

神经系统磁共振成像的进展

解放军总医院放射科
马 林

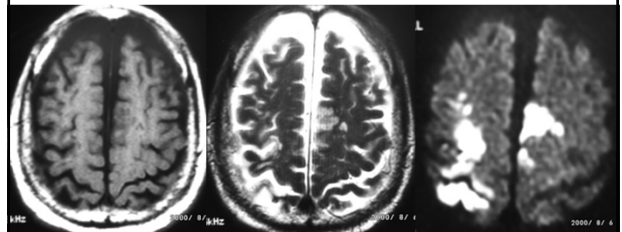
- 扩散加权成像 (DWI)
- 扩散张力成像 (DTI)
- 血氧水平依赖成像 (BOLD)
- 磁共振波谱分析 (MRS)
- 灌注成像 (PWI)
- 磁敏感加权成像 (SWI)

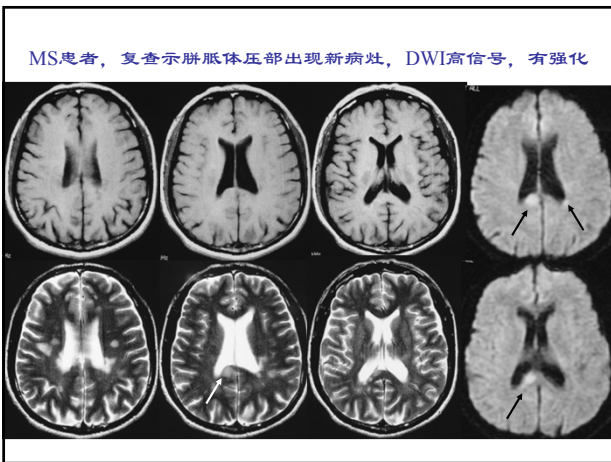
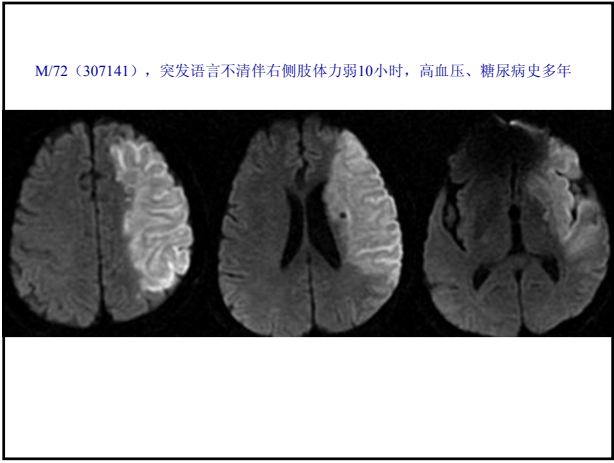
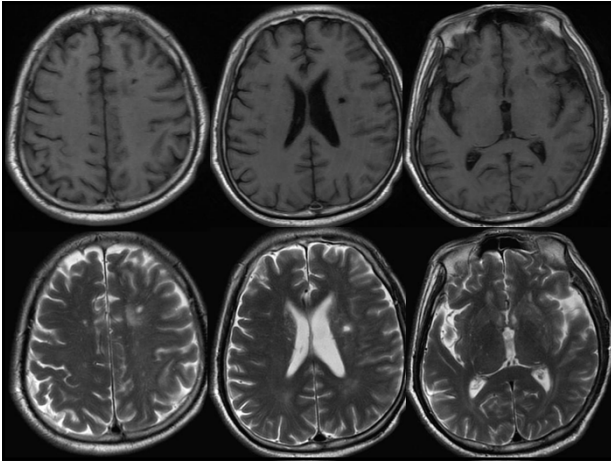
扩散加权成像 (DWI)

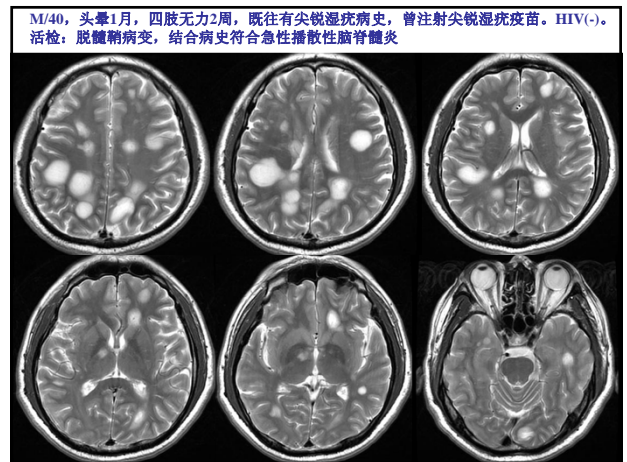
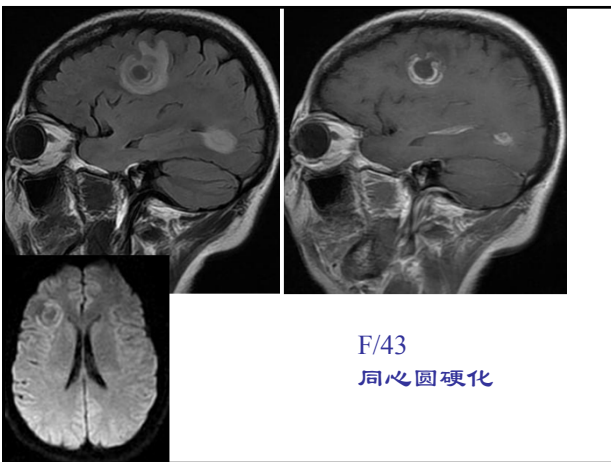
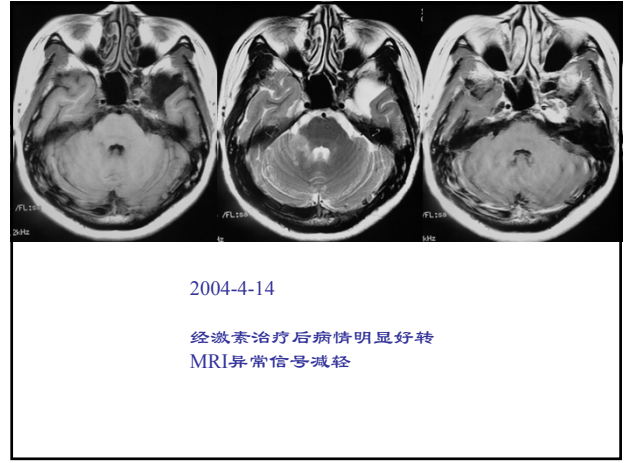
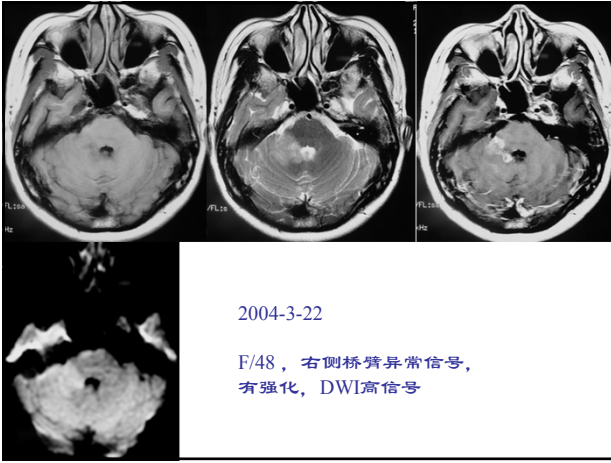
- 利用水分子扩散状态的差异显示病变
- 对于多种病理改变进行检测
- DWI呈现异常高信号的病变种类很多：
急性期及亚急性期脑梗死、炎性脱髓鞘（活动期）、细胞较致密的肿瘤（高级别胶质瘤、髓母细胞瘤、脑膜瘤、淋巴瘤等）、粘稠度较高的液体（表皮样囊肿、脓肿、血肿等）、外伤、特殊感染等
- 注意ADC值的作用

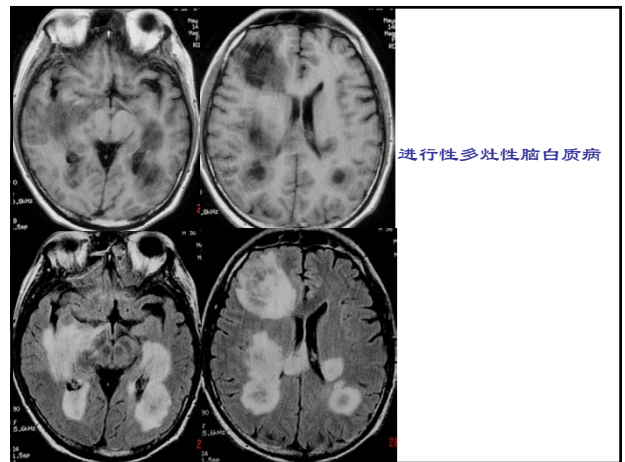
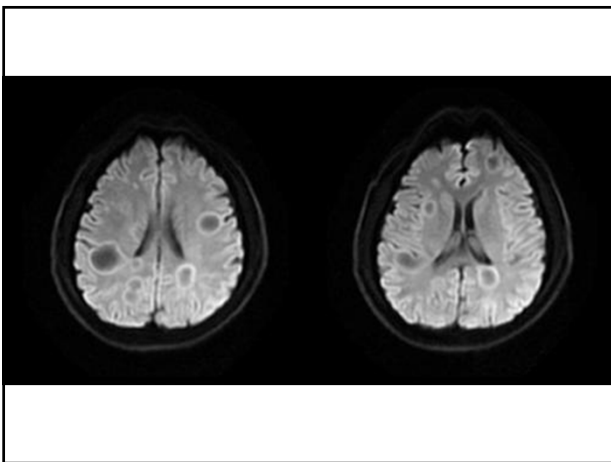
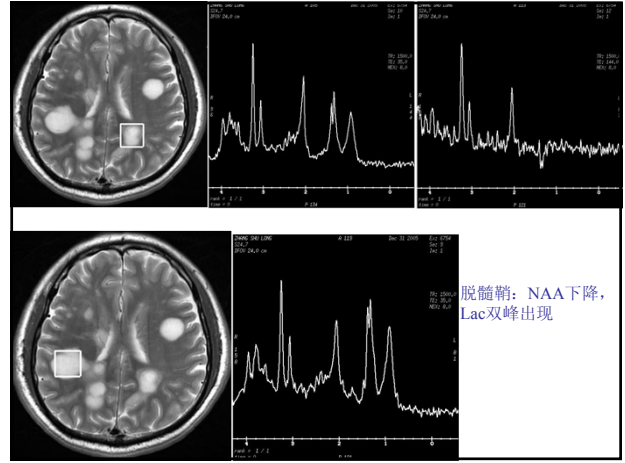
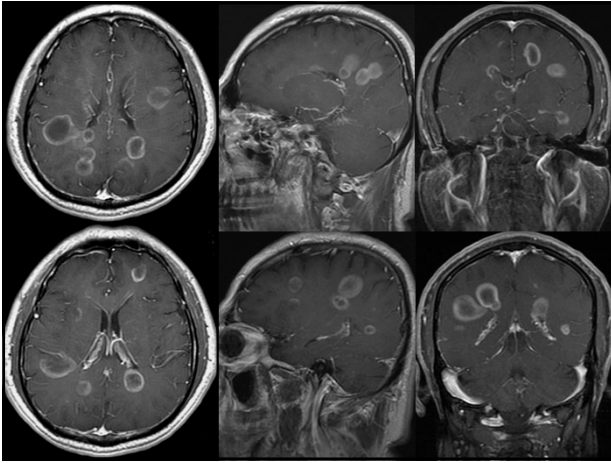
右侧侧脑室旁脑白质超急性期脑梗死

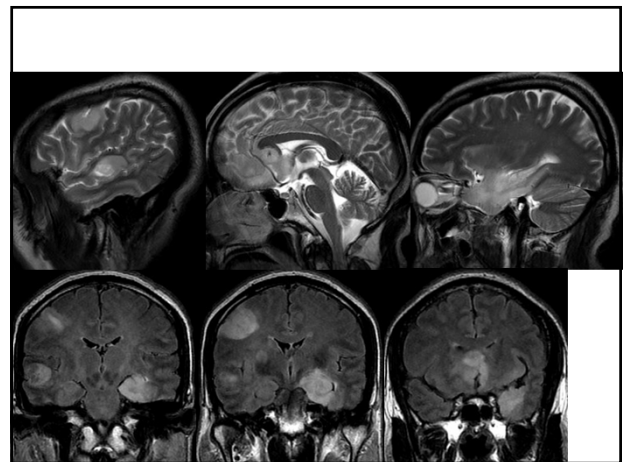
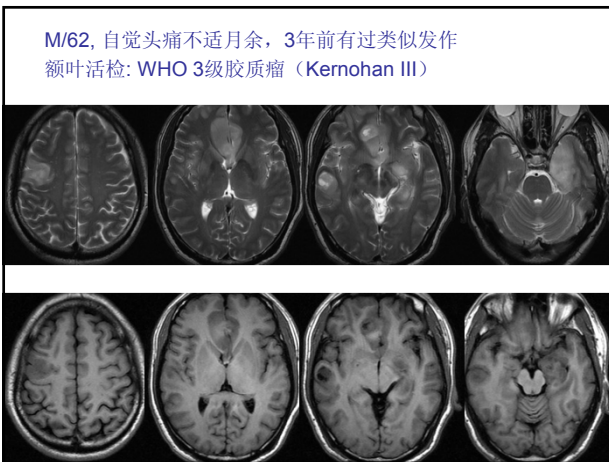
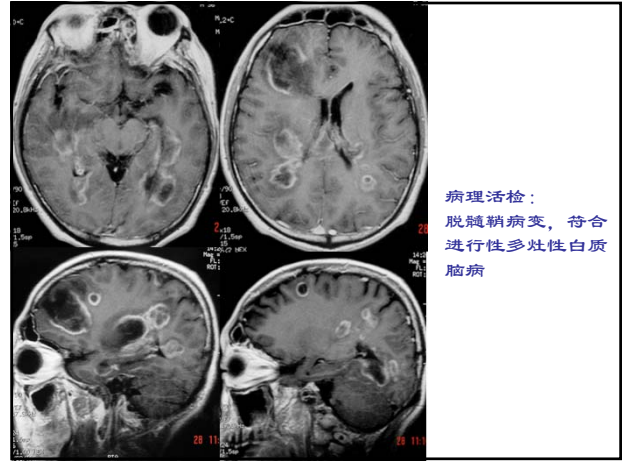
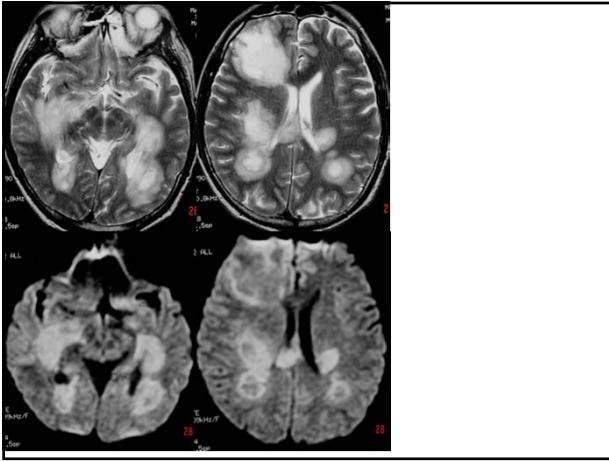
49岁女性，突发左侧肢体无力4小时

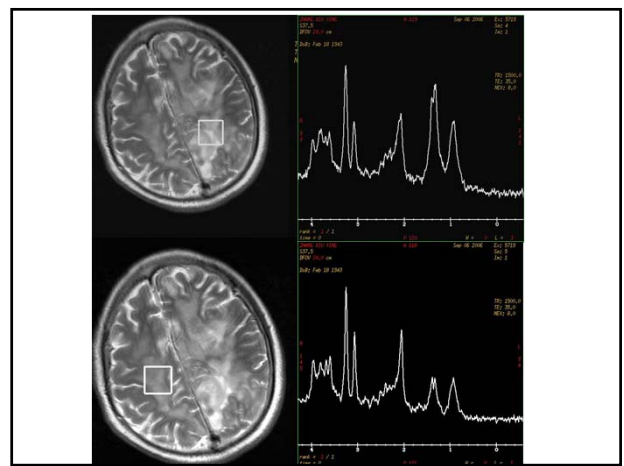
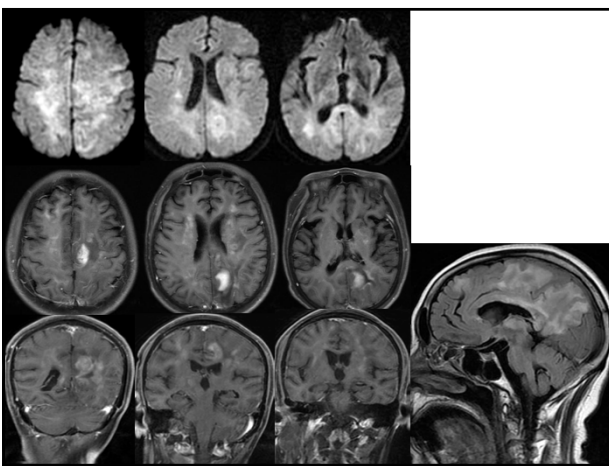
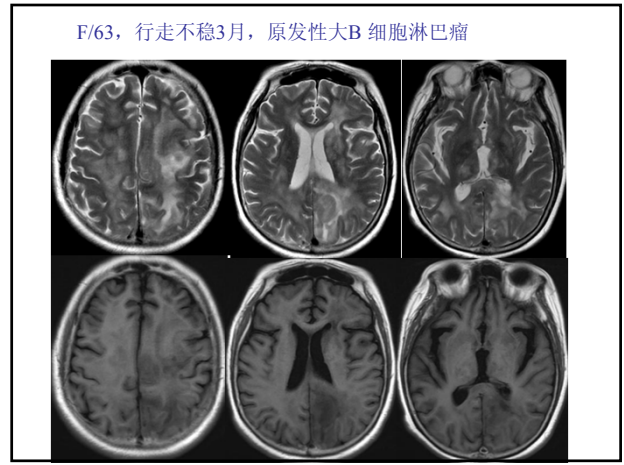
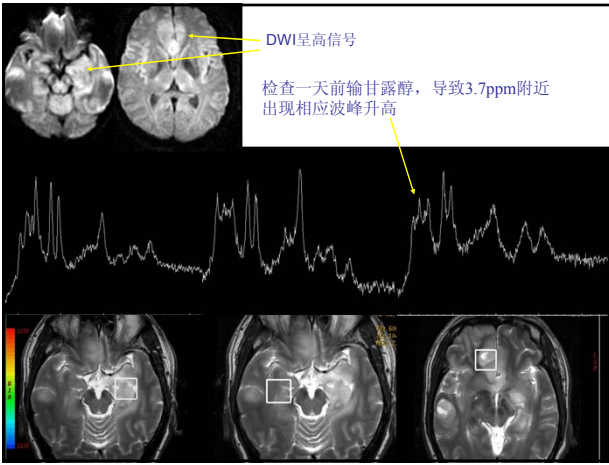


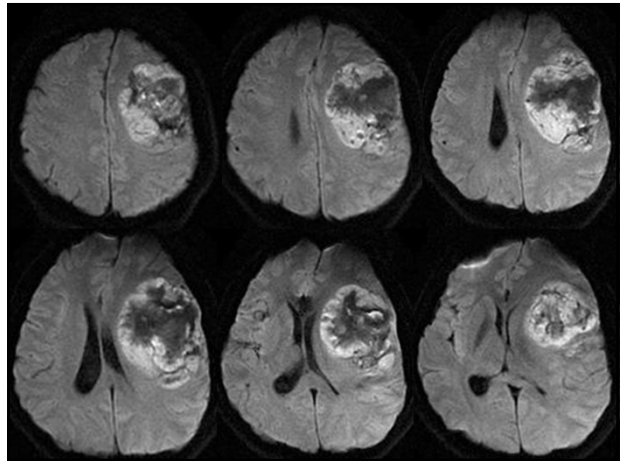
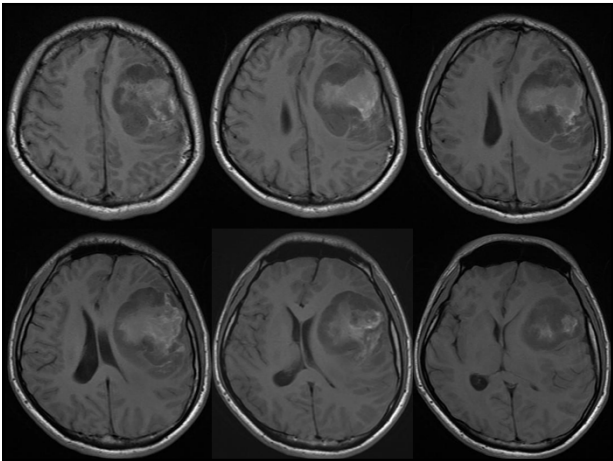
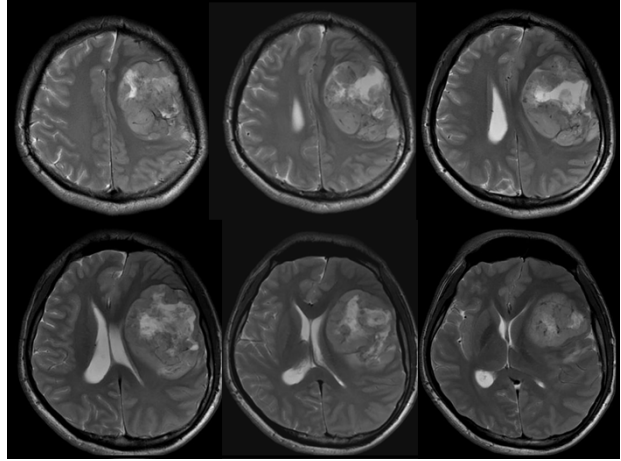
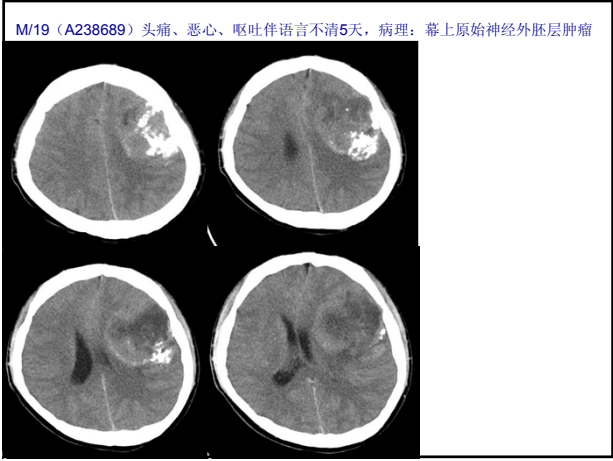


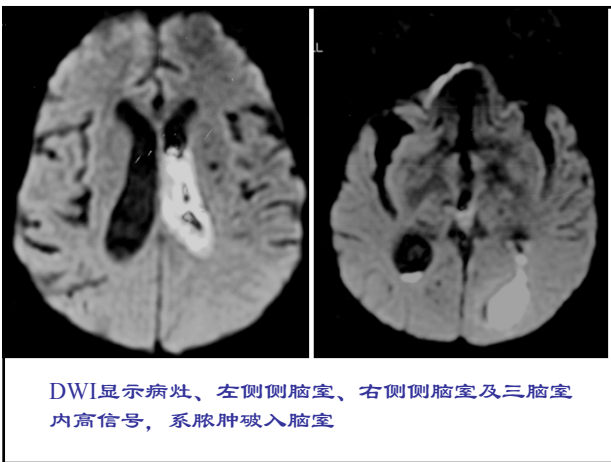
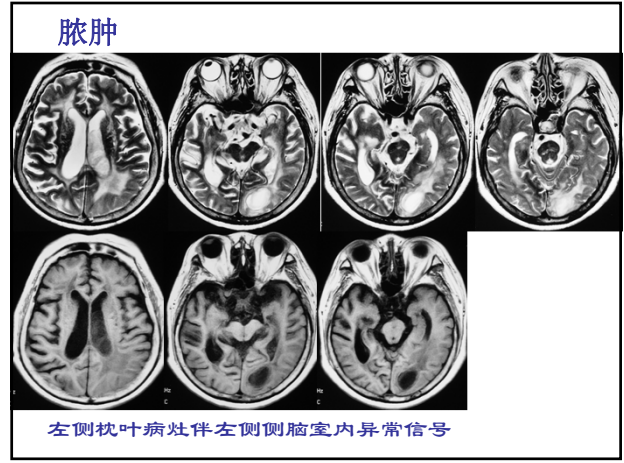
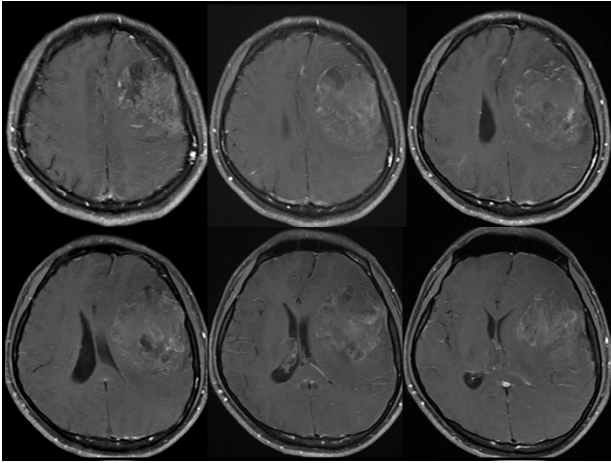




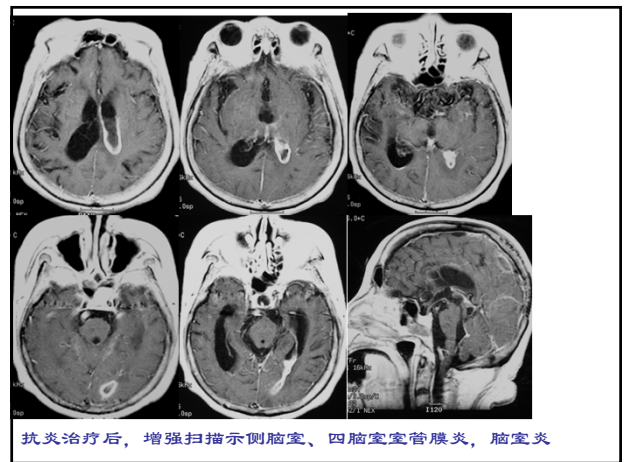






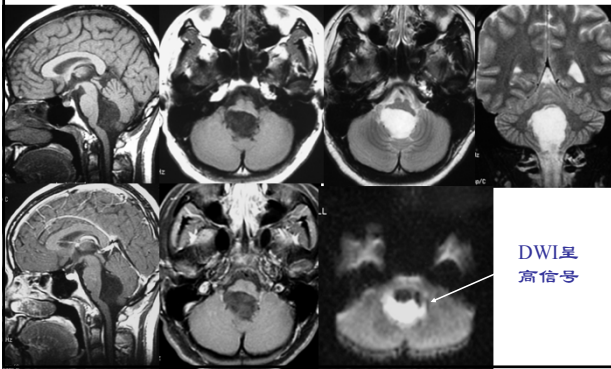


DWI显示病灶、左侧侧脑室、右侧侧脑室及三脑室内高信号，系脓肿破入脑室



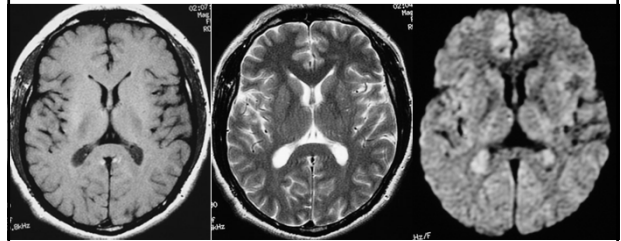
抗炎治疗后，增强扫描示侧脑室、四脑室室管膜炎，脑室炎

表皮样囊肿



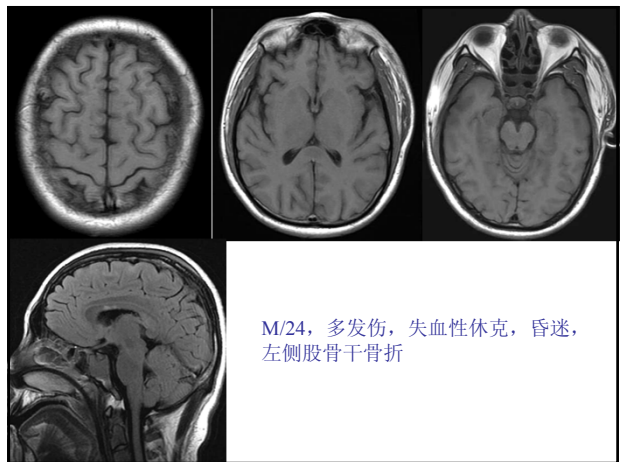
脉络膜丛囊肿

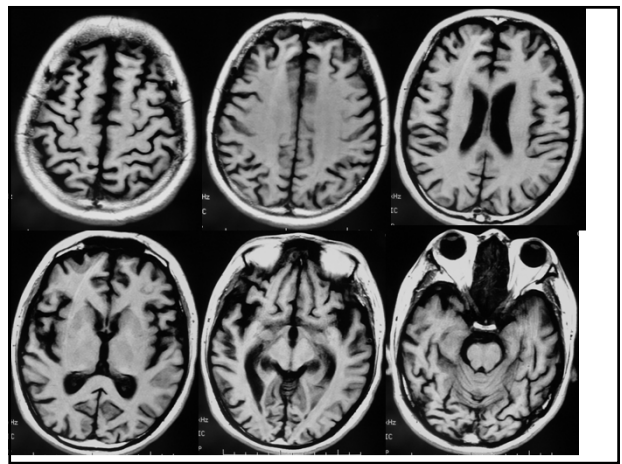
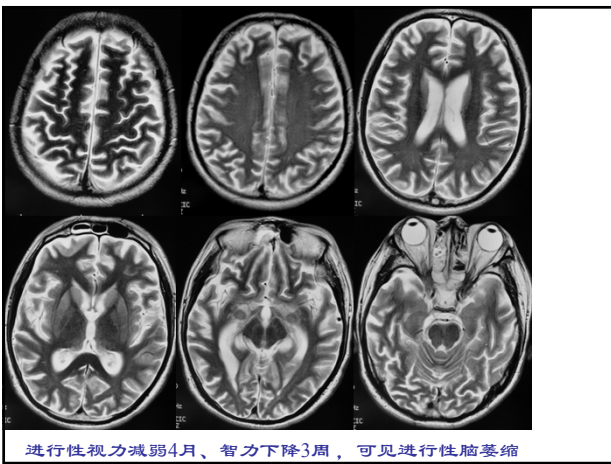
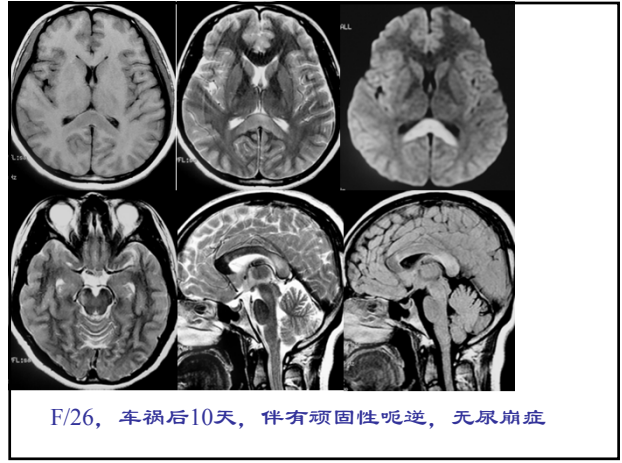
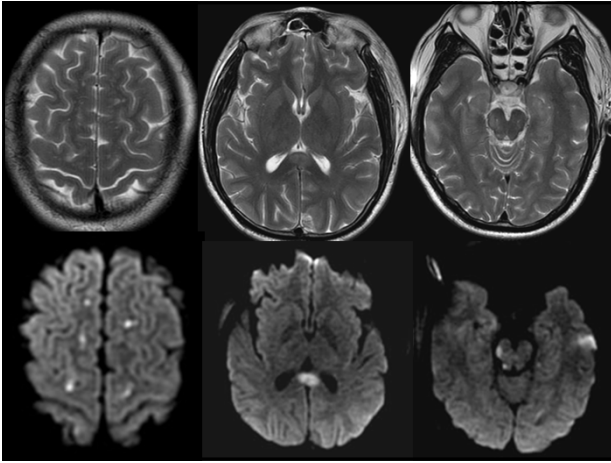
偶然发现双侧侧脑室后角囊性病変，无强化，DWI高信号

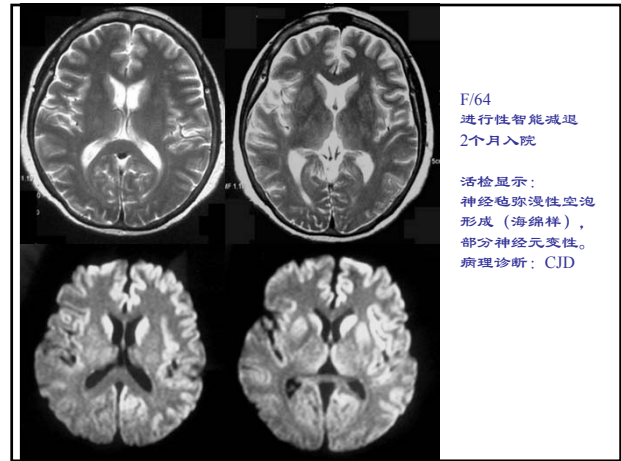
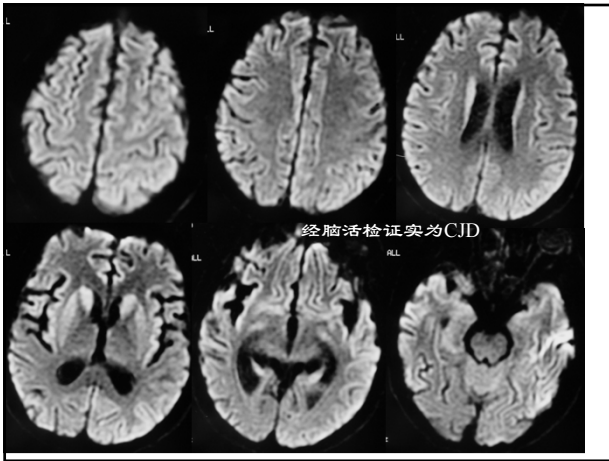


弥漫性轴索损伤

- 也称为剪力伤(**shearing injury**)，是严重脑外伤的常见并发症，患者常出现昏迷
- 机制：颅脑出现突然加速、减速或旋转，损伤主要累及轴索，穿支动脉损伤常出现多发小出血
- 病变常呈双侧弥漫性分布，特征部位包括大脑白质（特别是皮髓质交界区）（60%~70%）、胼胝体（主要在体后部及压部）以及上部脑干背外侧



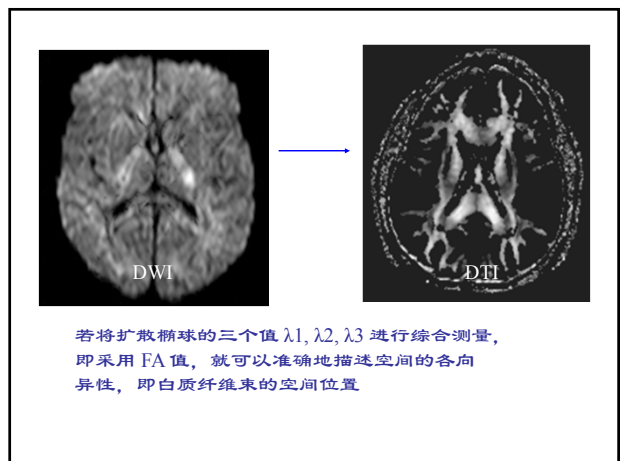
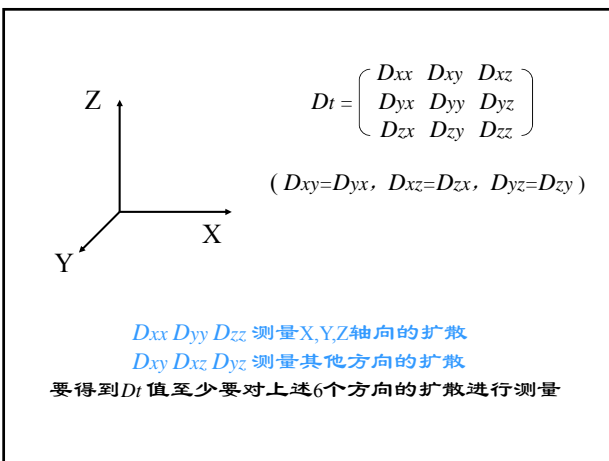
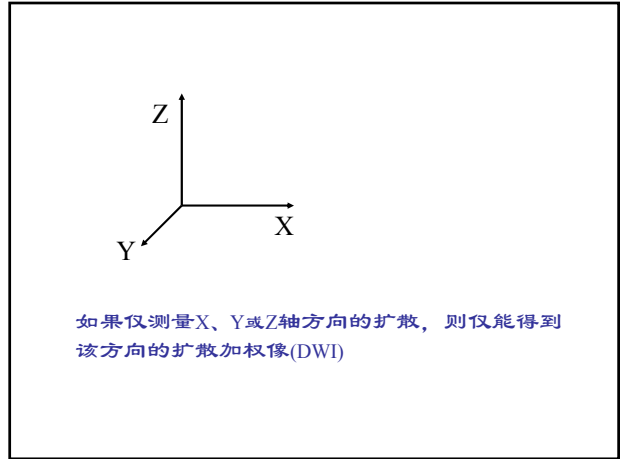
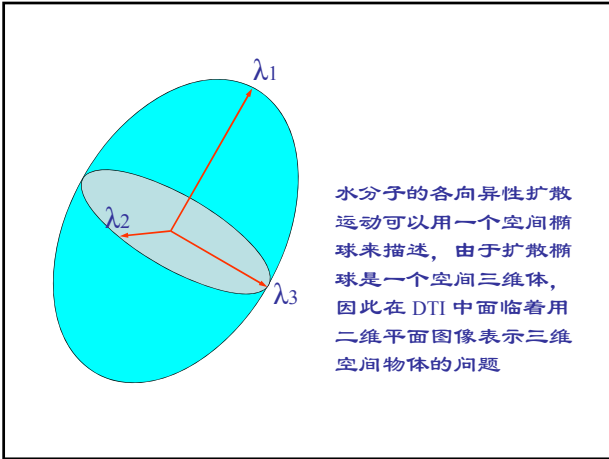


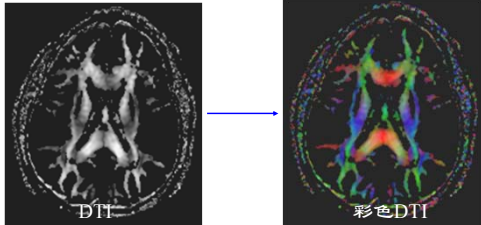


DTI

- 在均匀一致的介质（如纯水）中，水分子在各个方向上的扩散是各向同性的(isotropy)
- 在生物体内由于各种组织结构（如细胞膜）的存在，使各向同性扩散受到限制，沿某方向的扩散可能比其他方向的扩散更容易（如白质束中），即出现扩散的各向异性(anisotropy)，此时水分子的扩散称为表观扩散(apparent diffusion)
- 测量表观扩散系数(ADC) 仅能反映各向异性扩散的部分情况，而扩散张量成像(DTI)能描述各向异性扩散的完整信息

- 导致水分子扩散各向异性(anisotropy)的原因可能主要包括髓鞘、神经元的细胞膜以及轴索内的神经元蛋白丝
- 白质束区域扩散的各向异性高
- 而皮层扩散的各向异性低



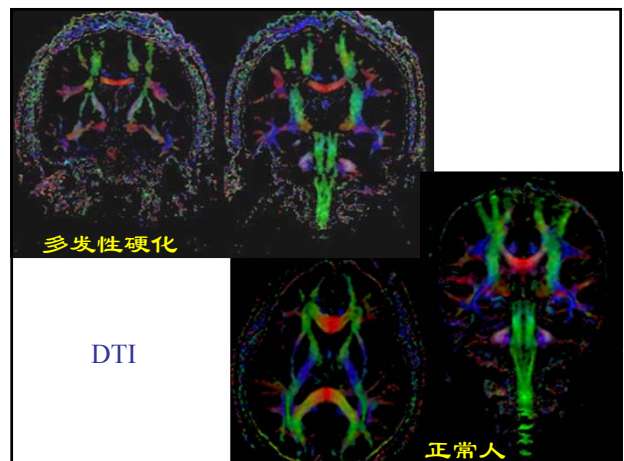


采用 FA 值虽然可以准确描述白质纤维束的空间位置，但 FA 图像仍然不能显示白质纤维束的空间立体走行方向（扩散方向），如果将 FA 值与 λ_1 的方向结合并在 X,Y,Z 三个方向进行空间投影，并用红、绿、蓝分别表示这三个方向的数值，就能得到彩色DTI，其中颜色代表白质走向，亮度代表各向异性的大小

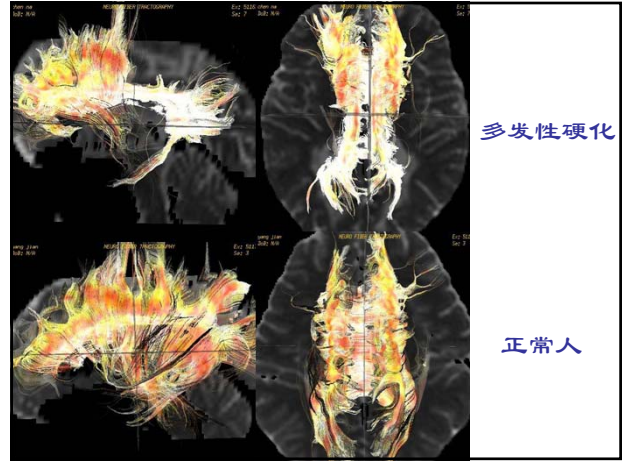
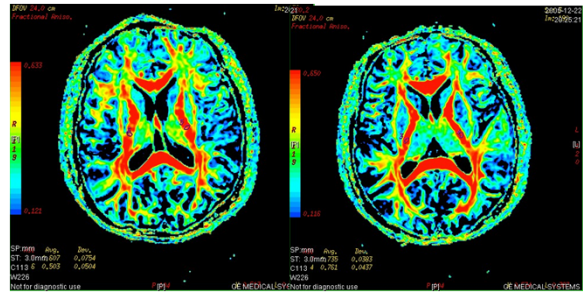
DTI的应用

- 定性分析：在病变明显时使用，如白质束的发育异常、肿瘤或梗死对白质束的影响等
- 定量分析：在病变不明显时，需对DTI数据进行统计学分析，如变性病或精神病等
- 对脑白质结构本身的研究：DTI具有独特的作用，如研究脑白质束的联系等

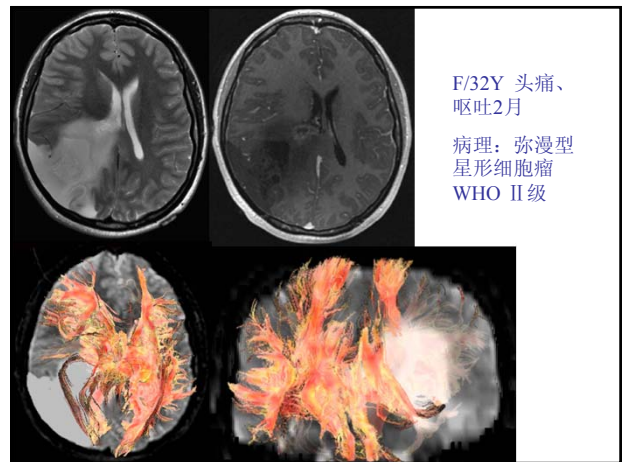
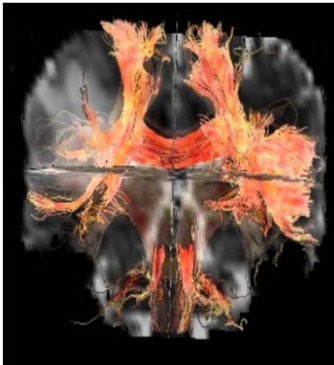
- DTI采集至少需要7种测量（1种b值=0以及6种扩散采集方向）；要提高分辨率，扩散的采集方向理论上越多越好（可达40个方向），但会使扫描时间更长，因此通常需使用快速成像技术
- 最常使用的序列为单次激发EPI，其优点为快速，缺点为空间分辨率低、磁敏感伪影较重
- DTI可分为2维和3维成像，后者称为tractography



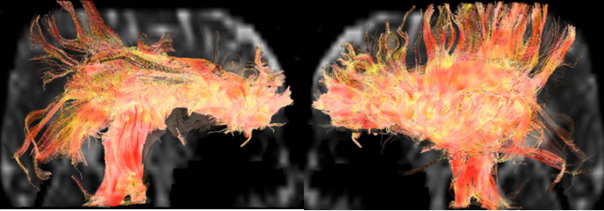
ALS患者DTI (FA图)



左侧额叶胶质瘤DTI图

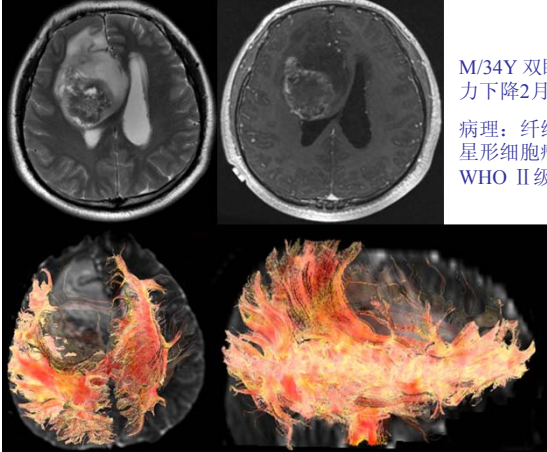


M/30Y 间断头痛、癫痫1年
病理：星形细胞胶质瘤 WHO II级

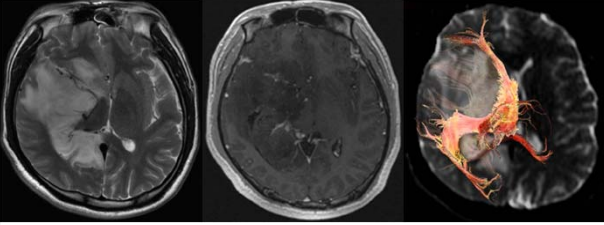


病变侧 正常侧

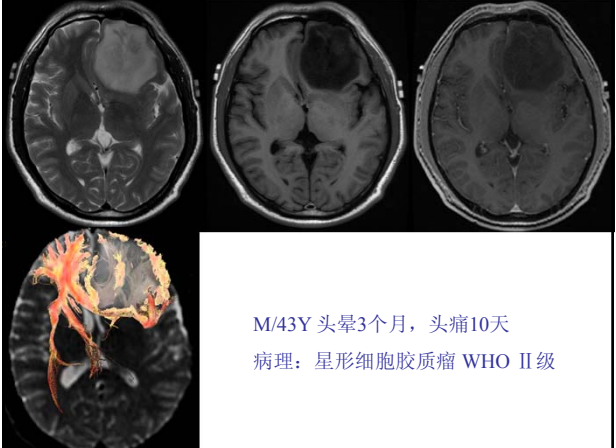
M/34Y 双眼视力下降2月
病理：纤维型星形细胞瘤 WHO II级

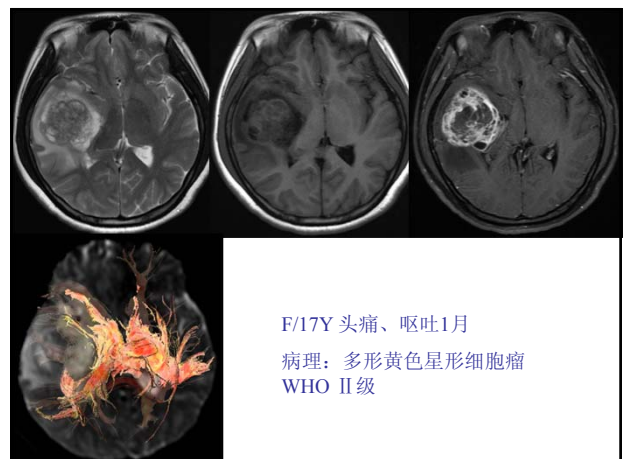
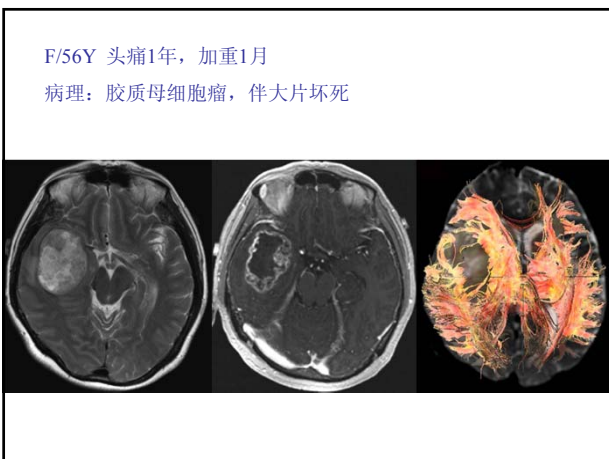
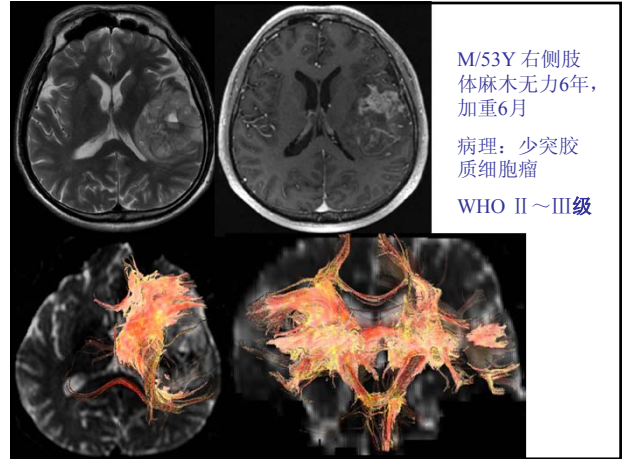
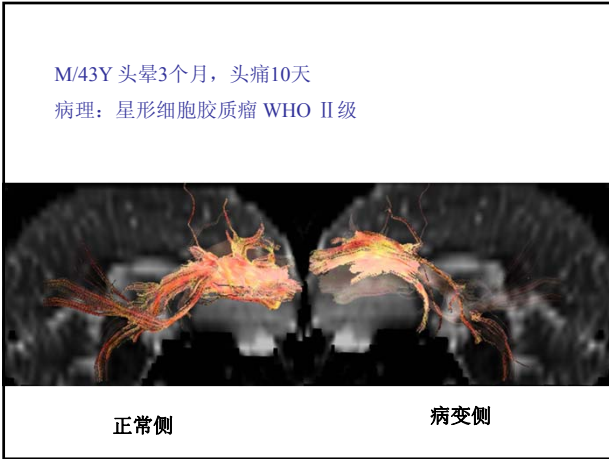


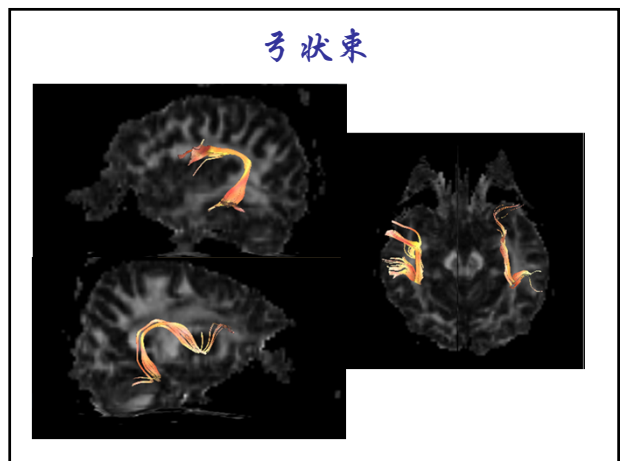
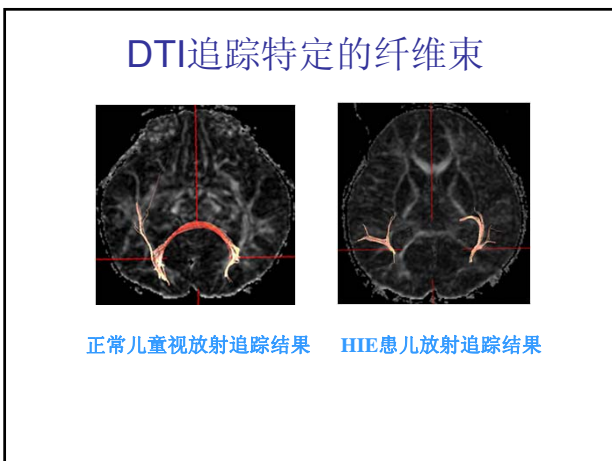
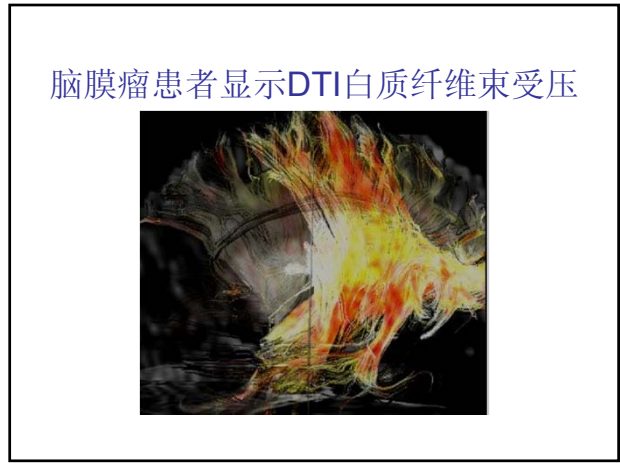
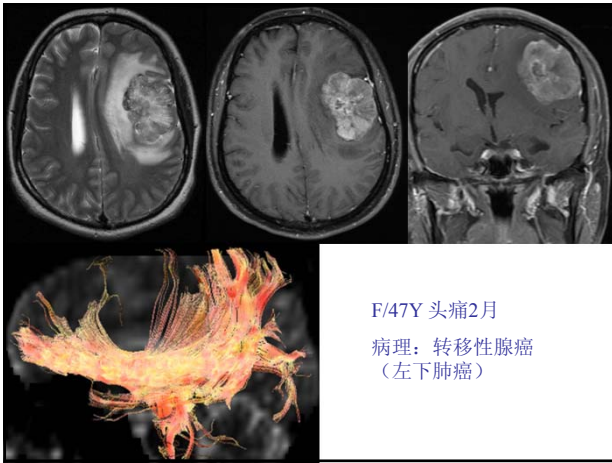
M/30Y 间断头痛、癫痫1年
病理：星形细胞胶质瘤 WHO II级



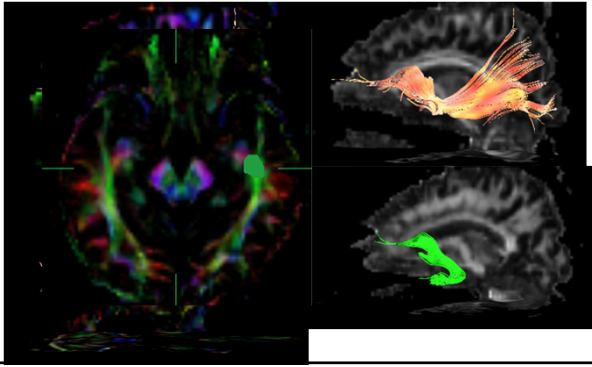
M/43Y 头晕3个月，头痛10天
病理：星形细胞胶质瘤 WHO II级



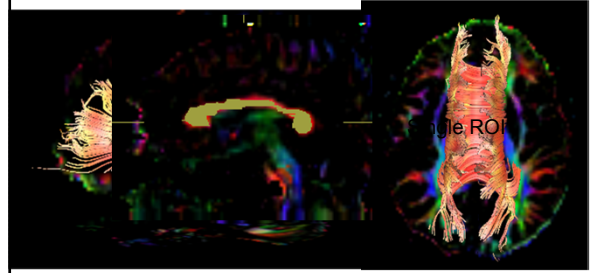




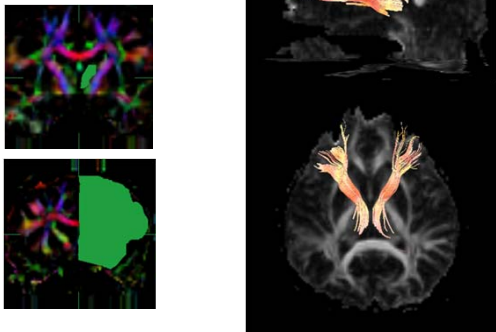
下额枕束和钩状束



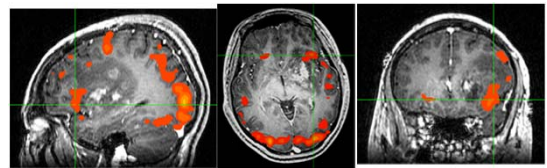
胼胝体

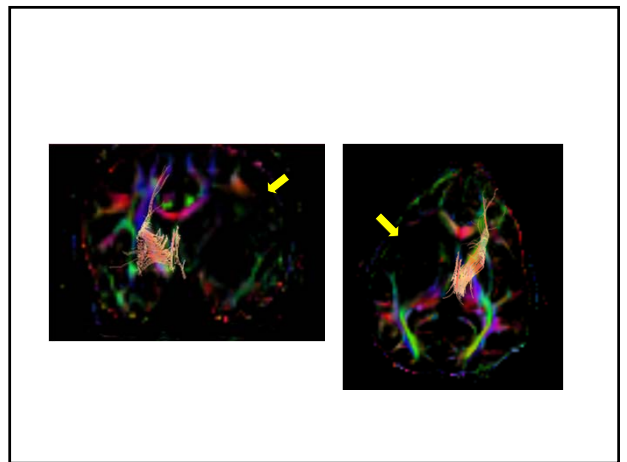
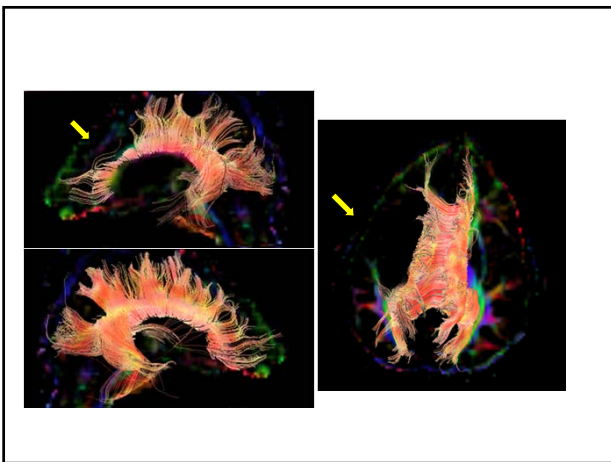
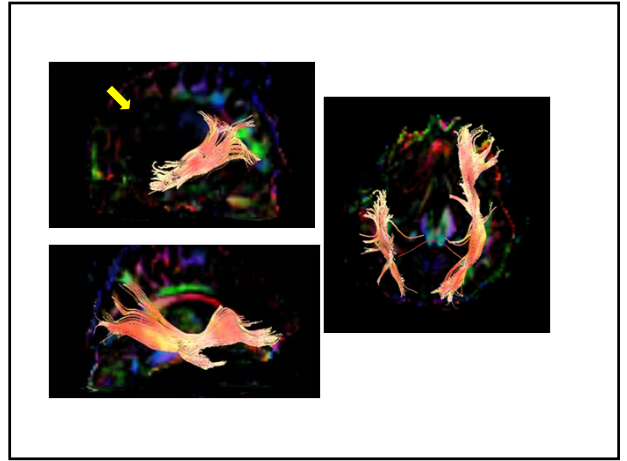
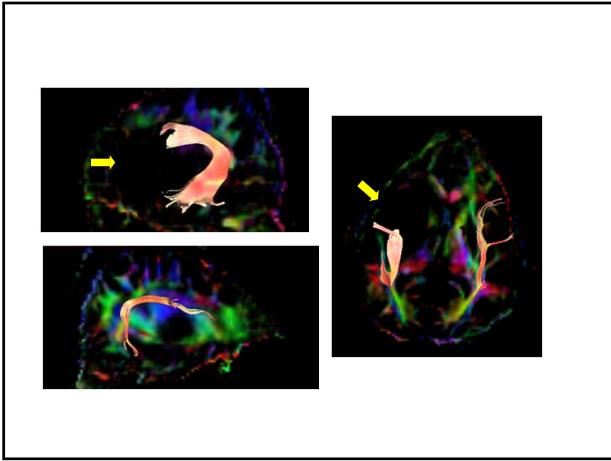


丘脑前辐射

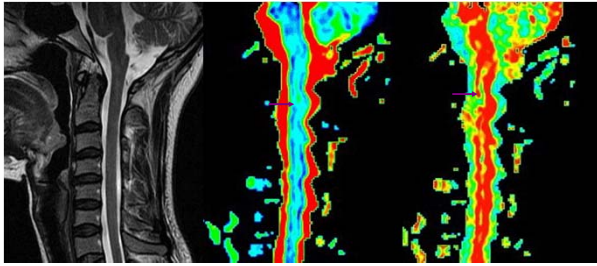


患者2 女，14岁，初中生，右侧肢体无力3月，术前评价语言功能为9分，并有计算力下降

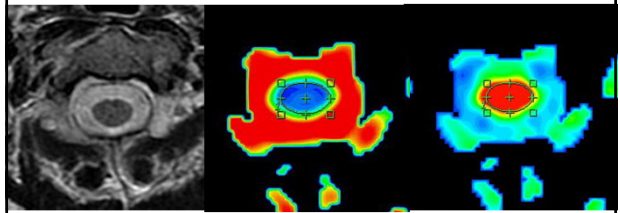




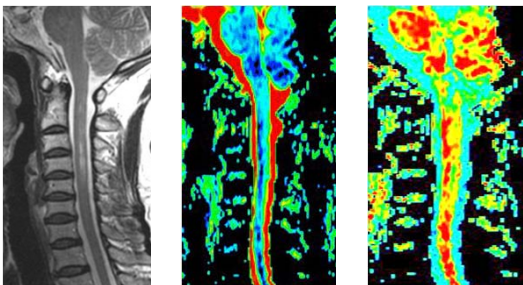
正常人颈髓矢状位DTI (ADC及FA图)



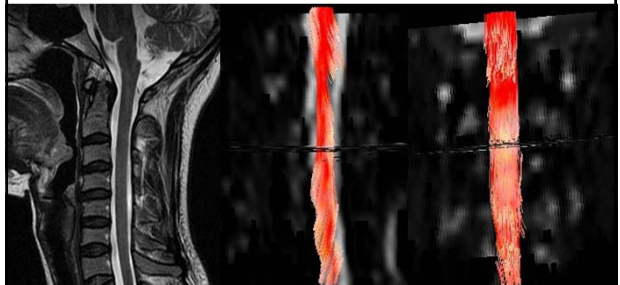
正常人颈髓横轴位ADC及FA图



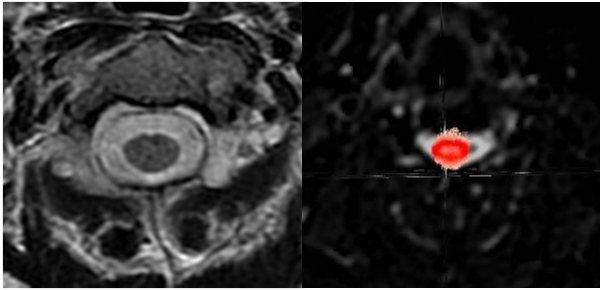
MS 27/F



正常人颈髓纤维跟踪图



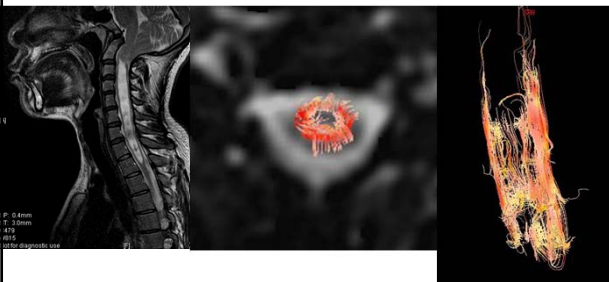
正常人颈髓纤维跟踪图



延髓肿瘤纤维跟踪图



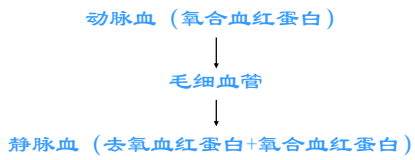
颈髓空洞纤维跟踪图



颈髓脱髓鞘纤维跟踪图

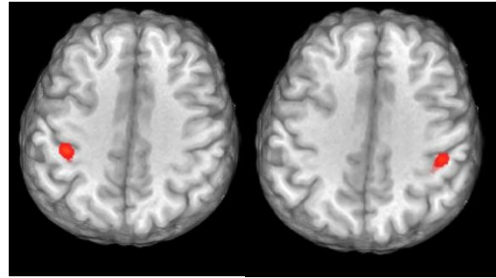


BOLD

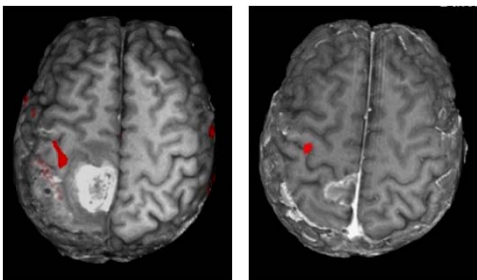


神经元兴奋区静脉血中氧合血红蛋白含量高于非兴奋区静脉血中氧合血红蛋白含量，在T2*图像中信号较高

健康人双手运动BOLD图

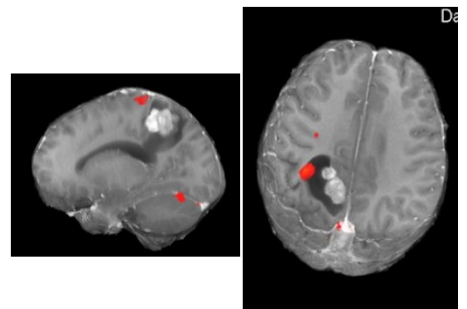


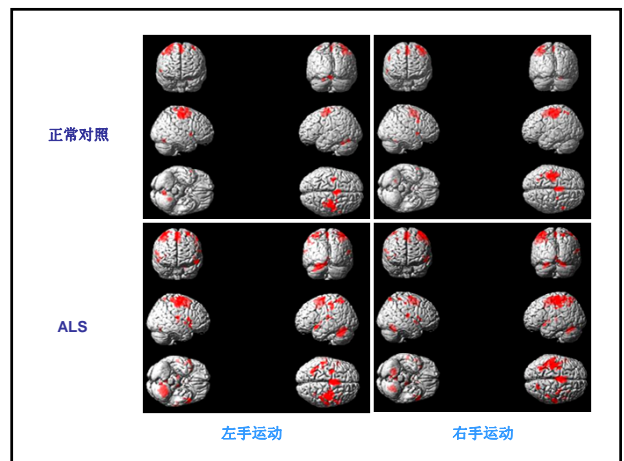
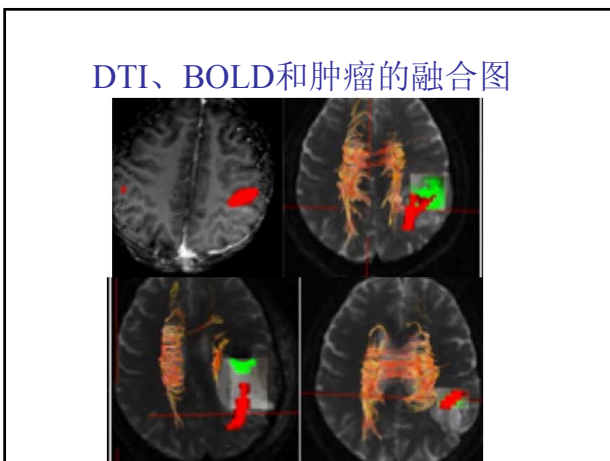
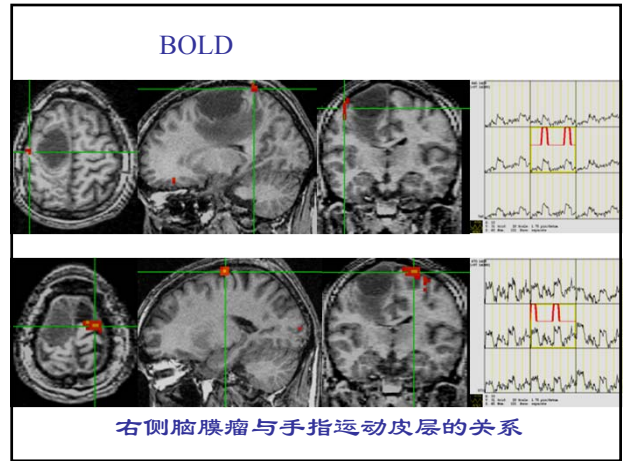
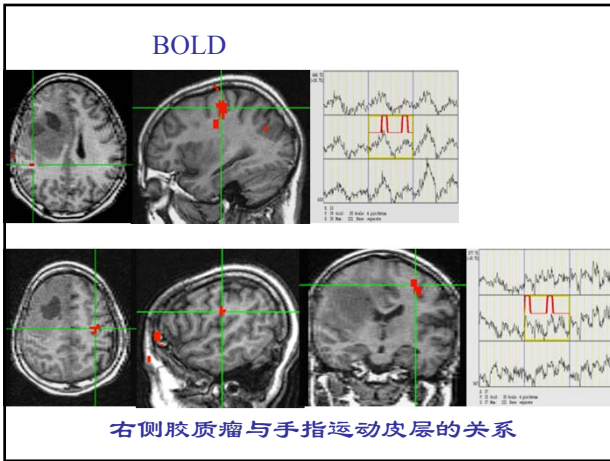
脑膜瘤患者手运动BOLD图

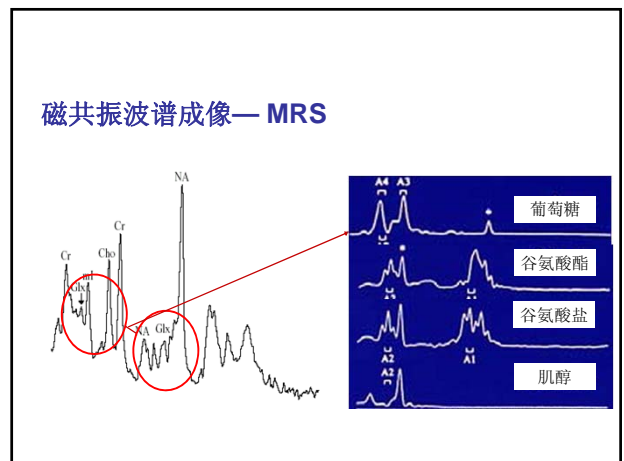
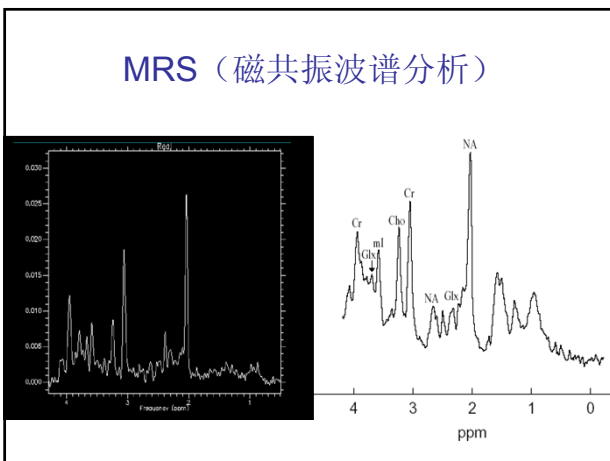
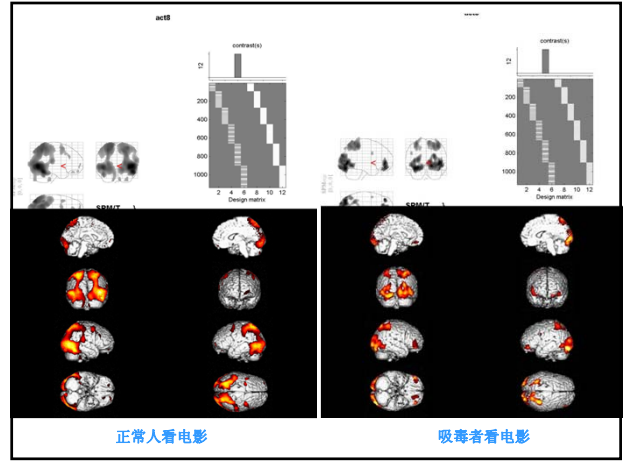
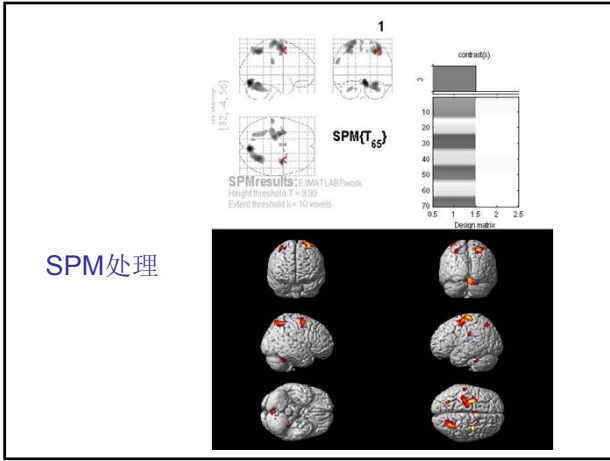


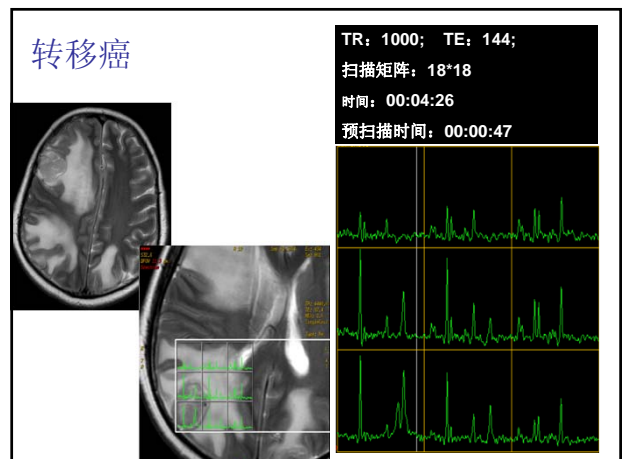
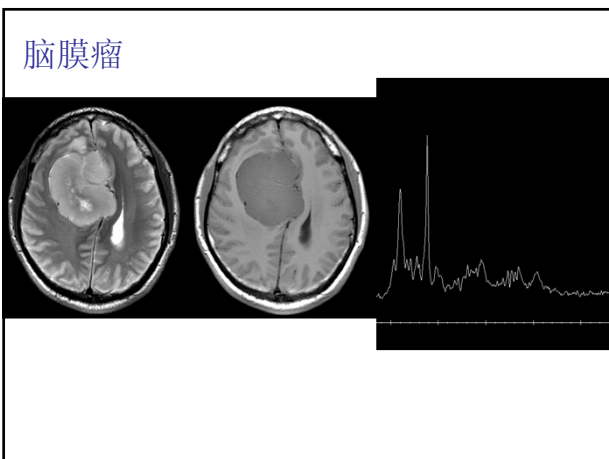
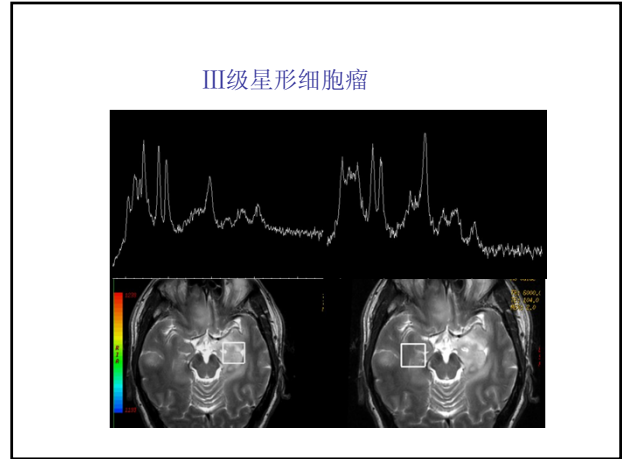
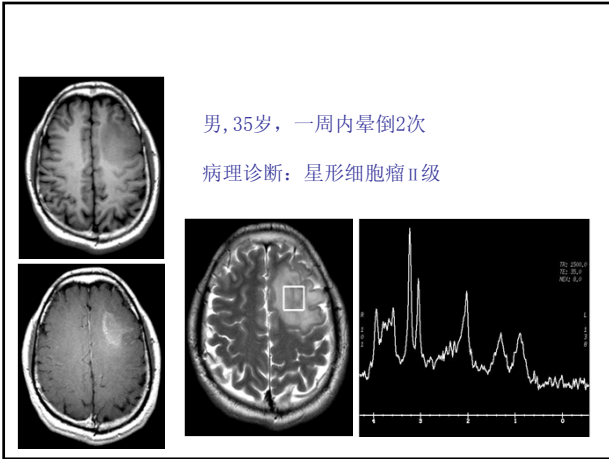
右侧大脑镰旁脑膜瘤，左手运动，术前及术后BOLD

胶质瘤患者术前手运动BOLD图





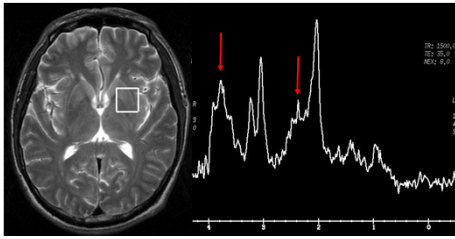




肝性脑病

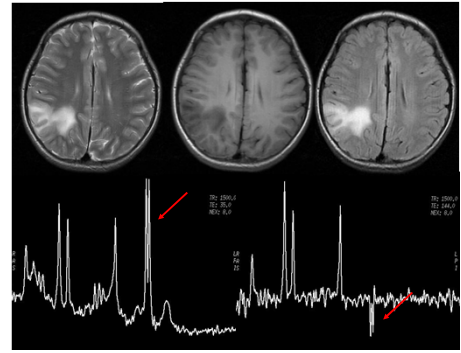
- 男，46岁，肝炎后肝硬化8年，间断性行为异常10月，再发5天
- 肝性脑病I期，肝功能失代偿期(chidd C级)，2型糖尿病，门脉高压，脾切除术后

TR: 1500
TE: 35
重复64次
时间: 00:01:42

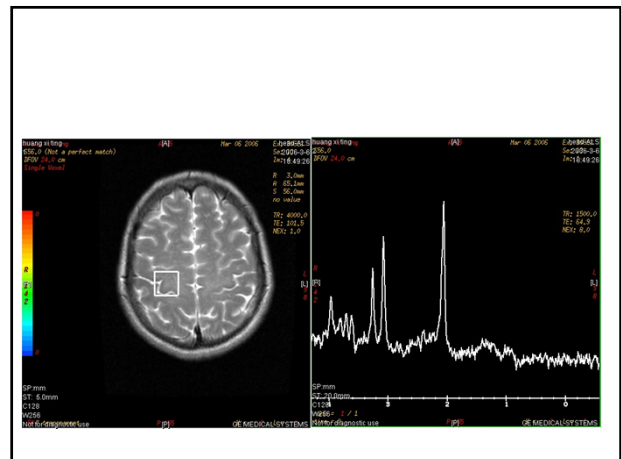
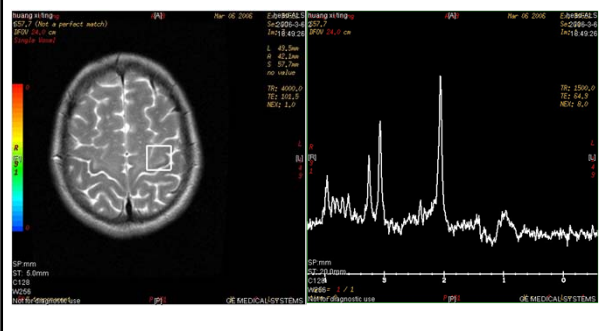


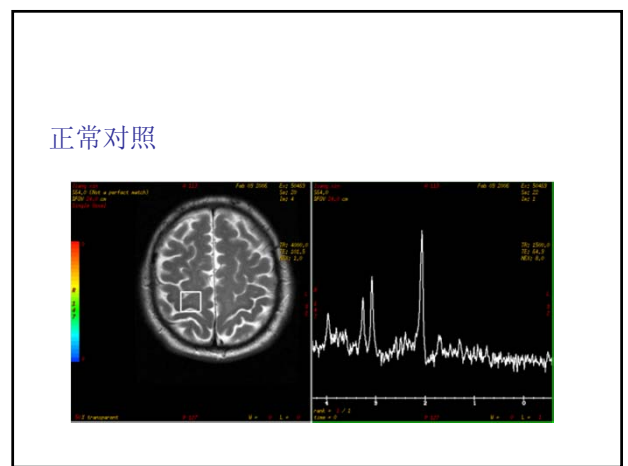
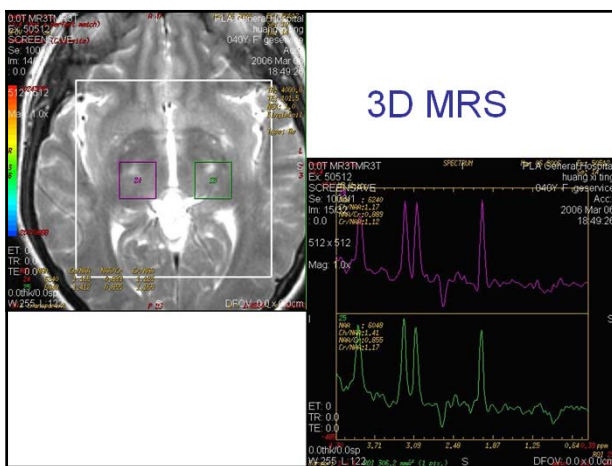
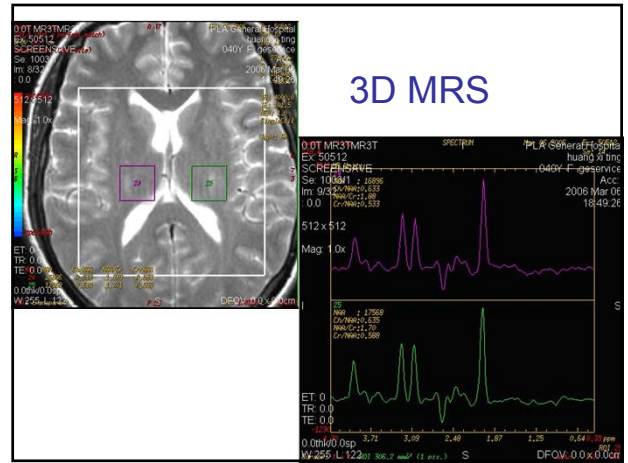
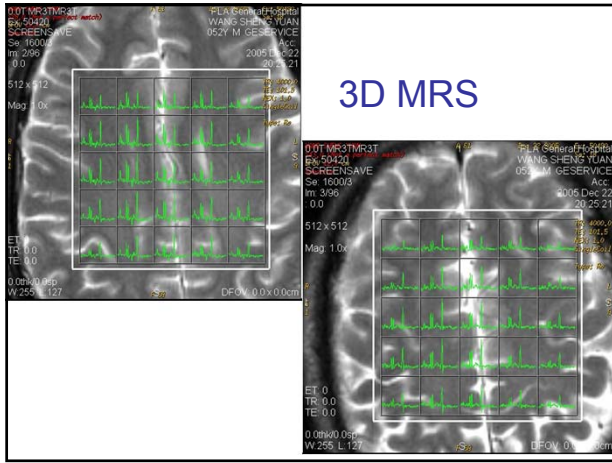
线粒体肌脑病

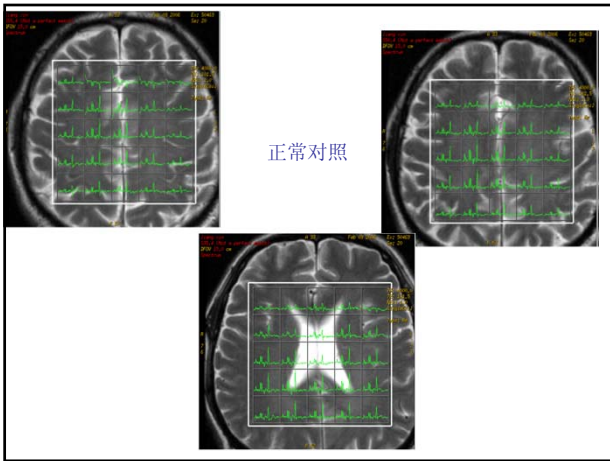
- 男，12岁
- 发作性左侧肢体抽搐伴意识障碍2年余，协调性差
- 查体：双上肢协调运动少，双手轮替运动差，双Barbinski征阳性
- 血象：乳酸水平增高



ALS患者MRS (2.4ppm Glu, 3.8ppm Glx)





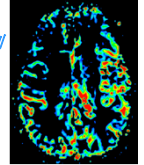


灌注成像 — PWI

❖ 增强：动态磁敏感对比增强 DSC-MRI — 需要注射造影剂

Dynamic Susceptibility Contrast

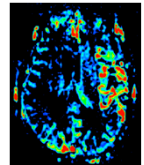
DSC成像对象：短T2*血液（主要指含造影剂血液）



❖ 非增强：动脉自旋标记ASL-MRI — 不需要注射造影剂

Artery Spin Labeling/Tagging

ASL成像对象：磁化标记的血液中的氢质子

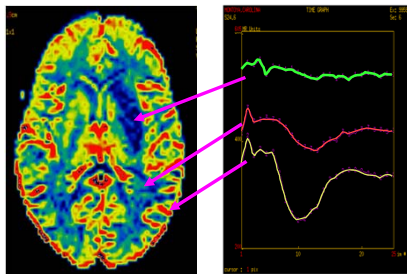


均可反映组织的微血管分布情况及血流灌注状态

灌注成像 — PWI

• 常用参数

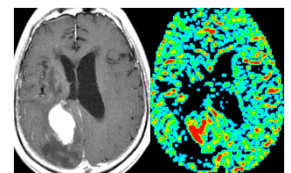
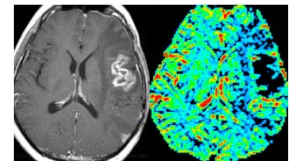
- ❖ rCBF: 脑血流
- ❖ rCBV: 脑血容量
- ❖ MTT: 平均通过时间



灌注成像 — PWI

PWI 在脑肿瘤的应用

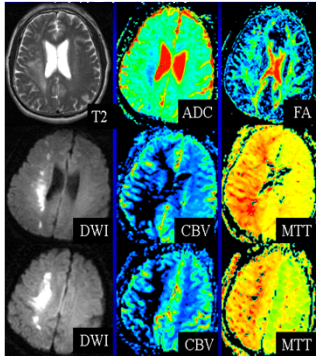
- ❖ rCBV图可反映肿瘤的血液供应程度
- ❖ 可更好的判断胶质瘤的恶性程度
- ❖ 指导立体定向活检
- ❖ 有助于鉴别肿瘤复发与放射性脑坏死
- ❖ 有助于鉴别血管外皮细胞瘤与脑膜瘤



灌注成像 — PWI

PWI 在脑中风中的应用

- ❖ 超急性期可显示缺血部位和范围
- ❖ 组织血供的具体情况
 - 灌注不足: M TT 延长, rCBV 减少, rCBF 明显减少;
 - 侧支循环: M TT 延长, rCBV 增加或正常;
 - 血流再灌注: M TT 缩短或正常, rCBV 增加, rCBF 正常或轻度增加;
 - 过度灌注: rCBV 与 rCBF 均显著增加。
- ❖ 与DWI结合对脑组织进行定性分析

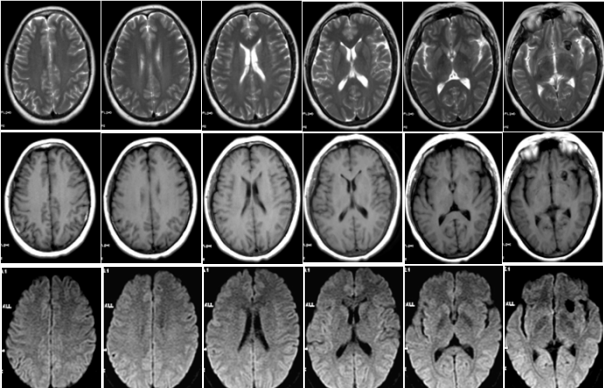


灌注成像 — PWI

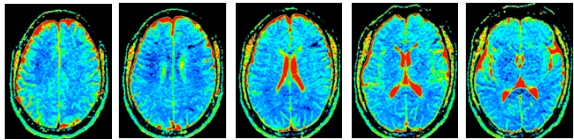
- ❖ 非增强: 动脉自旋标记ASL-MRI ——不需要注射造影剂

安全, 简单, 易被患者接受

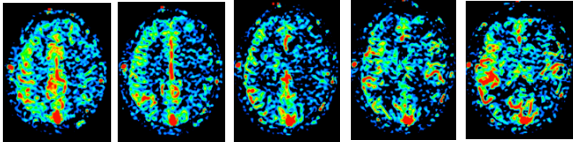
病例: 女性, 头痛 头晕一周, 常规MR未见异常



DWI后处理ADC图未见异常



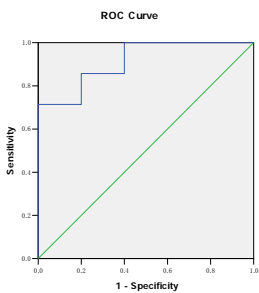
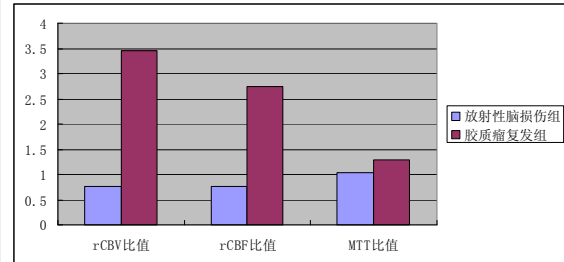
ASL后处理rCBF图见左侧大脑半球血流速度减慢



结论: 左侧大脑半球脑缺血, 建议临床进一步检查、治疗

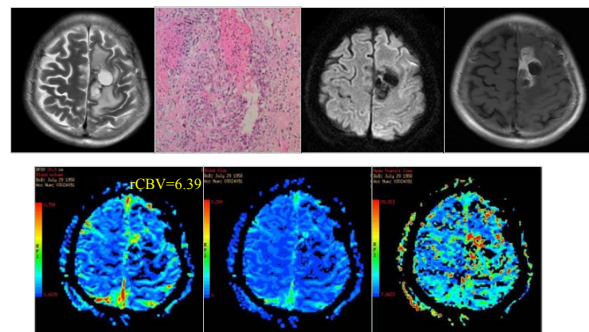
放射性脑损伤与胶质瘤复发的灌注成像比较

灌注参数	放射性脑损伤组 (5例)	胶质瘤复发组 (7例)	统计量	p值
rCBV 比值	0.76 ± 0.42	3.45 ± 2.27	18	0.018
CBF 比值	0.77 ± 0.40	2.74 ± 1.84	22	0.106
MTT 比值	1.03 ± 0.27	1.29 ± 0.30	25	0.268

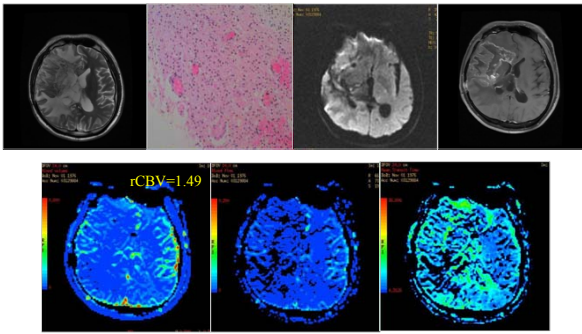


rCBV用于鉴别术后复发与放射性脑损伤的ROC曲线 (面积为0.914)

F, 50岁, 放疗后28个月, 二次手术病理证实为胶质瘤复发

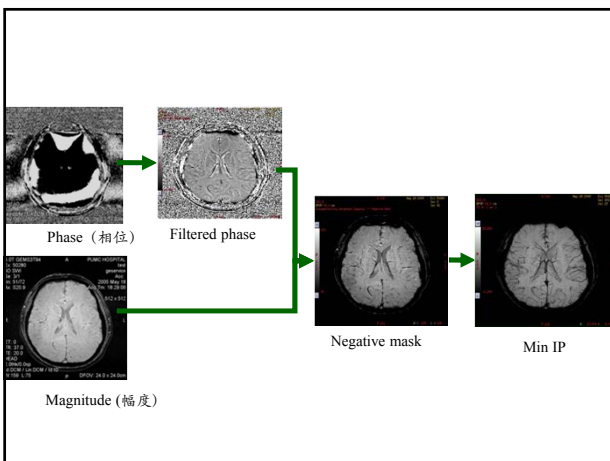


M, 32岁, 放疗后36个月, 二次手术病理证实为放射性脑损伤



磁敏感加权成像 (SWI)

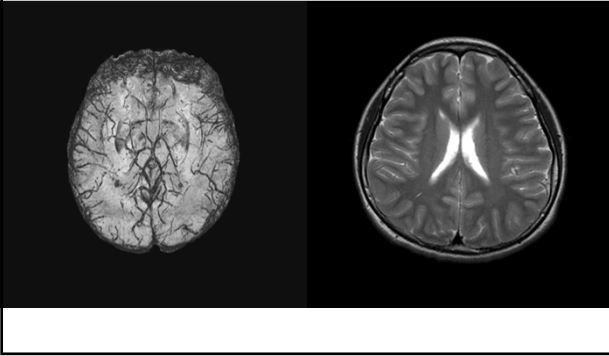
- 利用组织间磁敏感性差异, 通过幅度 (magnitude) 和相位 (phase) 图成像
- 高分辨率、3D采集、薄层重建的梯度回波成像
- 新的对比, 不同于传统的T1WI、T2WI
- 显示组织内在磁敏感性的差异
- 对静脉血管、出血、铁沉积敏感



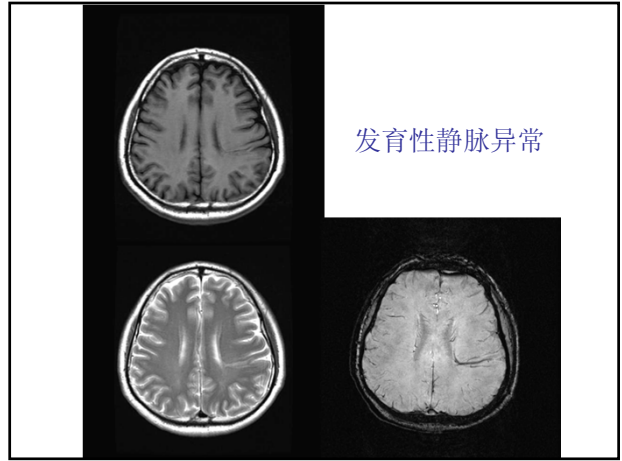
SWI低信号物质:

- 含铁血黄素沉积
- 去氧血红蛋白
- 铁蛋白沉积
- 钙化
- 其他金属物质
- 空气

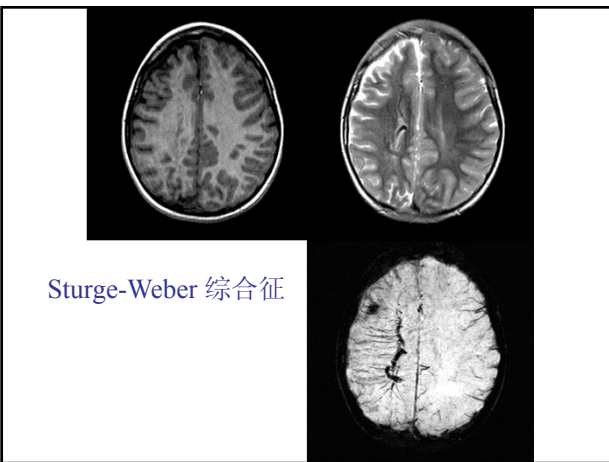
脑内小静脉的显示



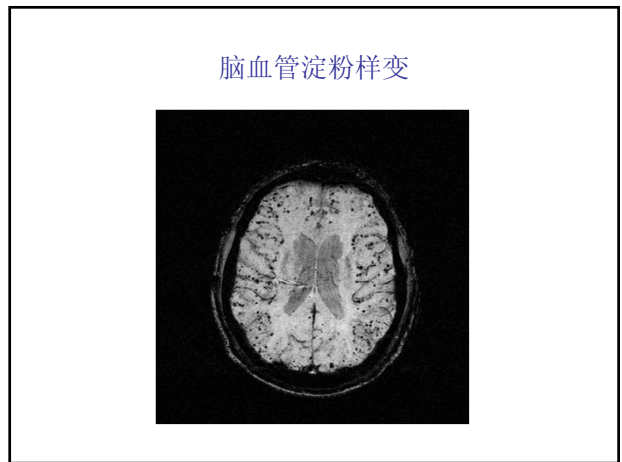
发育性静脉异常



Sturge-Weber 综合征

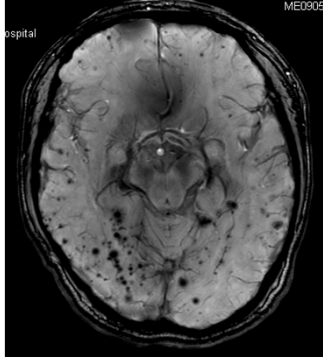


脑血管淀粉样变

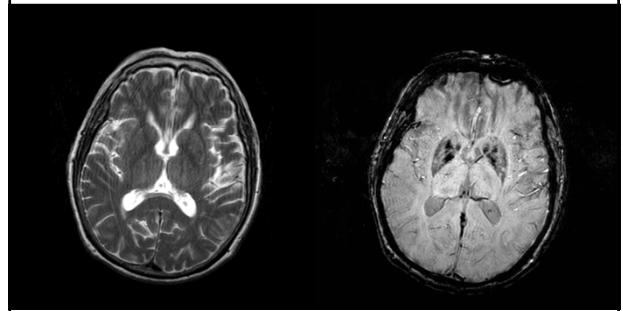


脑血管淀粉样变

微出血



PD patient



基底节区生殖细胞瘤
Basal Ganglia Germinoma

- 基底节区生殖细胞瘤可以很小，无明显异常信号，无异常强化，无明显占位效应或灶周水肿
- 病程可以较长，同侧中脑大脑脚可以出现萎缩
- SWI可以显示肿瘤内少量出血，特别在最大径小于10mm的“早期”基底节区生殖细胞瘤

- 2006-2008年期间，6例患者，均为男性，年龄12~16岁，平均14岁
- 3.0T磁共振扫描仪，常规平扫及增强扫描，均行SWI扫描
- 常规扫描肿瘤最大径小于10mm的定义为“早期”，大于10mm的定义为“晚期”
- 临床表现2~16月
- 5例脑脊液检查为阴性（AFP、HCG、肿瘤细胞）
- 3例活检，3例手术证实

肿瘤在T1WI、T2WI及SWI测量值

Case No.	T1WI (mm)	T2WI (mm)	SWI (mm)
1*	4	7	18
2*	N/A	8	21
3	38	38	32
4	45	45	35
5	15	15	12
6*	N/A	8	20

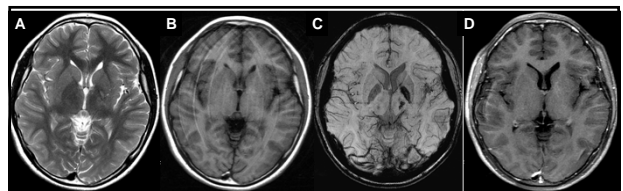
*: “早期”

肿瘤在T1WI、T2WI及SWI的对比噪声比(CNR)

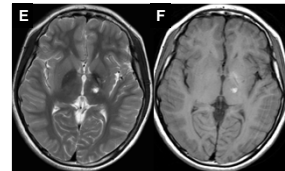
Case No.	T1WI	T2WI	SWI
1*	22.58	32.29	-80.43
2*	13.30	67.48	-100.29
3	152.46	16.62	-10.74
4	25.60	130.10	-15.90
5	-18.19	197.00	-8.64
6*	18.94	45.13	-70.98

基底节区生殖细胞瘤

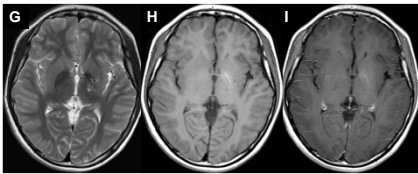
- 男，14岁，右腿无力6月入院
- 脑脊液HCG: 1.88U/L (正常范围)
- 血HCG: 0.391U/L (正常范围)



2007-3-15, 第一次MR检查。患者拒绝二次腰穿复查HCG, 由于生殖细胞瘤证据不足, 建议两月后复查

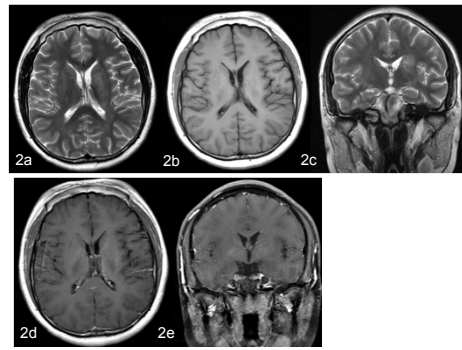


2007-5-21, 第二次检查, 病灶增大, 出现出血

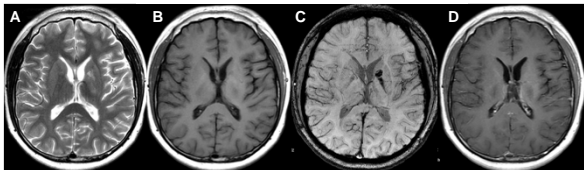


2007-6-18, 进行实验性放疗后病灶缩小

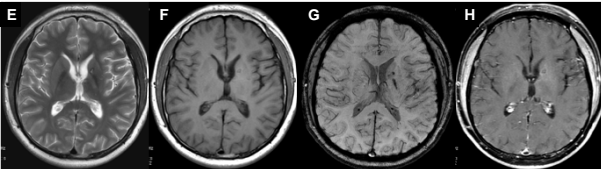
男, 16岁, 右侧肢体力弱4月



男, 16岁, 右侧肢体力弱4月

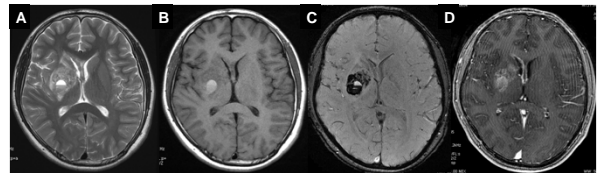


2007-4-13, 考虑生殖细胞瘤

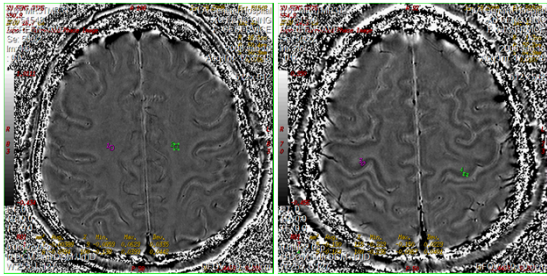


2007-10-30, 放疗后复查, 病灶范围缩小

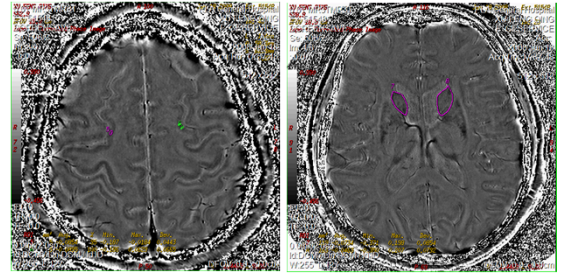
男, 14岁, 左侧肢体力弱1年, 头痛4月, 呕吐2月。病理证实右侧基底节区生殖细胞瘤



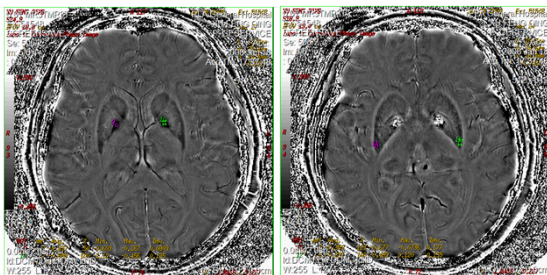
ALS患者与正常对照的SWAN研究



半卵圆中心 (25~35 pixel) 中央前回 (15~25 pixel)

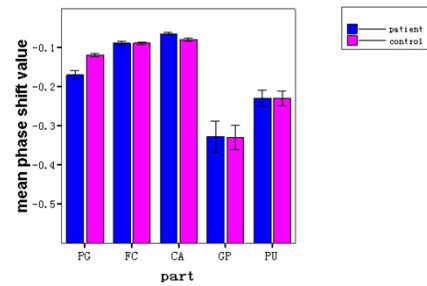


额叶皮层 (15~25 pixel) 尾状核 (在内囊前肢层面依解剖而定)



苍白球 (25~35 pixel) 壳核 (25~35 pixel)

ALS患者与对照组各部位相位偏移量均数对比分析



仅在中央前回, ALS组相位偏移量均值明显较对照组数值小, 相移最明显, 且有统计学意义 (F=16.859, P=0.000)

ALS患者与对照组各部位相位偏移量均数对比条图 (PG: 中央前回 FC: 额叶皮层 CA: 尾状核 GP: 苍白球 PU: 壳核)

神经系统应用总结

