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### 3.0MR 高分辨磁敏感加权成像对颅脑弥漫性轴索损伤的诊断价值

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**摘要 目的:**探讨 3.0TMR 高分辨磁敏感加权成像(SWI)序列对颅脑弥漫性轴索损伤(DAI)的诊断价值。**方法:**选择临床诊断为 DAI 的 30 例患者行 SWI 及常规序列扫描,观察患者病灶等,对比 SWI 与常规 MR 序列对 DAI 病灶形态、分布、数目显示的敏感性,并分析与格拉斯哥昏迷(GCS)评分及预后的相关性。**结果:**① 30 例 DAI 患者 SWI 序列平均病灶个数为 22.83 个,明显高于 T1WI、T2WI、T2flair 序列的 1.5 个、2.13 个、4.1 个,比较差异有统计学意义( $X^2=11.44, P<0.05$ );② SWI 序列皮髓质交界区、白质区、基底节、脑干、小脑、胼胝体 DAI 病灶呈边界清晰、大小不等点状、片状、串珠状、条状、团块不均低信号;③ GCS 分值越高 DAI 平均病灶数目越少,两者呈明显负相关( $r=-0.715, P<0.05$ );④ 痊愈、好转、死亡患者 DAI 平均病灶数目、脑中线条累及率依次增高,比较差异有统计学意义( $F=9.29, X^2=13.52, P<0.05$ )。**结论:**3.0TMR 高分辨 SWI 序列对 DTI 的敏感性优于常规序列,病灶数目与 GCS 评分具有相关性,能够较好地预测患者预后情况。

**关键词:**磁共振;磁敏感加权成像;颅脑;弥漫性轴索损伤

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## Diagnostic Value of 3.0MR High Resolution Magnetic Susceptibility Weighted Imaging for Cerebral Diffuse Axonal Injury

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**ABSTRACT Objective:** To investigate the diagnostic value of 3.0MR high resolution magnetic susceptibility weighted imaging (SWI) for cerebral diffuse axonal injury (DAI). **Methods:** 30 cases of patients who were diagnosed with DAI underwent SWI and conventional sequence scan, the sensitivity and lesion morphology, distribution and lesion number of DAI tested by SWI and conventional sequence scan were compared, and its correlation with Glasgow Coma Score (GCS) and the prognosis were analyzed. **Results:** ① lesion number tested by SWI sequence in 30 cases of patients with DAI was 22.83, significantly higher than those (1.5, 2.13, 4.1 respectively) of T1WI, T2WI, T2flair sequence, the difference was statistically significant ( $X^2=11.44, P<0.05$ ); ② The SWI sequence presented that corticomedullary junction zone, white matter regions, basal ganglia, brain stem, cerebellum, corpus callosum DAI lesions showed clear boundaries, different size dot, sheet, strip, beaded, dough nonuniform low signal; ③ The average number of lesions was smaller when the GCS value was higher, there was a significant negative correlation between them ( $r=-0.715, P<0.05$ ); ④ The DAI average number of DAI lesions, midline involving rate increased in cases of recovery, improvement, death, the difference was statistically significant ( $F=9.29, X^2=13.52, P<0.05$ ). **Conclusion:** High resolution 3.0 TMR SWI sequences is more sensitive for DTI than conventional sequence, number of lesions is correlated with GCS score, which can predict prognosis of patients.

**Key words:** Magnetic resonance; Susceptibility weighted imaging; Brain; Diffuse axonal injury

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## 前言

随着社会进步,交通与工业生产及其他因素所造成的外伤性颅脑损伤发生率明显增高,其中弥漫性轴索损伤(diffuse axonal injury, DAI)是该类外伤最严重的病理类型<sup>[1]</sup>,具有较高的死

亡率及致残率,早期颅脑 CT 及常规 MRI 序列扫描多成阴性或呈病情低估状态,不能真实的反映脑内微小出血的变化情况,导致临床观察数天后才能做出诊断<sup>[2]</sup>,而错过早期最佳治疗时间窗,对患者预后造成不可挽回的影响,因此,如何早期诊断、评估 DAI 成为极为迫切需要解决的问题。3.0TMR 高分辨磁敏感加权成像(susceptibility weighted imaging, SWI)序列对脑内微小出血的大小、数目、形态等具有较高的敏感性,为此,笔者对 DAI 患者进行 SWI 序列扫描,在 DAI 检出率及病情评估方面收到较好效果,现报告如下:

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## 1 资料与方法

### 1.1 一般资料

2011年1月-2013年12月在我院神经外科收治的临床初步诊断为DAI的患者30例,男21例,女9例,年龄18-56岁,平均(39.25±15.38)岁,其中车祸伤25例,滚动伤2例,高处坠落伤3例。格拉斯哥昏迷(Glasgow coma scale, GCS)评分:3-5分者13例,6-8分者11例,9-12分者6例。所有患者均在伤后3h-12d内完成MRI常规序列与3D高分辨SWI序列扫描。

### 1.2 纳入与排除标准<sup>[3]</sup>

纳入标准:①患者有明确的颅脑加速、减速或旋转等暴力外伤史;②伤后短时间内即出现昏迷,时间>6h;③无明确神经系统定位体征;④颅内压增高的程度与病情严重程度不符;⑤病情允许行MRI检查;排除标准:①昏迷原因不能排除其他原因导致者;②不能配合检查,图像质量较差者;③既往有脑血管疾病、脑损伤、肿瘤等疾病者。

### 1.3 检查方法

应用Siemens 3.0T扫描仪超导型核磁共振成像仪,8通道头部线圈,常规扫描:横轴位自旋回波(SE)序列T1WI(TR250ms,TE5ms),矩阵320×320,层厚6.0mm;快速自旋回波T2WI(TR2800ms,TE90ms),矩阵640×640;液体衰减翻转恢复T2flair序列(TR4800ms,TE95ms),层厚6mm,FOV均选择230mm×230mm。SWI序列扫描:采用高分辨率3D梯度回波序列(TR63ms,TE50ms),矩阵320×320,FOV230mm×230mm,层厚2mm,覆盖全脑,扫描时间为6min,所采集的原始数据发送至Achieva4.1影像工作站进行后处理重建。

### 1.4 图像后处理及诊断

采用3DMIP软件对SWI扫描所得数据进行最小密度投

影(minimal intensity projection, MinIP)重建,层厚均选择6.0mm,保证病灶形态与测量的一致性。所有患者MRI诊断采用双盲法,由两名经验丰富的具有副主任医师以上职称MRI诊断医师通过观察常规序列与后处理后的SWI图像分析病灶的形态、数目及部位分布特点做出,对诊断有异议者由全科会诊得出。

### 1.5 随访及观察指标

对每位MRI检查后的患者,进行为期3个月的临床追踪,记录其预后情况,包括①痊愈:精神状态与肢体功能基本恢复正常,达到恢复日常工作水平;②好转:脱离生命危险,精神状态及肢体功能有所恢复,尚不能达到恢复工作的水平;③死亡。观察指标:①常规序列序列与SWI序列DAI病灶分布与数目;②常规序列序列与SWI序列DAI影像学表现;③不同GCS分级与SWI序列DAI病灶数目比较及两者相关性;④DAI病灶数目、累计部位与临床预后的关系。

### 1.6 统计学方法

所得数据应用医学统计软件SPSS17.0进行分析,计量资料采用均数±标准差( $\bar{X} \pm S$ )表示,多组间比较采用方差分析,计数资料应用 $\chi^2$ 检验,相关性检验采用直线(Pearson)相关分析,以 $P < 0.05$ 表示有统计学意义。

## 2 结果

### 2.1 3.0TMRI 常规序列与 SWI 序列病灶分布与数目

30例DAI患者SWI序列皮髓质交界区、白质区、基底节、脑干、小脑、胼胝体均检出病灶,以皮髓质交界区病灶最多,平均病灶个数为22.83个,明显高于T1WI、T2WI、T2flair序列的1.5个、2.13个、4.1个,比较差异有统计学意义( $\chi^2=11.44, P < 0.05$ ),见表1。

表1 3.0TMRI 常规序列与 SWI 序列 DAI 病灶分布与数目比较(n=30)

Table 1 Comparison of the distribution and number of DAI lesions between Routine 3.0TMRI sequence and SWI sequence(n=30)

| 序列<br>Sequence | 皮髓质交界区<br>Corti-<br>comedullary<br>junction | 白质<br>White<br>matter | 基底节<br>Basal<br>ganglia | 脑干<br>Brainstem | 小脑<br>Cerebellum | 胼胝体<br>Callosum | 合计<br>Totals | 平均病灶个数                          |                |       |
|----------------|---------------------------------------------|-----------------------|-------------------------|-----------------|------------------|-----------------|--------------|---------------------------------|----------------|-------|
|                |                                             |                       |                         |                 |                  |                 |              | Average<br>number of<br>lesions | X <sup>2</sup> | P     |
| T1WI           | 22                                          | 11                    | 8                       | 0               | 1                | 3               | 45           | 1.5                             | 11.44          | 0.002 |
| T2WI           | 26                                          | 15                    | 10                      | 1               | 3                | 9               | 64           | 2.13                            |                |       |
| T2flair        | 56                                          | 23                    | 17                      | 3               | 6                | 18              | 123          | 4.1                             |                |       |
| SWI            | 288                                         | 196                   | 54                      | 25              | 51               | 71              | 685          | 22.83                           |                |       |

### 2.2 3.0TMRI 常规序列序列与 SWI 序列 DAI 影像学表现

磁共振常规序列成像:微小出血灶呈不规则点状、斑片及索条状异常信号,T1WI序列呈混杂信号,32个表现为稍长、等T1信号,13个呈短T1高信号;T2WI序列58个呈稍长或长T2高信号,6个呈稍短T2低信号;T2flair序列123个病灶均呈高信号。

SWI序列:皮髓质交界区、白质区、基底节、脑干、小脑、胼胝体示大小不等点状、片状、串珠状、条状、团状不均低信号,边界清晰,皮髓质交界区病灶多呈点状、片状、串珠状,白质区及

小脑多呈点状或团状,基底节、脑干、胼胝体多呈点状、片状及团状。

### 2.3 GCS 分级与 SWI 序列 DAI 病灶数目相关性

GCS分值越高DAI平均病灶数目越少,两者呈明显负相关( $r = -0.715, P < 0.05$ ),见表2。

### 2.4 DAI 病灶数目与临床预后的关系

痊愈、好转、死亡患者DAI平均病灶数目依次增高,比较差异有统计学意义( $F = 9.29, P < 0.05$ ),见表3。

### 2.5 DAI 病灶累及部位与临床预后的关系

表 2 GCS 分级与 SWI 序列 DAI 病灶数目相关性(  $\bar{X} \pm S$  )Table 2 The correlation of DAI lesions between GCS classification and SWI sequence(  $\bar{X} \pm S$  )

| GCS 分级(分)<br>GCS classification( score ) | n  | 平均病灶数目( 个 )<br>Average number of lesions(n ) | r      | P     |
|------------------------------------------|----|----------------------------------------------|--------|-------|
| 3-5                                      | 12 | 25.86± 6.45                                  | -0.715 | 0.002 |
| 6-8                                      | 11 | 19.66± 4.29                                  |        |       |
| 9-12                                     | 7  | 10.25± 3.28                                  |        |       |

表 3 DAI 病灶数目与临床预后的关系(  $\bar{X} \pm S$  )Table 3 The relationship between number of DAI lesions and clinical prognosis(  $\bar{X} \pm S$  )

| 预后<br>Prognosis | n  | 平均病灶数目<br>Average number of lesions | F    | P     |
|-----------------|----|-------------------------------------|------|-------|
| 痊愈 Recovery     | 8  | 10.12± 3.35                         | 9.29 | 0.013 |
| 好转 Improvement  | 15 | 19.89± 4.59                         |      |       |
| 死亡 Death        | 7  | 25.67± 6.24                         |      |       |

痊愈、好转、死亡患者脑中线累及率依次为 37.5%、66.67%、85.71%，比较差异有统计学意义( $X^2=13.52, P<0.05$ )，见表 4。

表 4 DAI 病灶累及部位与临床预后的关系

Table 4 The relationship between DAI lesions location and clinical prognosis

| 预后<br>Prognosis | n  | 脑中线 Brain midline |                    |                              | $X^2$ | P     |
|-----------------|----|-------------------|--------------------|------------------------------|-------|-------|
|                 |    | 累及<br>Involved    | 未累及<br>No-involved | 累及率( % )<br>Rate of involved |       |       |
| 痊愈 Recovery     | 8  | 3                 | 5                  | 37.5                         | 13.52 | 0.001 |
| 好转 Improvement  | 15 | 10                | 5                  | 66.67                        |       |       |
| 死亡 Death        | 7  | 6                 | 1                  | 85.71                        |       |       |

### 3 讨论

DAI 是临床常见的危重脑外伤之一，国内外对其发病机制认识基本统一，均认为由于颅骨、脑膜、灰白质及脑脊液的质量存在差异，在外力作用下，尤其是在能使颅脑产生旋转加、减速度运动和(或)角加速度运动的外力作用下，各组织运动加速度不同，而产生瞬间剪切力，导致神经轴索破坏和小血管断裂出血而致<sup>[3-5]</sup>，灰、白质交界区，双侧大脑半球间的胼胝体以及脑干头端是剪切力作用下的易损区<sup>[6]</sup>。DAI 患者临床表现呈多样化，入院时多伴有昏迷、昏睡、呼吸功能、肢体功能障碍等，具有较高的死亡、致残及植物生存状态发生率，预后较差<sup>[7]</sup>，本研究 30 例患者治疗 3 个月 7 例死亡，15 例未痊愈，成分说明 DAI 的危险性。

CT 一般是颅脑损伤首选的检查方式，能够发现颅骨骨折、较大的脑内出血灶、脑脊液循环障碍及轻微脑肿胀，但是难以真实反映 DAI 的存在及真实状态<sup>[8]</sup>。MRI 常规序列 T1WI 及 T2WI 可以显示外伤后的脑实质的形态变化，显示较大 DAI 病灶形态、部位、大小及脑肿胀情况<sup>[9]</sup>，T2flair 序列通过抑制脑脊液高信号对 DAI 病变显示的影响，较容易的显示出脑室旁白质区及皮层下病灶，从而提高了 DAI 病灶检出率<sup>[10]</sup>，本组病例

充分证实 T2flair 序列 DAI 病灶检出个数明显多于 T1WI 及 T2WI 序列。但 DAI 病灶具有散发、多灶、微小的特点，CT 与常规 MRI 序列对脑内微出血灶不敏感，对评价预后而提供的信息非常有限。

SWI 是一种高分辨 3D 梯度回波序列，利用不同脑组织磁化率差异产生不同的图像，尤其对顺磁性物质高度敏感<sup>[11,12]</sup>，它通过调整长 TE，完全流动补偿，高分辨率参数，首先产生强度图像与相位图像<sup>[13]</sup>，后者经适当频率滤波处理产生相位蒙片，再与强度图像整合，进行最小密度投影(MinIP)而得到失相位区的负性信号(低信号)，使对磁敏感效应的敏感性达到最大<sup>[14]</sup>，出血后脱氧血红蛋白、含铁血黄素、正铁血红蛋白等顺磁性物质，在 SWI 序列表现为明显的低信号，能够很好的与周围组织区分，发现常规 MRI 序列不能显示的微小出血灶，明显提高 DAI 病灶的检出率<sup>[15,16]</sup>。本研究 30 例患者 SWI 序列显示 DAI 病灶 685 个，平均 22.83 个，而常规 MRI 序列扫描最多检出 123 个，平均仅 4.1 个，SWI 序列检出病灶数目超出常规序列 5 倍多。

DAI 病灶在 SWI 序列上多呈边界清晰的大小不等点状、片状、串珠状、条状、团状不均低信号，其形态学表现与轴索损伤部位及严重程度有关<sup>[17,18]</sup>。本研究 DAI 病灶以皮髓质交界

区、胼胝体较多,皮髓质交界区、白质区、基底节、脑干、小脑、胼胝体示大小不等点状、片状、串珠状、条状、团状不均低信号,边界清晰,皮髓质交界区病灶多呈点状、片状、串珠状,白质区及小脑多呈点状或团状,基底节、脑干、胼胝体多呈点状、片状及团状。国外研究报道 DAI 多发生于脑深部白质、额叶、颞叶皮髓质交界区域,胼胝体、基底节、小脑、脑干等有较高累及率<sup>[19,20]</sup>,本研究 30 例患者 DAI 病灶分别基本与文献报道一致。

通过 3.0TMRISWI 序列对患者病情及预后的评价中发现,GCS 分值越高 DAI 平均病灶数目就越少,两者具有显著负相关性( $r=-0.715$ , $P<0.05$ ),DAI 平均病灶数目、脑中线累及率越高患者转归愈差,充分说明 3.0TMRISWI 序列不仅能够显示 DAI 病灶数目,对预测病情及转归也具有较高的临床价值。

综上所述,3.0TMRISWI 序列对 DAI 具有较高的敏感性,可以清晰显示 DAI 病灶形态、分布特征及数目,并能对预测患者的转归,为临床制定治疗方案提供有力的影像学支持。

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