

颅内孤立性纤维性肿瘤的显微手术治疗分析

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【摘要】目的 探讨颅内孤立性纤维性肿瘤的临床特点、影像学特征、病理学特征、显微手术方法及其疗效。方法 回顾性分析 2014 年 8 月至 2023 年 7 月手术治疗并经术后病理证实的 31 例颅内孤立性纤维性肿瘤的临床资料。结果 31 例中,男 17 例,女 14 例;年龄 16~65 岁;初次手术 17 例,再次手术 14 例;临床表现以头晕、头痛等非特异性症状为主;影像学表现为边界多清晰,MRI 呈稍低 T₁ 信号、高 T₂ 信号,T₂ FLAIR 大多高信号,近半数(14 例,45.2%)可见明显瘤周水肿;MRI T₁ 增强表现为明显均匀强化 18 例(58.1%),不均匀及环形强化 12 例(38.7%)。25 例(80.6%)肿瘤全切除,6 例(19.3%)行次全切除。术后病理检查显示肿瘤特征性表达 STAT6(100.0%,31/31),不同程度表达 CD34(93.5%,29/31)、Vimentin(64.5%,20/31)及 Bcl-2(25.8%,8/31);Ki-67 阳性率 2%~30%,平均(11±7)%,Ki-67 阳性率随肿瘤病理级别升高而升高。失访 9 例,成功随访 22 例,随访时间 6~80 个月,平均(35.0±23.8)个月;死亡 3 例,其余 19 例存活。结论 颅内孤立性纤维性肿瘤瘤周水肿常见,可呈不均匀强化或环形强化,确诊依靠病理检查。肿瘤易复发,可能全身转移,早期诊断、尽早行手术有助于改善病人的预后。

【关键词】 颅内孤立性纤维性肿瘤;血管外皮细胞瘤;显微手术;疗效

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Microsurgical treatment of intracranial solitary fibrous tumors: report of 31 cases

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【Abstract】 Objective To investigate the clinical features, imaging characteristics, pathological features, and microsurgical techniques and outcomes of intracranial solitary fibrous tumors (SFTs). Methods The clinical data of 31 patients with intracranial SFTs who underwent microsurgery from August 2014 to July 2023 were retrospectively analyzed. Results Of these 31 patients with intracranial SFTs, 17 were male and 14 were female; the age ranged from 16 to 65 years; 17 patients underwent the first surgery, and 14 underwent the secondary surgery; the clinical manifestations were mainly non-specific symptoms such as dizziness and headache; most SFTs had the imaging characteristics of well-defined borders, slightly low T₁ signals, high T₂ signals, and high T₂ FLAIR signals; 14 cases (45.2%) showed obvious peritumoral edema; the contrast-enhanced MR T₁ images showed uniform enhancement in 18 cases (58.1%) and non-uniform and ring-like enhancement in 12 cases (38.7%). Total resection of tumor was achieved in 25 patients (80.6%) and subtotal in 6 (19.3%). Postoperative pathological examination showed that positive expression of STAT6 was found in all 31 patients (100%), positive CD34 in 29 patients (93.5%), positive Vimentin in 20 patients (64.5%), and positive Bcl-2 in 8 patients (25.8%); the Ki-67 positive rate ranged from 2% to 30%, with a mean of (11±7)%, and the positive rate increased with the increase of tumor pathological grade. Nine patients were lost to follow-up, and 22 patients were successfully followed up for 6~80 months, with a mean of (35.0±23.8) months; three patients died, and the remaining 19 patients were alive. Conclusions Peritumoral edema is common in intracranial SFTs, and the tumors may show non-uniform enhancement or ring-like enhancement on contrast-enhanced MR T₁ images. Pathological examination is necessary for the diagnosis of SFTs. SFTs are prone to recurrence and may spread throughout the body. Early diagnosis and surgery at an early stage can help improve the prognosis of the patients with intracranial SFTs.

【Key words】 Intracranial solitary fibrous tumor; Hemangiopericytomas; Microsurgery; Efficacy

颅内孤立性纤维性肿瘤(solitary fibrous tumor, SFT)是一种少见的肿瘤,大多起源于脑膜,往往有非常丰富的血液供应,多具有侵袭性,容易复发^[1]。SFT的生长部位和临床表现与脑膜瘤高度类似,术前若能准确地诊断并进行全面地评估和充分地准备,将对临床制定诊疗计划提供更多有利的帮助。本文回顾性分析手术治疗的 31 例 SFT 的临床、影像

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学及病理学资料,并结合文献进行分析,以积累对此类肿瘤的诊治经验。

1 资料与方法

1.1 病例选择标准 纳入标准:①术后病理检查明确诊断为SFT和/或血管外皮细胞瘤(hemangiopericytoma,HPC);②病变位于颅内。排除标准:①临床病例资料不完善;②诊断不明确,不能除外其他病理类型的肿瘤。

1.2 研究对象 回顾性分析2014年8月至2023年7月手术治疗的31例颅内SFT的临床资料,其中男性17例,女性14例;年龄16~65岁,平均(47±11)岁。再次手术14例,术后复发时间2个月至9年,平均(4.5±2.8)年。临床表现以头晕、头痛为主(16例),其他临床表现包括视力、视野障碍(7例)、听力下降(2例)、行走/站立不稳(3例)、肢体运动/感觉障碍等(4例)。1例以突发癫痫为首发症状,1例以突发肿瘤卒中为首发症状,1例因头部外伤检查意外发现。

1.3 影像学资料 15例位于幕上(其中2例位于额叶,

4例位于枕叶,3例位于颞叶,1例位于顶叶,另有5例肿瘤较大,累及两个或两个以上脑叶),5例位于桥脑小脑角区,5例位于小脑,3例位于鞍区,2例位于颅底,1例位于松果体区。肿瘤大小15 mm×10 mm×5mm~105 mm×90 mm×40 mm。8例出现中线结构移位,14例出现明显瘤周水肿。21例表现为低T₁、高T₂信号,19例表现为T₂ FLAIR高信号。T₁增强显示均匀强化19例,肿瘤边缘环形强化2例,不均匀强化10例(图1、2)。磁共振灌注成像显示肿瘤区域存在丰富血供,磁共振波谱分析显示NAA峰及Cho峰均降低(图3)。16例术前行CT检查,其中10例表现为均匀高密度影,6例密度不均;未见明显钙化影,1例有颅骨侵犯。

1.4 手术方法 31例均行开颅肿瘤切除术。针对不同区域肿瘤选择不同手术入路,充分暴露肿瘤后,以保证重要神经功能为前提分块切除肿瘤,分为全切除(无手术显微镜下可见残留)、次全切除(残余肿瘤体积<10%)及部分切除(残余肿瘤体积≥10%)。术中观察肿瘤的特征,包括部位、大小、形态、质地、有

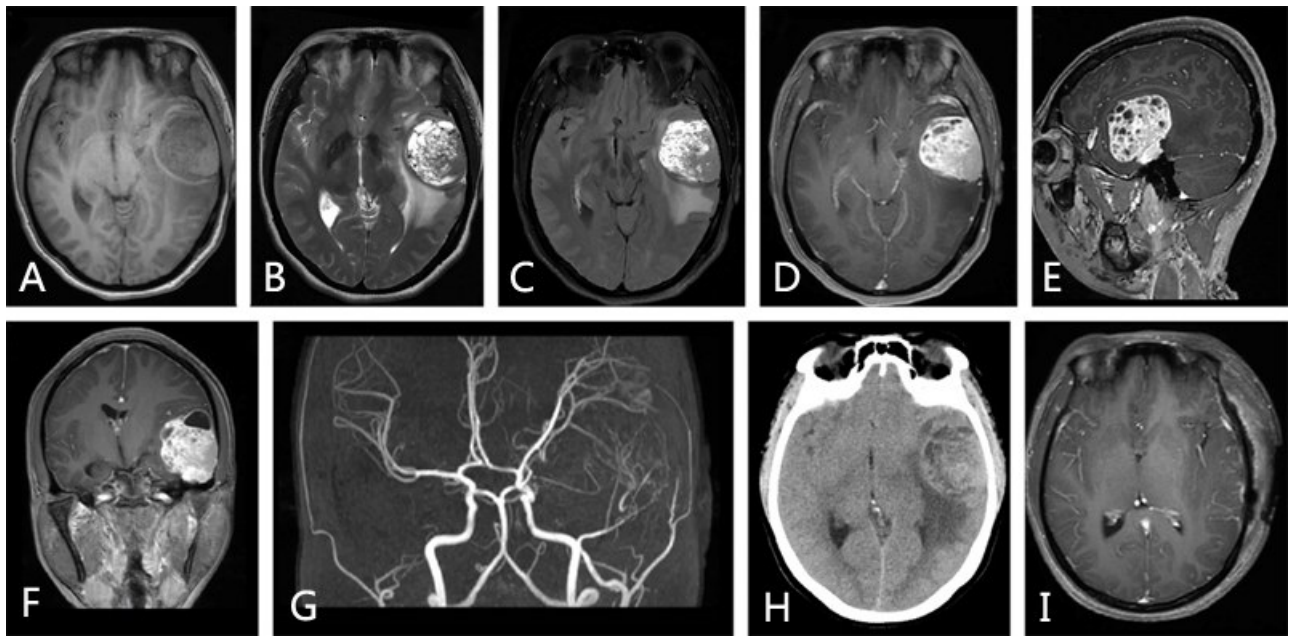


图1 左侧额颞叶WHO分级1级孤立性纤维性肿瘤的影像学表现

A. MRI T₁平扫呈不均匀稍低信号,中线结构向健侧明显移位;B. MRI T₂平扫呈不均匀高信号,可见瘤周水肿;C. MRI T₂ FLAIR像呈高信号,可见瘤周水肿;D~F. MRI T₁像增强显示肿瘤呈明显不均匀强化,与周围组织分界清晰;G. MRA显示肿瘤主要由左侧大脑中动脉和脑膜中动脉供血;H. CT示肿瘤密度不均匀,伴瘤周水肿;I. 术后MRI T₁像增强显示肿瘤全切除

Figure 1 Imaging findings of a solitary fibromatous tumor (WHO grade 1) in the left temporal and frontal lobes

A: Preoperative MR T₁ images show uneven slightly low signal and the midline structures shifted markedly to the contralateral side. B: Preoperative MR T₂ images show uneven high signal and visible peripheral edema. C: Preoperative MR T₂ FLAIR images show high signal and visible peripheral edema. D~F: Preoperative contrast-enhanced MR T₁ show markedly uneven enhancement of the tumor, with clear delineation of the boundary with surrounding tissues. G: Preoperative MRA shows that the tumor was mainly supplied by the left middle cerebral artery and the middle meningeal artery. H: Preoperative CT shows uneven density of the tumor, accompanied by peripheral edema. I: Postoperative contrast-enhanced MR T₁ images show complete resection of the tumor.

无包膜等。

2 结果

2.1 手术结果 术中观察发现,肿瘤大多呈分叶状,质软,灰白至淡红色多见,18 例(58.1%)具有完整的包膜;27 例(87.1%)肿瘤血供丰富,术中出血多。25 例(80.6%)肿瘤全切除,6 例(19.3%)因位于重要的功能区,行次全切除。术后并发症包括:1 例出现硬膜外血肿。14 例术后接受放射治疗。

2.2 病理检查结果 显微镜下观察显示肿瘤细胞以梭形细胞为主,细胞间可见大量粗细不等的血管走行;细胞核明显红染,排列密集,异型性明显,核分裂象较多。WHO 分级 1 级 2 例(6.4%),2 级 19 例(61.3%),3 级 10 例(32.3%)。

免疫组化染色显示:Ki-67 阳性率 2%~30%,平

均(11±7)%,其中 WHO 分级 1 级 2 例分别为 2%和 4%,WHO 分级 2 级平均(10±6)%,WHO 分级 3 级平均(16±6)%。7 例(22.6%)Ki-67 阳性率≤5%,24 例(77.4%)>5%。STAT6 阳性 31 例(100%);CD34 阳性 29 例(93.5%);Vimentin 阳性 20 例(64.5%);Bcl-2 阳性 8 例(25.8%)。见图 4。

2.3 随访结果 失访 9 例,成功随访 22 例,随访时间 6~80 个月,平均(35.0±23.8)个月。死亡 3 例,其中 1 例 WHO 分级 2 级,行肿瘤大部切除,术后积极行放疗,术后 51 个月肿瘤复发死亡;1 例 WHO 分级 2 级,行肿瘤全切除术,术后未行放疗,术后 5 个月肿瘤复发死亡;1 例 WHO 分级 3 级,行肿瘤全切除术,未见复发征象,术后 38 个月因其他疾病死亡。其余存活的 19 例中,1 例行肿瘤全切除术,并积极放疗,术后出现复发,伴有全身多处转移,行放疗+化疗控制病

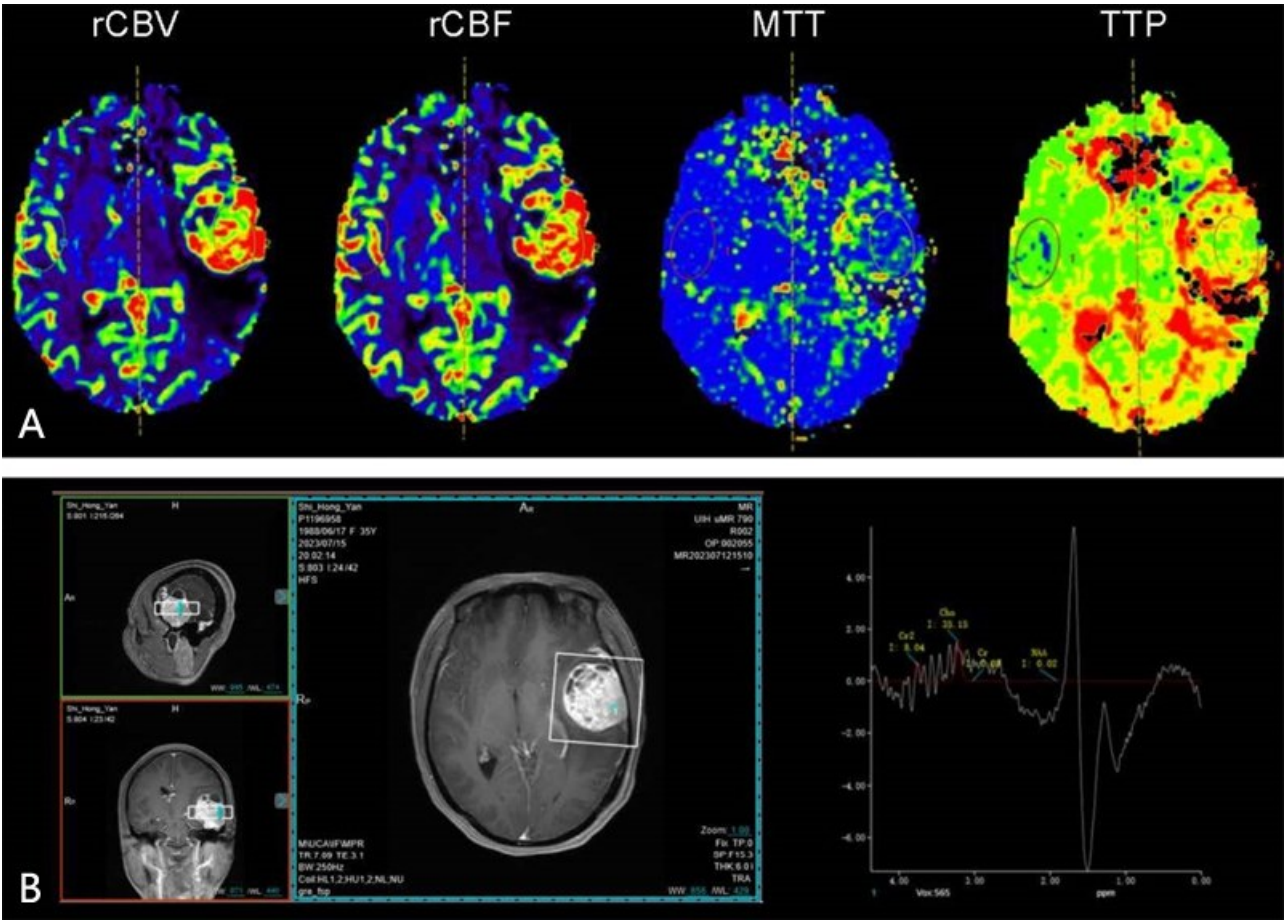


图2 左侧额颞叶WHO 分级1 级孤立性纤维性肿瘤的影像学表现

A. PWI 显示肿瘤存在丰富血供,水肿区血供减低,肿瘤处局部脑血容量、局部脑血流量明显升高,对比剂平均通过时间明显降低,对比剂达峰时间稍低;B. MRS 显示肿瘤组织 NAA 峰及 Cho 峰均降低

Figure 2 Imaging findings of a solitary fibromatous tumor (WHO grade 1) in the left temporal and frontal lobes

A: PWI demonstrates that the tumor possessed abundant blood supply, while the blood supply in the edema area was reduced; the regional cerebral blood volume and regional cerebral blood flow were conspicuously elevated, the mean transit time was significantly decreased, and the time to peak was slightly lower. B: MRS indicates that both the NAA and Cho peaks of the tumor tissue were decreased.

情进展;18 例无复发。

3 讨论

SFT 是一种少见的肿瘤,起源于间充质细胞,由 Klemperer 于 1931 年首次报道^[2]。HPC 起源于毛细血管壁的周细胞,由 Stout^[3]于 1949 年首次报道。2013 年,Schweizer 等^[4]首次发现 HPC 内存在 SFT 的特征性融合基因,即神经生长因子 1A 结合蛋白 2(nerve growth factor 1A binding protein 2, NAB2)-信号转导

和转录激活因子 6(signal transducer and activator of transcription 6, STAT6)^[5,6],这提示 SFT 和 HPC 可在病理学上归类为同种肿瘤。在 2021 版 WHO 中枢神经系统肿瘤分类中,取消“血管外皮细胞瘤”的诊断,将其合并至 SFT 中^[7]。SFT 可发生于全身各处,包括胸膜、腹膜、鼻窦、口腔、眼眶、甲状腺、乳腺及颅内等^[8,9]。颅内 SFT 罕见,占中枢神经系统原发性肿瘤的比例不到 1%^[10]。
本文纳入的 31 例 SFT 中,男性略多于女性,年龄

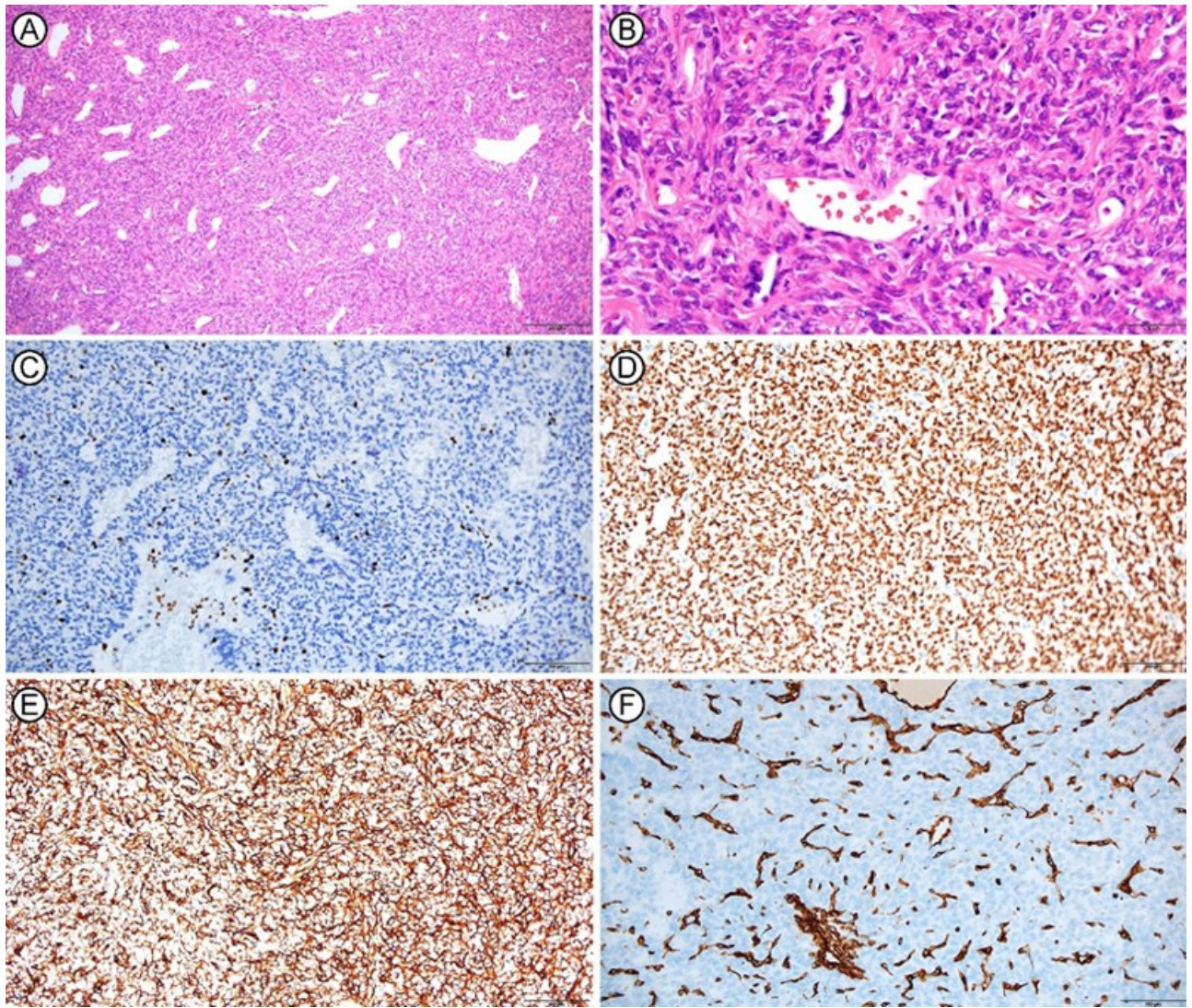


图 3 左侧额颞叶 WHO 分级 1 级孤立性纤维性肿瘤的病理表现
A. HE 染色显示细胞排列紧密,细胞间可见胶原,血管非常丰富(×100);B. HE 染色,高倍镜(×400)下观察,可见血管弯曲、扩张,呈现“鹿角”样,异形性低;C. Ki-67 免疫组化染色显示阳性率 3%~5%(×200);D. STAT6 免疫组化染色显示肿瘤细胞核阳性(×200);E. CD34 免疫组化染色显示肿瘤细胞胞浆阳性(×200);F. Viventin 免疫组化染色显示肿瘤细胞阴性,血管阳性(×200)

Figure 3 Pathological findings of a solitary fibrotic tumor (WHO grade 1) in the left temporal and frontal lobes
A: HE staining reveals a compact arrangement of cells, with collagen discernible between them and an abundance of blood vessels (×100). B: HE staining shows tortuous and dilated blood vessels presenting a stag horn-like configuration, and low atypia (×400). C: Ki-67 immunohistochemical staining indicates a positive rate ranging from 3% to 5% (×200). D: STAT6 immunohistochemical staining demonstrates positive expression of STAT6 in the nuclei of tumor cells (×200). E: CD34 immunohistochemical staining shows positive expression of CD34 in the cytoplasm of tumor cells (×200). F: Viventin immunohistochemical staining reveals negative expression of Viventin in tumor cells and positive expression of Viventin in blood vessels (×200).

分布集中在 40~60 岁。SFT 可发生在颅内任何部位,其临床表现多不典型,以头晕、头痛为主,累及枕部的 SFT 多有视力障碍,累及小脑的 SFT 可出现行走/站立不稳等表现。

SFT 的影像学表现无特异性,较难与其他中枢神经肿瘤鉴别。研究报道,SFT 的 CT 可表现为密度高,可见坏死、囊性变,但很少见钙化;MRI T₁ 相信号强度与脑组织相等或较低,T₂ 相信号强度等于或高于脑组织,伴有明显的均匀或不均匀强化^[11-13]。本文 SFT 的 CT 多表现为稍高密度影,MRI 多表现为 T₁ 低信号、T₂ 高信号,这与既往报道大致相符。本文近 40% 的 SFT 表现为不均匀或环形强化,近半数 (45.2%) 病例伴有明显的中线移位及瘤周水肿。这提示该肿瘤侵袭性较强,可作为肿瘤鉴别的特征之一。

术中通常可见 SFT 质韧,与周围组织边界清晰,肿瘤外观可呈淡红色,有明显的包膜,与脑膜瘤类似。肿瘤呈血窦样,血供较脑膜瘤更为丰富。组织学上,肿瘤由圆形或梭形细胞构成,大小较为一致,间质可有胶原纤维增生;瘤周可见丰富的、管壁厚薄不一的血管结构,这些血管结构可呈现具有特征性的“鹿角”样扩张。高级别 SFT 细胞可存在明显异型性,伴核分裂象增多。2021 年 WHO 中枢神经系统肿瘤分类依据组织病理学将 SFT 分为 3 级:1 级,肿瘤细胞呈梭形,细胞疏松,间质较多;2 级,肿瘤细胞呈圆形,密度较高,间质较少,可见“鹿角”样血管扩张;3 级,肿瘤细胞密度高,异型性明显,核分裂象≥4 个/10 个高倍镜视野^[14];其中 1 级为良性肿瘤,预后较好;2 级为低度恶性,积极治疗后可获得较好的预后;3 级恶性程度高,预后不良。本文 1 级仅 2 例,2 级 19 例,3 级 10 例。

免疫组化染色是确诊 SFT 的重要依据。SFT 细胞最具特征的标志物是 NAB2-STAT6 融合基因^[15, 16],其余指标如 CD34、CD99、Vimentin、Bcl-2 等也具有参考价值,多种指标联合检测有助于提高 SFT 的诊断准确度。本文病例 STAT6 阳性率为 100%,具有很高的敏感性;CD34 阳性率为 93.5%、Vimentin 阳性率为 64.5%、Bcl-2 阳性率为 25.8%,也具有一定的诊断价值。Ki-67 指数与 SFT 的 WHO 分级以及预后密切相关^[17]。本文 26 例 (80.7%) SFT 的 Ki-67 指数>5%,提示该肿瘤恶性程度较高;WHO 分级 2 级 SFT 的 Ki-67 指数平均值为 (10±6)%,而 WHO 分级 3 级 SFT 的 Ki-67 指数平均值为 (16±6)%,具有明显的增高趋势。

SFT 的首选治疗方法为手术切除,术后辅以足量的放疗可降低肿瘤的复发率^[18, 19]。本文 31 例 SFT 中,25 例肿瘤完全切除,6 例因肿瘤位于重要的功能区而未能完全切除,行大部切除;术后 1 例出现硬膜外血肿,再次手术后预后良好。SFT 复发率较高,并可出现全身转移^[20-22]。本文病例中复发而再次手术者 14 例,占比较高 (45.2%)。本文病例出院后随访发现,14 例术后接受进一步放疗,3 例出现复发,其中 1 例伴全身转移,行再次手术,并辅以放化疗;其余 2 例术后复发死亡。这提示该肿瘤较容易复发,且具有较高的侵袭性。本文死亡病例中,1 例 WHO 分级 2 级,行肿瘤全切除而未行放疗,术后 5 个月肿瘤复发死亡。这例提示术后放疗有助于改善病人预后。

SFT 的血供丰富,手术出血量大,风险较高。术前栓塞供血动脉降低手术出血量、缩短手术时间,有助于降低手术风险。术前栓塞已在颅内其他肿瘤,如脑膜瘤、血管母细胞瘤中得到运用,显著降低出血量和手术并发症^[23, 24]。因此,术前栓塞可能对于 SFT 病人具有明显的临床意义。

总之,SFT 易复发、可能转移、具有侵袭性,早期发现、尽早行手术治疗有助于改善病人预后。STAT6 免疫组化对 SFT 诊断具有较高敏感性,具有鉴别价值。

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【参考文献】

[1] BISCEGLIA M, GALLIANI C, GIANNATEMPO G, *et al.* Solitary fibrous tumor of the central nervous system: a 15-year literature survey of 220 cases (August 1996–July 2011) [J]. *Adv Anat Pathol*, 2011, 18(5): 356–392.

[2] KLEMPERER P, COLEMAN BR. Primary neoplasms of the pleura: a report of five cases [J]. *Am J Ind Med*, 1992, 22(1): 1–31.

[3] STOUT AP. Hemangiopericytoma: a study of 25 cases [J]. *Cancer*,

- 1949, 2(6): 1027–1054.
- [4] SCHWEIZER L, KOELSCHE C, SAHM F, *et al.* Meningeal hemangiopericytoma and solitary fibrous tumors carry the NAB2–STAT6 fusion and can be diagnosed by nuclear expression of STAT6 protein [J]. *Acta Neuropathol*, 2013, 125(5): 651–658.
- [5] ISHIZAWA K, TSUKAMOTO Y, IKEDA S, *et al.* ‘Papillary’ solitary fibrous tumor/hemangiopericytoma with nuclear STAT6 expression and NAB2–STAT6 fusion [J]. *Brain Tumor Pathol*, 2016, 33(2): 151–156.
- [6] DAVANZO B, EMERSON R E, LISY M, *et al.* Solitary fibrous tumor [J]. *Transl Gastroenterol Hepatol*, 2018, 3: 94.
- [7] GRITSCH S, BATCHELOR TT, GONZALEZ CASTRO LN. Diagnostic, therapeutic, and prognostic implications of the 2021 World Health Organization classification of tumors of the central nervous system [J]. *Cancer*, 2022, 128(1): 47–58.
- [8] NEGURĂ I, IANOLE V, DĂNILĂ R, *et al.* Primary solitary fibrous tumor of the thyroid gland: a review starting from a case report [J]. *Arch Clin Cases*, 2021, 8(4): 97–105.
- [9] NITTA T, KIMURA K, TOMINAGA T, *et al.* Malignant solitary fibrous tumor of the breast [J]. *Breast J*, 2021, 27(4): 391–393.
- [10] HA MH, JUNG TY, KIM SK, *et al.* Primary intraparenchymal central nervous system solitary fibrous tumor/hemangiopericytoma presenting with intracerebral hemorrhage: a case report [J]. *Brain Tumor Res Treat*, 2019, 7(1): 53–56.
- [11] METELLUS P, BOUVIER C, GUYOTAT J, *et al.* Solitary fibrous tumors of the central nervous system: clinicopathological and therapeutic considerations of 18 cases [J]. *Neurosurgery*, 2007, 60(4): 715–722.
- [12] CAROLI E, SALVATI M, ORLANDO ER, *et al.* Solitary fibrous tumors of the meninges: report of four cases and literature review [J]. *Neurosurg Rev*, 2004, 27(4): 246–251.
- [13] KIM KA, GONZALEZ I, MCCOMB JG, *et al.* Unusual presentations of cerebral solitary fibrous tumors: report of four cases [J]. *Neurosurgery*, 2004, 54(4): 1004–1009.
- [14] LOUIS DN, PERRY A, WESSELING P, *et al.* The 2021 WHO Classification of Tumors of the Central Nervous System: a summary [J]. *Neuro Oncol*, 2021, 23(8): 1231–1251.
- [15] DEMICCO EG, HARMS PW, PATEL RM, *et al.* Extensive survey of STAT6 expression in a large series of mesenchymal tumors [J]. *Am J Clin Pathol*, 2015, 143(5): 672–682.
- [16] BERGHOFF AS, KRESL P, BIENKOWSKI M, *et al.* Validation of nuclear STAT6 immunostaining as a diagnostic marker of meningeal solitary fibrous tumor (SFT)/hemangiopericytoma [J]. *Clin Neuropathol*, 2017, 36(2017)(2): 56–59.
- [17] YAMAMOTO Y, HAYASHI Y, MURAKAMI I. Recurrence of solitary fibrous tumor/hemangiopericytoma could be predicted by Ki-67 regardless of its origin [J]. *Acta Med Okayama*, 2020, 74(4): 335–343.
- [18] SWAMINATHAN S, RUZEVICK J, VENUR V, *et al.* Intracranial solitary fibrous tumor/hemangiopericytoma treated with microsurgical resection: retrospective cohort analysis of a single-center experience [J]. *Ther Clin Risk Manag*, 2022, 18: 901–912.
- [19] RAMAKRISHNA R, ROSTOMILY R, SEKHAR L, *et al.* Hemangiopericytoma: radical resection remains the cornerstone of therapy [J]. *J Clin Neurosci*, 2014, 21(4): 612–615.
- [20] HENDRICKSON RAHMLow T, KOLAGATLA S, MATTINGLY K, *et al.* Liver metastasis from intracranial hemangiopericytoma 8 year after initial resection: case report [J]. *J Investig Med High Impact Case Rep*, 2022, 10: 23–24.
- [21] ALABSSI H, ALISMAIL M, TAHA MS, *et al.* Primary intracranial solitary fibrous tumor with metachronous pulmonary and bone metastasis: a case report [J]. *Cureus*, 2022, 14(12): 32607.
- [22] XIAO L, LI L. Bilateral renal metastasis from intracranial solitary fibrous tumor/hemangiopericytoma revealed on (18)F–FDG PET/CT and contrast-enhanced CT [J]. *Hell J Nucl Med*, 2021, 24(3): 272–273.
- [23] CHEN L, LI DH, LU YH, *et al.* Preoperative embolization versus direct surgery of meningiomas: a meta-analysis [J]. *World Neurosurg*, 2019, 128: 62–68.
- [24] DONZELLI GF, NELSON J, MCCOY D, *et al.* The effect of preoperative embolization and flow dynamics on resection of brain arteriovenous malformations [J]. *J Neurosurg*, 2019, 132(6): 1836–1844.

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