.90	3.02 ± 0.75	4.49 ± 1.12	13.25 ± 3.31
急性期组	45	0.62 ± 0.15 ^a	32.05 ± 8.11 ^a	3.65 ± 0.91 ^a	4.02 ± 1.01 ^a	11.50 ± 2.87 ^a
亚急性期组	33	1.23 ± 0.31 ^{ab}	39.42 ± 9.75 ^{ab}	4.20 ± 1.05 ^{ab}	3.48 ± 0.87 ^{ab}	9.84 ± 2.45 ^{ab}
F 值		265.158	25.895	23.133	11.347	15.704
P 值		<0.001	<0.001	<0.001	<0.001	<0.001

注：ADC=表观弥散系数，rCBV=局部脑血容量，rCBF=局部脑血流量，MTT=平均通过时间，TTP=达峰时间；^a表示与超急性期组比较， $P < 0.05$ ；^b表示与急性期组比较， $P < 0.05$



注: A为超急性期组, 左侧为弥散加权成像 (DWI), 显示豆状核内囊与胼胝体呈显著高信号; 右侧为表现弥散系数 (ADC) 图, 呈显著低信号。B为急性期组, 左侧为DWI, 显示放射冠呈椭圆高信号; 右侧为ADC图, 呈低信号。C为亚急性期组, 左侧为DWI, 显示额颞顶叶呈大片扇形稍低信号; 右侧为ADC图, 呈高信号

图1 三组患者梗死区DWI特点

Figure 1 DWI features of infarct zones of the three groups

表3 超急性期组患者溶栓治疗前后梗死区DWI、PWI检查指标比较 ($\bar{x} \pm s$, $n=78$)

Table 3 Comparison of examination indexes of DWI and PWI of infarct zone before and after thrombolytic therapy in hyperacute group

时间	ADC	rCBV (ml)	rCBF (ml/min)	MTT (s)	TTP (s)
溶栓治疗前	0.38 ± 0.10	27.63 ± 6.90	3.02 ± 0.75	4.49 ± 1.12	13.25 ± 3.31
溶栓治疗后	1.01 ± 0.25	47.38 ± 11.75	5.02 ± 1.26	3.78 ± 0.94	10.26 ± 2.56
$t_{\text{配对}}$ 值	31.794	18.705	17.576	6.088	8.997
P值	<0.001	<0.001	<0.001	<0.001	<0.001

表4 超急性期组不同预后患者梗死区DWI、PWI检查指标比较 ($\bar{x} \pm s$)

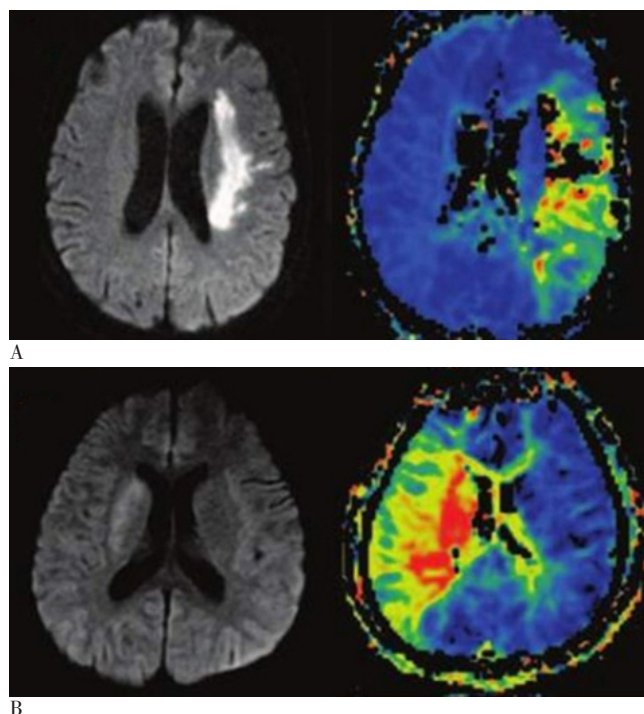
Table 4 Comparison of examination indexes of DWI and PWI of infarct zone in patients with different prognosis in hyperacute group

预后	例数	ADC	rCBV (ml)	rCBF (ml/min)	MTT (s)	TTP (s)
预后良好	38	0.49 ± 0.13	31.12 ± 7.78	3.45 ± 0.86	4.10 ± 1.02	12.03 ± 3.03
预后不良	40	0.28 ± 0.07	24.31 ± 6.08	2.61 ± 0.65	4.86 ± 1.21	14.41 ± 3.60
t 值		8.944	4.319	4.882	2.991	3.151
P值		<0.001	<0.001	<0.001	0.004	0.002

疗后15 d NIHSS评分及预后比较 超急性期组DWI-PWI匹配患者30例, DWI-PWI不匹配患者48例, 超急性期组DWI-PWI匹配与DWI-PWI不匹配患者的影像学检查结果见图2。超急性期组DWI-PWI不匹配患者溶栓治疗后15 d NIHSS评分低于DWI-PWI匹配患者, 预后优于DWI-PWI匹配患者, 差异有统计学意义 ($P < 0.05$), 见表5。

2.5 梗死区DWI、PWI检查指标对超急性期脑梗死的诊断价值 ADC、rCBV、rCBF、MTT、TTP诊断超急性期脑梗死的AUC分别为0.841 [95%CI (0.780, 0.903)]、0.859 [95%CI (0.803, 0.916)]、0.873 [95%CI (0.821, 0.926)]、0.725 [95%CI (0.646, 0.804)]、0.783 [95%CI (0.711, 0.855)], 见图3、表6。

2.6 梗死区DWI、PWI检查指标对超急性期脑梗死患者预后的



注: A为DWI-弥散加权成像 (PWI) 匹配, 左侧为DWI, 右侧为PWI; B为DWI-PWI不匹配, 左侧为DWI, 右侧为PWI

图2 超急性期组DWI-PWI匹配与DWI-PWI不匹配患者的影像学检查结果

Figure 2 Imaging findings of DWI-PWI matched and DWI-PWI mismatched patients in hyperacute group

预测价值 ADC、rCBV、rCBF、MTT、TTP预测超急性期脑梗死患者预后的AUC分别为0.860 [95%CI (0.777, 0.943)]、0.815 [95%CI (0.721, 0.909)]、0.826 [95%CI (0.732, 0.920)]、0.673 [95%CI (0.552, 0.795)]、0.677 [95%CI (0.556, 0.798)], 见图4、表7。

3 讨论

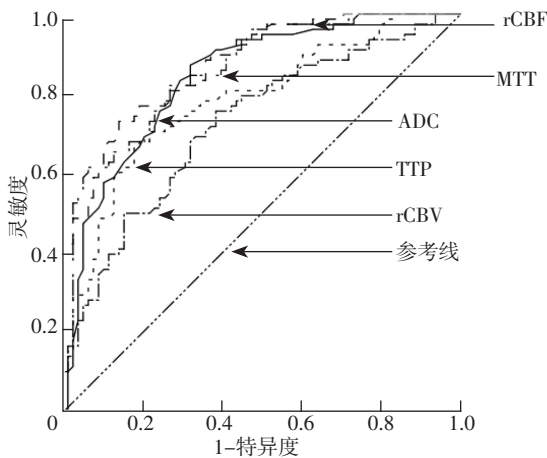
脑梗死溶栓治疗的病理生理学机制是挽救缺血半暗带, 一

表5 超急性期组DWI-PWI匹配与DWI-PWI不匹配患者溶栓治疗后15 dNIHSS评分及预后比较

Table 5 Comparison of NIHSS score after thrombolytic therapy and prognosis between DWI-PWI matched and DWI-PWI mismatched patients in hyperacute group

DWI-PWI 匹配情况	例数	溶栓治疗后15 d NIHSS评分 ($\bar{x} \pm s$, 分)	预后 [n (%)]		
			痊愈/康复良好	残疾	死亡
匹配	30	5.8 ± 1.4	10 (33.3)	18 (60.0)	2 (6.7)
不匹配	48	3.7 ± 0.9	28 (58.3)	20 (41.7)	0
t (Z) 值		8.023		2.343 ^a	
P值		<0.001		0.019	

注：^a表示Z值



注：ADC=表观弥散系数，rCBV=局部脑血容量，rCBF=局部脑血流量，MTT=平均通过时间，TTP=达峰时间

图3 梗死区DWI、PWI检查指标诊断超急性期脑梗死的ROC曲线

Figure 3 ROC curve of examination indexes of DWI and PWI of infarct size for diagnosing hyperacute cerebral infarction

表6 DWI、PWI检查指标对超急性期脑梗死的诊断价值

Table 6 Value of examination indexes of DWI and PWI of infarct size in diagnosing hyperacute cerebral infarction

指标	AUC	95%CI	最佳截断值	灵敏度 (%)	特异度 (%)	约登指数
ADC	0.841	(0.780, 0.903)	0.47	87.18	67.95	0.551
rCBV	0.859	(0.803, 0.916)	30.89 ml	82.05	71.79	0.538
rCBF	0.873	(0.821, 0.926)	3.38 ml/min	73.08	85.90	0.590
MTT	0.725	(0.646, 0.804)	4.25 s	75.64	61.54	0.372
TTP	0.783	(0.711, 0.855)	12.30 s	70.51	78.21	0.487

般认为在不可逆梗死灶周围存在未完全梗死的缺血半暗带，脑梗死发病后3~6 h内进行溶栓治疗可以挽救缺血半暗带，恢复其血流灌注，改善神经功能，减少偏瘫的发生^[10-11]。但如果脑梗死发病时间>6 h，则缺血半暗带神经元将发生凋亡。

DWI在中枢神经系统疾病中的应用较为广泛，其原理是不同组织中水分子弥散梯度存在差异，表现为DWI信号强度差异。脑梗死早期，血-脑脊液屏障受损，能量代谢被破坏，水钠转运离子泵发生障碍，脑细胞从细胞外间隙吸收大量水分，进而导致细胞内外水分子弥散特征改变，梗死灶水分子弥散受限，ADC降低，DWI表现为显著高信号^[12-13]，本研

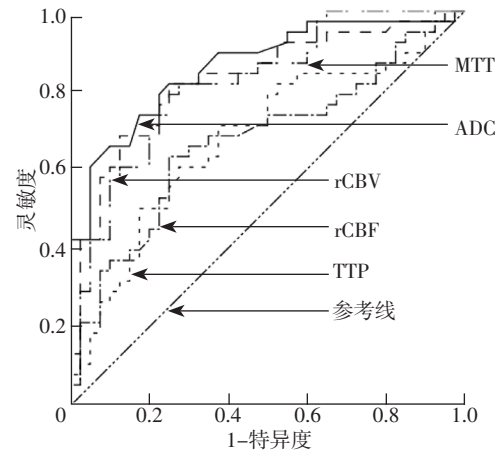


图4 DWI、PWI检查指标预测超急性期脑梗死患者预后的ROC曲线
Figure 4 ROC curve of examination indexes of DWI and PWI in predicting prognosis of patients with hyperacute cerebral infarction

表7 DWI、PWI检查指标对超急性期脑梗死患者预后的预测价值

Table 7 Value of examination indexes of DWI and PWI in predicting prognosis of patients with hyperacute cerebral infarction

指标	AUC	95%CI	最佳截断值	灵敏度 (%)	特异度 (%)	约登指数
ADC	0.860	(0.777, 0.943)	0.38	81.58	75.00	0.566
rCBV	0.815	(0.721, 0.909)	26.86 ml	81.58	72.50	0.541
rCBF	0.826	(0.732, 0.920)	2.83 ml/min	81.58	72.50	0.541
MTT	0.673	(0.552, 0.795)	4.31 s	65.79	70.00	0.358
TTP	0.677	(0.556, 0.798)	13.03 s	71.05	62.50	0.336

究结果与其一致。既往研究表明，DWI鉴别诊断超急性期与急性期脑梗死的灵敏度为88%~100%、特异度为85%~100%，优于常规T1WI、T2WI，故DWI可作为诊断超急性期脑梗死的必查序列^[14-15]。本研究结果显示，ADC诊断超急性期脑梗死的AUC为0.841，最佳截断值为0.47，其灵敏度为87.18%、特异度为67.95%；ADC预测超急性期脑梗死患者预后的AUC为0.860 [95%CI (0.777, 0.943)]，最佳截断值为0.38，其灵敏度为81.58%、特异度为75.00%。本研究中ADC对超急性期脑梗死的诊断价值稍低于上述研究的原因可能与统计偏倚有关。

PWI是一种功能成像技术，其利用对比剂在血管中的首过效应观察血流动力学改变，可反映组织的血流灌注情况^[16]。本研究结果显示，急性期组和亚急性期组患者梗死区rCBV、rCBF大于超急性期组，梗死区MTT、TTP短于超急性期组；亚急性期组患者梗死区rCBV、rCBF大于急性期组，梗死区MTT、TTP短于急性期组，提示超急性期脑梗死患者梗死区血容量降低、血流量增大、对比剂灌注时间延迟，与AMUKOTUWA等^[17]研究报道一致；且溶栓治疗后，超急性期组患者梗死区rCBV、rCBF大于溶栓治疗前，梗死区MTT、TTP短于溶栓治疗前，提示超急性期脑梗死患者行溶栓治疗有效^[18]。本研究结果显示，梗死区rCBV、rCBF、MTT、TTP诊断超急性期脑梗死的AUC分别为0.859、0.873、0.725、0.783，其预测超急性期脑梗死患者预后的AUC分别为0.815、0.826、0.673、0.677。

近年来,脑梗死DWI-PWI不匹配研究成为热点,一般认为DWI显示缺血核心病灶,PWI显示缺血核心病灶+缺血半暗带,DWI-PWI不匹配意味着患者存在大面积的缺血半暗带。研究发现,超急性期脑梗死患者DWI-PWI不匹配居多,随着病情进展,缺血半暗带发生动态改变,DWI-PWI逐渐匹配,提示不可逆梗死灶扩大^[19]。本研究结果显示,超急性期组DWI-PWI不匹配患者溶栓治疗后15 d NIHSS评分低于DWI-PWI匹配患者,预后优于DWI-PWI匹配患者,提示DWI-PWI不匹配的超急性期脑梗死患者溶栓治疗效果更好。

综上所述,ADC、rCBV、rCBF对超急性期脑梗死具有一定诊断价值,对超急性期脑梗死患者预后具有一定预测价值;且DWI-PWI不匹配患者溶栓治疗效果、预后更好。

作者贡献:王朝刚进行文章的构思与设计;王朝刚、张晓曼、李兆妍、徐远杰、范建江进行研究的实施与可行性分析;张晓曼、李兆妍、徐远杰进行数据收集、整理、分析;李兆妍、徐远杰、范建江进行结果分析与解释;王朝刚、张晓曼负责撰写、修订论文,负责文章的质量控制及审校,并对文章整体负责、监督管理。

本文无利益冲突。

参考文献

- [1] CAPRIO F Z, SOROND F A. Cerebrovascular disease: primary and secondary stroke prevention [J]. *Med Clin North Am*, 2019, 103 (2): 295-308. DOI: 10.1016/j.mcna.2018.10.001.
- [2] BARTHELS D, DAS H. Current advances in ischemic stroke research and therapies [J]. *Biochim Biophys Acta Mol Basis Dis*, 2020, 1866 (4): 165260. DOI: 10.1016/j.bbdis.2018.09.012.
- [3] FRÖHLICH K, MACHA K, GERNER S T, et al. Angioedema in stroke patients with thrombolysis [J]. *Stroke*, 2019, 50 (7): 1682-1687. DOI: 10.1161/STROKEAHA.119.025260.
- [4] TOYODA K, KOGA M, IGUCHI Y, et al. Guidelines for intravenous thrombolysis (recombinant tissue-type plasminogen activator), the third edition, March 2019: a guideline from the Japan Stroke Society [J]. *Neurol Med Chir (Tokyo)*, 2019, 59 (12): 449-491. DOI: 10.2176/nmc.st.2019-0177.
- [5] POTTER C A, VAGAL A S, GOYAL M, et al. CT for treatment selection in acute ischemic stroke: a code stroke primer [J]. *Radiographics*, 2019, 39 (6): 1717-1738. DOI: 10.1148/rg.2019190142.
- [6] VAGAL A, WINTERMARK M, NAEL K, et al. Automated CT perfusion imaging for acute ischemic stroke: pearls and pitfalls for real-world use [J]. *Neurology*, 2019, 93 (20): 888-898. DOI: 10.1212/WNL.00000000000008481.
- [7] 吴雅蔚,叶靖,征锦,等. IVIM-DWI与DCE-PWI在急性缺血性脑梗死中各灌注参数的相关性研究 [J]. *临床放射学杂志*, 2020, 39 (3): 596-599. DOI: 10.13437/j.cnki.jcr.2020.03.038.
- [8] 胡明辉. 灌注加权成像/弥散加权成像图像融合半定量评估缺血性脑卒中病人缺血半暗带价值分析 [J]. *安徽医药*, 2020, 24 (9): 1825-1827, 后插6. DOI: 10.3969/j.issn.1009-6469.2020.09.033.
- [9] 中国中西医结合学会神经科专业委员会. 中国脑梗死中西医结合诊治指南 (2017) [J]. *中国中西医结合杂志*, 2018, 38 (2): 136-144. DOI: 10.7661/j.cjim.20171221.483.
- [10] KAESMACHER J, OSPEL J M, MEINEL T R, et al. Thrombolysis in cerebral infarction 2b reperfusion: to treat or to stop? [J]. *Stroke*, 2020, 51 (11): 3461-3471. DOI: 10.1161/STROKEAHA.120.030157.
- [11] 陈海清,任岩,郑玉明. DWI-PWI在诊治急性脑梗死患者中的应用 [J]. *中国CT和MRI杂志*, 2021, 19 (1): 19-21, 27. DOI: 10.3969/j.issn.1672-5131.2021.01.007.
- [12] SABBEN C, DESILLES J P, CHARBONNEAU F, et al. Early successful reperfusion after endovascular therapy reduces malignant middle cerebral artery infarction occurrence in young patients with large diffusion-weighted imaging lesions [J]. *Eur J Neurol*, 2020, 27 (10): 1988-1995. DOI: 10.1111/ene.14330.
- [13] 陈庆华,王向明,方权,等. DWI在MCA区急性脑梗死患者诊断中的应用价值 [J]. *医学影像学杂志*, 2019, 29 (12): 2015-2018.
- [14] 曹晓轩,宗素英,白秀艳,等. 磁共振弥散加权成像对急性脑梗死的诊断作用及优于MRI常规检查特征 [J]. *中国CT和MRI杂志*, 2020, 18 (7): 22-25.
- [15] KHOURY N, DARGAZANLI C, GUENEGO A, et al. Visual assessment of diffusion weighted imaging infarct volume lacks accuracy and reliability [J]. *J Neurointerv Surg*, 2019, 11 (9): 947-954. DOI: 10.1136/neurintsurg-2018-014613.
- [16] DANGOULOFF-ROS V, VARLET P, LEVY R, et al. Imaging features of medulloblastoma: conventional imaging, diffusion-weighted imaging, perfusion-weighted imaging, and spectroscopy: from general features to subtypes and characteristics [J]. *Neurochirurgie*, 2021, 67 (1): 6-13. DOI: 10.1016/j.neuchi.2017.10.003.
- [17] AMUKOTUWA S, STRAKA M, AKSOY D, et al. Cerebral blood flow predicts the infarct core: new insights from contemporaneous diffusion and perfusion imaging [J]. *Stroke*, 2019, 50 (10): 2783-2789. DOI: 10.1161/STROKEAHA.119.026640.
- [18] 冯中全,钱伟军,李杰,等. 磁共振成像评估大面积脑梗死慢性期患者预后的临床价值 [J]. *新乡医学院学报*, 2020, 37 (1): 52-56. DOI: 10.7683/xyxyxb.2020.01.013.
- [19] XU K X, GU B D, ZUO T S, et al. Predictive value of Alberta stroke program early CT score for perfusion weighted imaging-diffusion weighted imaging mismatch in stroke with middle cerebral artery occlusion [J]. *Medicine (Baltimore)*, 2020, 99 (50): e23490. DOI: 10.1097/MD.00000000000023490.

(收稿日期: 2022-07-15; 修回日期: 2022-10-20)

(本文编辑: 谢武英)