·专题讲座·

颅内动-静脉畸形的外科治疗评价

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【摘要】 颅内动-静脉畸形的治疗目的是消除颅内出血风险,最大限度地保护神经功能。治疗方法包括显微外科手术、血管内栓塞治疗和立体定向放射外科治疗。本文主要讨论颅内动-静脉畸形的各种治疗方法,评价其优劣,以利于制定合理的治疗策略,提高治愈率并最大限度地降低并发症的发生。

【关键词】 颅内动静脉畸形; 显微外科手术; 栓塞,治疗性; 放射外科手术; 综述

Evaluation of surgical treatment for intracranial arteriovenous malformations

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【Abstract】 The main purpose of the treatment of intracranial arteriovenous malformations (AVMs) is complete obliteration of the nidus to prevent primary or recurrent intracranial hemorrhage and protect neurological functions maximally. Currently, microsurgical resection, endovascular embolization, or stereotactic radiosurgery are the most commonly used therapies which are utilized either alone or in combination. This study will discuss the pros and cons of the three therapeutic methods of AVMs in order to determine the optimal treatment. The choice of a multimodality treatment should follow the principle of improving the cure rate and avoiding complications as much as possible.

【Key words】 Intracranial arteriovenous malformations; Microsurgery; Embolization, therapeutic; Radiosurgery; Review

颅内动-静脉畸形(AVMs)系指供血动脉与引流静脉之间存在迂曲、盘旋的血管结构和异常分流,无毛细血管床,因而导致动-静脉直接交通和异常分流,产生一系列脑血流动力学紊乱,并出现相应临床症状与体征。目前,颅内动-静脉畸形的治疗方法主要包括显微外科手术、血管内栓塞治疗和立体定向放射外科(SRS)治疗。本文重点讨论分析各种颅内动-静脉畸形治疗方法的优劣,有助于制定合理的治疗策略,从而提高治愈率,并且最大限度地减少手术并发症。

一、显微外科手术

显微外科手术可直接切除病灶,是最为直接和彻底的治疗方法。但对于体积较大、位置较深、存在深部供血和引流的颅内动-静脉畸形病灶,手术风险较大。目前,Spetzler-Martin(S-M)分级被广泛应用于预测手术风险和治疗效果[1]。S-M分级为低级别的颅内动-静脉畸形(Ⅰ～Ⅱ级)可以通过显微外科手术予以切除,术后病残率<1%;而高级别的颅内动-静脉畸形(Ⅳ～Ⅴ级)术后病残率可高达31%和50%[1-2]。S-MⅢ级颅内动-静脉畸形,包括S1V1E1、S2V1E0、S2V0E1和S3V0E0等类型,由于类型复杂且个体差异性显著,据美国加州大学旧金山分校研究小组报告,S1V1E1、S2V1E0和S2V0E1型颅内动-静脉畸形患者术后病残率和病死率分别为2.9%、7.1%和14.8%[3]。而Davidson和Morgan[4]报告的S1V1E1、S2V1E0、S2V0E1和S3V0E0型颅内动-静脉畸形患者术后病残率和病死率分别为9%、15%、15%和17%;其中S-MⅠ～Ⅱ级颅内动-静脉畸形患者术后病残率和病死率<3%,位于脑非功能区的Ⅲ～Ⅳ级颅内动-静脉畸形患者术后病残率和病死率<30%,位于脑功能区的Ⅲ～Ⅳ级颅内动-静脉畸形患者术后病残率和病死率高达41%。因此,显微外科手术主要适用于治疗S-MⅠ～Ⅱ级和部分Ⅲ级(S1V1E1)颅内动-静脉畸形,尤其是有破裂出血

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史的颅内动-静脉畸形患者。

二、血管内栓塞治疗

由于缺乏理想的血管内栓塞材料，因此血管内栓塞治疗颅内动-静脉畸形的治愈率一直较低。以往使用的α-氰基丙烯酸正丁酯（NBCA）存在微导管粘管的危险，故不能长时间注射，因此对于大型颅内动-静脉畸形的血管内栓塞治疗效果欠佳。近年来，新型液态栓塞剂Onyx逐渐应用于临床。这种新型栓塞剂由于不易发生微导管粘连，可以长时间缓慢注射，且弥散性和可控性良好，使颅内动-静脉畸形的栓塞治疗效果明显提高。因此，应用Onyx血管内栓塞治疗是目前治疗颅内动-静脉畸形的重要措施之一。

血管内栓塞治疗可分为：(1)靶向性栓塞。主要针对颅内动-静脉畸形高危出血的危险因素，如合并血流相关性动脉瘤或畸形团内动脉瘤、引流静脉严重狭窄、明显扩张的引流静脉球（占位效应）等。(2)治愈性栓塞。即完全栓塞颅内动-静脉畸形，使供血动脉远端、全部畸形团和引流静脉近端不再显影。对于直径 < 3 cm的单根供血动脉（终末型）的小型颅内动-静脉畸形，通过Onyx血管内栓塞治疗，绝大多数患者能够获得治愈[5]，因此有国外学者提出以治愈性栓塞为目标。然而，对于大型颅内动-静脉畸形的单纯血管内栓塞治愈率仍较低，病残和病死率约为6.8% ~ 12.5%[6-11]。目前应用于临床的新材料如头端可解脱式微导管或新型栓塞技术如双微导管，均能有效提高血管内栓塞治愈率，减少并发症的发生[12-14]。笔者认为，针对部分血管构筑适用于栓塞的病灶，如终末型供血的致密型畸形团，微导管容易到达畸形团内，且允许Onyx返流2 ~ 3 cm，以分次分期栓塞的方法可以达到治愈之目的[15]。(3)手术前栓塞。对于血管内栓塞手术过程中不易到达的深部供血动脉，可通过闭塞畸形团内高流量的动-静脉瘘，缩小病灶体积，提高手术安全性。Natarajan等[16]应用Onyx对28例大型颅内动-静脉畸形患者施行手术前血管内栓塞术，栓塞后畸形团体积平均缩小74.1%，经手术切除后仅1例畸形团残留，病残率和病死率约为7.1%。(4)放射治疗前的栓塞治疗。于放射治疗前施行血管内栓塞以缩小颅内动-静脉畸形体积，使其残余畸形团最大直径 < 3 cm，适宜行放射外科治疗。目前对血管内栓塞结合放射外科治疗颅内动-静脉畸形的确切疗效尚存争议，其治愈率在文献报道中存在较明显差异，约为14% ~ 90%[17-28]。更有学者认为，血管内栓塞结合放射外科治疗的治愈率低于单纯放射外科治疗，而并发症发生率则高于单纯放射外科治疗[17-22]。笔者认为，血管内栓塞结合放射外科治疗效果欠佳的原因可能与下列因素有关。首先，选择性偏倚为主要因素。血管内栓塞结合放射外科通常用于治疗大型颅内动-静脉畸形，若放射治疗前血管内栓塞治疗不能有效缩小畸形团体积，则部分栓塞无益；由于大型颅内动-静脉畸形血管构筑复杂，精确定位畸形团比较困难，易造成靶向放射治疗剂量的非均一性。其次，血管内栓塞特定的解剖空间。如畸形团边缘有利于放射外科治疗，而对于弥散性栓塞畸形团其体积并未缩小反而不利于放射治疗；而且部分血管内栓塞易导致靶向照射区域形成不规则团簇状，增加适形放射治疗的难度。再次，应用颗粒栓塞材料栓塞颅内动-静脉畸形后血管再通率为2% ~ 19%，仅栓塞供血动脉而不栓塞畸形血管团将增加相邻细小供血动脉的应切力，增加未栓塞部分畸形团的血流供应，造成局部缺血缺氧及炎症反应，刺激新生血管形成。有学者认为，血管内栓塞结合放射外科治疗能够有效栓塞大型颅内动-静脉畸形，栓塞后残余畸形团的体积与治愈率密切相关。据Zabel-du Bois等[26]报告，栓塞后畸形团直径 < 3 cm组的颅内动-静脉畸形结合放射外科治疗后的治愈率（92%）明显高于残余直径 > 3 cm组（60%）；Izawa等[27]报告，栓塞后残余畸形团体积 < 12 ml的动-静脉畸形结合放射外科治疗后的治愈率（90%）明显高于残余体积 > 12 ml患者（60%）。Blackburn等[28]报告通过多次栓塞治疗可使颅内动-静脉畸形残余体积 ≤ 10 ml，明显有利于放射外科治疗。因此有效的血管内栓塞结合放射外科治疗能够有效缩小大型颅内动-静脉畸形体积。

三、立体定向放射外科治疗

立体定向放射外科治疗是利用现代立体定向技术和计算机功能，将高能量射线聚焦于病灶使畸形血管团闭塞。然而因其存在延迟效应，病灶依然存在再出血的风险。一般认为，立体定向放射外科治疗的效果与病灶大小和照射剂量密切相关，颅内动-静脉畸形体积较大、位于脑功能区（边缘照射剂量低）、高流量和畸形团定位偏差可导致低闭塞率。最近，Kano等[29-32]报告了应用立体定向放射外

科治疗颅内动-静脉畸形的单中心系列临床试验结果。共纳入217例S-MⅠ～Ⅱ级的颅内动-静脉畸形患者，采用立体定向放射外科治疗，5年后畸形血管完全闭塞率达90%，10年后完全闭塞率达93%；其中133例基底节和丘脑动-静脉畸形患者5年后畸形血管完全闭塞率达72%，平均年出血率为4.7%，67例脑干动-静脉畸形患者，经立体定向放射外科治疗，5年后畸形血管完全闭塞率达70%，平均年出血率为1.9%。然而，在他们的观察结果中，采用立体定向放射外科治疗大型颅内动-静脉畸形患者疗效欠佳，47例大型颅内动-静脉畸形患者经分期立体定向放射外科治疗后，3年畸形血管完全闭塞率仅为28.2%，平均年出血率达6.5%。因此，单纯立体定向放射外科治疗仅推荐用于治疗位于脑功能区的S-MⅠ～Ⅱ级的未破裂颅内动-静脉畸形，以及位于基底节、丘脑和脑干等深部的病灶，而大型颅内动-静脉畸形则不适宜。

综上所述，颅内动-静脉畸形的治疗目的是消除颅内出血风险，最大限度地保护神经功能。因此，我们推荐对于颅内动-静脉畸形患者的治疗应遵循以下策略：位于浅表脑非功能区的小型颅内动-静脉畸形，建议施行显微外科手术切除畸形血管团；位于重要脑功能区或脑深部的小型颅内动-静脉畸形，应予以立体定向放射外科治疗；位于脑非功能区的大型颅内动-静脉畸形，建议有目的地施行部分血管内栓塞结合显微外科手术治疗（可结合术中功能影像导航）；位于脑功能区的大型颅内动-静脉畸形，推荐分次行血管内栓塞治疗以使其体积缩小至适宜行放射外科治疗；而对于无症状的脑功能区大型颅内动-静脉畸形，仍然建议以观察为主。总之，颅内动-静脉畸形的治疗原则应针对具体病例，术前充分评价颅内动-静脉畸形血管构筑、形态、位置和血流动力学，制定个体化外科治疗方案，争取以最小的代价获得最大的利益。

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·小词典·

中英文对照名词词汇(三)

小脑后下动脉　posterior inferior cerebellar artery(PICA)

小脑前下动脉　anterior inferior cerebellar artery(AICA)

小脑上动脉　superior cerebellar artery(SCA)

心电图　electrocardiogram(ECG)

CT血管造影　CT angiography(CTA)

血红蛋白　hemoglobin(Hb)

吲哚菁绿荧光血管造影
indocyanine green angiography(ICGA)

硬脑膜动-静脉瘘　dural arteriovenous fistula(DAVF)

Glasgow预后分级　Glasgow Outcome Scale(GOS)

运动神经元病　motor neuron disease(MND)

诊断优势比　diagnostic odds ratio(DOR)

诊断准确性研究质量评价
Quality Assessment of Diagnostic Accuracy Studies (QUADAS)

症状性重度颈动脉狭窄患者内膜切除术与血管成形术
Endarterectomy Versus Angioplasty in Patients with Symptomatic Severe Carotid Stenosis(EVA-3S)

症状性椎动脉或颅内动脉粥样硬化性病变的血管内支架成形术
Stenting of Symptomatic Atherosclerotic Lesions in the Vertebral or Intracranial Arteries(SSYLVIA)

支架和强化药物治疗预防颅内动脉狭窄患者脑卒中复发
Stenting and Aggressive Medical Management for Preventing Recurrent Stroke in Intracranial Stenosis(SAMMPRIS)

支架内再狭窄　in-stent restenosis(ISR)

蛛网膜下隙出血　subarachnoid hemorrhage(SAH)

最大扫视速度　maximal saccade velocity(MSV)