

# 颅内血泡样动脉瘤治疗进展

贾强 范一木

**【摘要】** 颅内血泡样动脉瘤常起源于颈内动脉床突上段,其发病率低,但进展迅速、再破裂率高、并发症和病死率高,目前临床治疗方法主要包括显微外科手术及血管内介入治疗。尽管治疗方式多样,但临床上对其治疗策略尚未达成统一的共识。本文结合最新文献,对其治疗进展进行综述,以期对血泡样动脉瘤的治疗提供临床依据,提高其治疗效果。

**【关键词】** 颅内动脉瘤; 显微外科手术; 栓塞,治疗性; 支架; 综述

## The therapeutic progress of intracranial blood blister-like aneurysms

JIA Qiang, FAN Yi-mu

Department of Neurosurgery, Tianjin Huanhu Hospital; Tianjin Key Laboratory of Cerebral Vascular and Neurodegenerative Diseases, Tianjin 300350, China

Corresponding author: FAN Yi-mu (Email: fanyimu@sina.com)

**【Abstract】** The intracranial blood blister-like aneurysms (BBA) arising from the supraclinoid segment of internal carotid artery are very rare, and grow aggressively with high reruptured rate and mortality. Currently, the treatment methods of BBA are various but achieve no consensus, although including microsurgery and interventional therapy. The article collects the recent research and makes a review of the therapeutic progress of BBA, in order to provide clinical basis for the treatment of BBA and improve its therapeutic effect.

**【Key words】** Intracranial aneurysm; Microsurgery; Embolization, therapeutic; Stents; Review

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颅内血泡样动脉瘤(BBA)系指常发生于颈内动脉床突上段前壁、非血管分叉处、外观呈血泡样的一组动脉瘤,其特点为瘤壁薄、体积小、基底宽、瘤颈不明显,且常伴周围载瘤动脉壁缺损,占颅内动脉瘤的0.3%~1%、占颅内破裂动脉瘤的0.9%~6.5%<sup>[1-2]</sup>。颅内血泡样动脉瘤发病机制不详,可能与动脉粥样硬化、高血压及动脉夹层引发的假性动脉瘤有关<sup>[3]</sup>。一项尸检病理学研究表明,血泡样动脉瘤发生于粥样硬化与正常血管壁之间,其内弹力层退化,瘤壁缺乏胶原层,仅有一层菲薄的血管外膜及纤维组织构成,周围管壁发育缺陷<sup>[3]</sup>。血泡样动

脉瘤诊断困难,CT及MRI无特异性表现,DSA往往表现为一小型隆状凸起,若短期内明显增大,则倾向考虑血泡样动脉瘤。基于血泡样动脉瘤的自身特点,无论显微外科手术还是血管内介入治疗,术中及术后的出血风险均较高,且术后极易复发,目前临床对血泡样动脉瘤的最佳治疗方案尚未达成共识。鉴于此,本文拟就近年颅内血泡样动脉瘤的治疗进展进行综述,以期对血泡样动脉瘤的治疗提供临床依据,提高其治疗效果。

### 一、显微外科手术

显微外科手术主要包括单纯动脉瘤夹闭术、动脉瘤包裹夹闭术、血管缝合术以及动脉瘤孤立术伴或不伴颅内血管搭桥术等多种术式,但疗效迥异。Bojanowski等<sup>[4]</sup>认为,造成此种结果的原因主要是忽视了血泡样动脉瘤的自身特点,他们回顾分析既往治疗的血泡样动脉瘤病例,按照其形态分为经典型、浆果型、纵向生长型、周围生长型共4种类

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作者单位:300350 天津市环湖医院神经外科 天津市脑血管与神经变性重点实验室

通讯作者:范一木,Email:fanyimu@sina.com

型,并指出应根据血泡样动脉瘤的不同形态采取相应的手术策略。

1. 单纯动脉瘤夹闭术 对于血泡样动脉瘤,单纯动脉瘤夹闭术的意见并不统一。Owen 等<sup>[5]</sup>认为,对于大部分血泡样动脉瘤患者,动脉瘤夹闭术仍为一线治疗方法。然而,血泡样动脉瘤与囊状动脉瘤不同,因其瘤壁薄、无明显瘤颈且累及周围载瘤动脉,直接夹闭极易造成瘤颈撕裂,可导致术中致命性出血,有文献报道术中出血率达 30%~50%<sup>[6]</sup>;且术后复发率及再出血率也较高。Lee 等<sup>[7]</sup>认为,因动脉瘤夹稳定性较差,移位易导致再出血,因此建议尽量应用套环动脉瘤夹平行载瘤动脉夹闭;夹闭范围应包括血泡样动脉瘤及瘤周部分正常管壁,但可能造成颈内动脉狭窄,并导致严重缺血并发症。Liu 等<sup>[8]</sup>总结 22 例血泡样动脉瘤患者的治疗结果,仅 10 例成功夹闭、12 例出现术中出血,其中 9 例术中行动脉瘤孤立术,且术后出现不同程度的缺血性病变。Meling<sup>[6]</sup>指出,对于血泡样动脉瘤的单纯夹闭应慎重选择,按照 Bojanowski 分型,仅经典型和浆果型的患者较为适用。

2. 动脉瘤包裹夹闭术 包裹后夹闭对于血泡样动脉瘤可以取得良好疗效,尤其是 Bojanowski 分型纵向生长型和周围生长型患者<sup>[4,9]</sup>。动脉瘤包裹夹闭术采用筋膜、棉片、肌肉、纤维织物或聚四氟乙烯等材料,跨过载瘤动脉并包裹动脉瘤,采用动脉瘤夹夹闭动脉瘤及部分载瘤动脉壁,若累及载瘤动脉过长,可采用多个动脉瘤夹串联夹闭<sup>[4]</sup>。包裹材料不仅可以加固薄弱的瘤壁,且增加动脉瘤夹叶片夹持的范围及摩擦力,使动脉瘤夹不易滑脱及撕裂瘤颈,可显著减低术中出血。Hanahara 等<sup>[10]</sup>采用动脉瘤包裹夹闭术治疗 9 例血泡样动脉瘤患者,除 1 例术后 1 个月复发再次行手术治疗外,其余患者均恢复良好,且经过长期随访(平均 37 个月),均未见复发及再出血,载瘤动脉未见进行性狭窄。然而,动脉瘤包裹夹闭术亦存在风险,由于包裹材料的阻挡,有时难以确定动脉瘤边界,易出现夹闭不全而造成动脉瘤复发、再出血或因过度夹闭而影响载瘤动脉供血。Meling 和 Patet<sup>[11]</sup>采用动脉瘤包裹夹闭术治疗的 3 例血泡样动脉瘤患者中,1 例于术后 9 天出现肢体偏瘫,经 DSA 证实系动脉瘤夹造成颈内动脉狭窄所致。故对于有条件的医疗中心,术中尽量采用荧光血管造影以确定载瘤动脉的通畅性<sup>[12]</sup>。

3. 血管缝合术 血管缝合术最初仅为血泡样动

脉瘤术中出血的补救性措施,且其初期疗效并不理想<sup>[6]</sup>。Lee 等<sup>[13]</sup>纳入 6 例术中发生出血后予以血管缝合的血泡样动脉瘤患者,1 例于术后死亡。但随着显微外科材料的发展、技术及理念的不断提高,血管缝合术逐渐作为血泡样动脉瘤治疗的首选手段之一,并取得良好的疗效。Chen 等<sup>[14]</sup>采用血管缝合术治疗 5 例血泡样动脉瘤患者,技术成功率为 100%,经 6 个月至 5 年的随访,未见动脉瘤复发及血管狭窄。石祥恩等<sup>[15]</sup>认为,对于颈内动脉及颅内血管近段仅累及不超过血管周长 1/3 的血泡样动脉瘤,血管缝合术治疗效果满意,而对于累及血管周长 >1/3 的病灶,缝合后存在血管狭窄的风险。他们报告的 8 例行血管缝合术的血泡样动脉瘤患者术后无一例出现血管狭窄及动脉瘤残留,无神经功能损失;经过 1.9~4.1 年的随访,7 例改良 Rankin 量表(mRS)评分为 0~2,1 例出现记忆力减退,mRS 评分为 3。亦有文献报道,血管缝合联合硬脑膜包裹治疗血泡样动脉瘤取得良好的临床效果<sup>[16-17]</sup>。相信随着临床技术水平的提高以及对血泡样动脉瘤的发生和解剖了解的不断深入,血管缝合术的治疗效果会越来越越好。

4. 动脉瘤孤立术伴或不伴颅内外血管搭桥术

因血泡样动脉瘤壁薄且无明显瘤颈,且开颅手术夹闭动脉瘤风险较大,对于部分累及载瘤动脉的血泡样动脉瘤,动脉瘤孤立术是一种可达到治愈效果的手术方式<sup>[18]</sup>。但行动脉瘤孤立术应注意:(1)术前应行球囊闭塞试验(BOT),观察对侧前循环和后循环的血流代偿情况。如对侧血流代偿不良,应在动脉瘤孤立术的基础上,同期行颅内外血管搭桥术。值得注意的是,即使在 BOT 试验阴性,闭塞动脉后,由于血管痉挛、血压波动、高凝状态等因素,仍有约 10% 的患者术后出现迟发性脑缺血发作<sup>[19]</sup>。(2)在不影响重要穿支动脉的前提下,须确保动脉瘤远端和近端均闭塞,防止血液逆流充盈动脉瘤。基于此,有学者认为,无论血流代偿情况如何,在采用动脉瘤孤立术的同时行颅内外血管搭桥术的方法,可能是目前治疗血泡样动脉瘤最好的方法,该方法不仅可以彻底闭塞动脉瘤,且保证脑组织充足的血供<sup>[20-21]</sup>。Kikkawa 等<sup>[22]</sup>采用动脉瘤孤立术伴颅内外血管搭桥术治疗 16 例血泡样动脉瘤患者,术后仅 2 例出现相关缺血性卒中,在平均 3 年的随访中,14 例无严重神经功能障碍,未见动脉瘤复发及再出血,因此他们认为,采用高流量搭桥及尽量保留后

交通动脉是取得良好临床效果之保证。

## 二、血管内介入治疗

血管内介入治疗主要包括单纯弹簧圈栓塞术、支架辅助弹簧圈栓塞术、密网支架(FD)及覆膜支架等治疗。与显微外科手术相比,血管内介入治疗具有创伤小,手术时间短,术后恢复迅速等优点,对于 Hunt-Hess 分级较低的血泡样动脉瘤患者,血管内介入治疗的临床预后优于显微外科手术,且病残率和病死率较低<sup>[23]</sup>。

1. 单纯弹簧圈栓塞术 基于血泡样动脉瘤独特的解剖学特点,在出血急性期单纯应用弹簧圈栓塞十分困难。Fiorella 等<sup>[24]</sup>指出,仅血泡样动脉瘤呈囊状时,才有单纯弹簧圈栓塞之可能。而 Tanoue 等<sup>[25]</sup>发现,血泡样动脉瘤急性期后可逐渐发展成囊状,瘤腔内出现血栓,并且周围可形成凝血块,从而巩固薄弱的血管壁,认为非急性期后行单纯弹簧圈栓塞术可取得良好疗效。然而,众所周知,血泡样动脉瘤急性期内再出血的风险较高,即使度过急性期,栓塞过程也并非像真性动脉瘤那样安全,发生动脉瘤破裂及缺血性卒中的概率较高,故单纯弹簧圈栓塞术并非是治疗破裂血泡样动脉瘤的适当方法,往往需支架辅助栓塞<sup>[6,26]</sup>。

2. 支架辅助弹簧圈栓塞 支架辅助弹簧圈栓塞一方面支架覆盖瘤颈,有利于弹簧圈形态及结构的稳定,促进动脉瘤内血栓形成;另一方面加速瘤颈部血管内膜增生,促进内皮化,达到载瘤动脉的重建;且植入支架可以部分改变血管的走行方向,因此改变载瘤动脉的血流动力学,降低瘤腔内压力,从而减少再出血<sup>[27]</sup>。临床上常用的支架包括雕刻支架,如 Neuroform 支架、Solitaire 支架、Enterprise 支架,以及编织支架,如 LVIS 支架。常用雕刻支架金属覆盖率为 6%~11%,该类型支架对肿瘤局部血流动力学的改变不足,辅助栓塞效果欠佳。Fang 等<sup>[28]</sup>报告 8 例单纯雕刻支架或支架辅助栓塞治疗的血泡样动脉瘤患者,1 例患者因术中出血而闭塞颈内动脉,2 例发生术后出血,3 例复查时发现动脉瘤复发。LVIS 支架的金属覆盖率为 23%,且通过“灯笼”技术,可明显提高瘤颈的金属覆盖率,降低瘤腔内压力。诸德源等<sup>[29]</sup>采用 LVIS 支架辅助弹簧圈栓塞治疗血泡样动脉瘤,未见出血并发症,治愈率达 78.6%。同时,可采用“铆钉”技术,即支架远端到位后,先经栓塞导管将弹簧圈推出 2~3 个袢,加固瘤颈及稳定微导管,逐步释放支架,使动脉瘤颈由宽

颈变成相对窄颈,且在支架和载瘤动脉之间形成楔形空间,继续栓塞动脉瘤腔,直至少量弹簧圈植入动脉内,完全释放支架,这样既可避免支架限制微导管的活动,降低微导管张力及栓塞过程中动脉瘤破裂风险;又因动脉与支架之间的弹簧圈致密封闭近端瘤颈,有利于动脉壁修复<sup>[30]</sup>。Hao 等<sup>[30]</sup>采用此技术治疗 8 例血泡样动脉瘤患者,除 2 例分别因多器官衰竭及颅内感染死亡外,余 6 例经 3~12 个月的随访,均未见复发及再出血。也有学者采用套叠支架的方法模拟密网支架的原理,提高瘤颈附近的金属覆盖率,取得了良好的效果<sup>[31-33]</sup>。然而套叠支架并不等于密网支架,新近一项回顾性研究比较包括套叠支架在内的多种介入方法与密网支架的治疗效果,结果发现,密网支架治疗的患者动脉瘤的闭塞率明显高于其他治疗组(90.8%对 69.7%)<sup>[2]</sup>,为血泡样动脉瘤的治疗指明了新的方向。

3. 密网支架治疗 随着血管内介入材料的发展和治疗理念的更新,现已从针对动脉瘤的栓塞过渡到载瘤动脉修复治疗的年代,密网支架应运而生。针对血泡样动脉瘤周围载瘤动脉壁发育缺陷的特点,越来越多的学者尝试应用密网支架<sup>[34-38]</sup>。密网支架主要是利用高金属覆盖率(30%~35%)的支架重塑局部载瘤动脉内的血液流向,减少动脉瘤内血液进入,降低血流对动脉瘤壁的冲击力,造成瘤内血栓形成;同时促进载瘤动脉的内皮化,修复动脉壁损伤。约 90%的血泡样动脉瘤患者经密网支架治疗后可获得良好的临床效果和完全闭塞率<sup>[36-37]</sup>。Yang 等<sup>[38]</sup>采用密网支架治疗 14 例血泡样动脉瘤患者,术后即刻闭塞率仅为 35.7%,但经 6~9 个月的随访,未见动脉瘤复发及再出血,动脉瘤完全闭塞率为 100%。但也有学者指出,若植入支架前未经充分双联抗血小板治疗,密网支架治疗后出现缺血性卒中并发症的概率较其他介入治疗高<sup>[2,26]</sup>,而且对于破裂血泡样动脉瘤急性期患者,后续的有创性治疗风险较大<sup>[39]</sup>;同时,双联抗血小板治疗不利于动脉瘤内血栓形成,可造成短期内肿瘤复发<sup>[40]</sup>。2018 年,Zhu 等<sup>[41]</sup>公布近年采用密网支架治疗血泡样动脉瘤的 Meta 分析结果,发现动脉瘤完全闭塞率为 72%,复发率为 13%,再出血率为 3%;围手术期病残率及病死率分别为 26%和 3%,长期预后良好率为 83%。密网支架可提高血泡样动脉瘤的治愈率,但仍存在一定的并发症,临床医师应准确评估患者的病情和血管条件,以为不同患者选择个体化治疗



方案。

4. 覆膜支架治疗 覆膜支架治疗可即刻将动脉瘤孤立于血液循环外,重建载瘤动脉;可即刻闭塞动脉瘤,逐渐促进周围血管内皮增生,修复血管内膜,达到解剖治愈;且其操作均在载瘤动脉内,对薄弱的动脉瘤壁无干扰,降低术中破裂再出血的风险;同时,动脉瘤腔无栓塞材料,不会引起占位效应;属于微创手术,操作简单,手术时间短,相对安全<sup>[42-43]</sup>。目前临床上常用的覆膜支架为 Willis 支架,其采用单层聚四氟乙烯膜裹覆于支架外层,膜两端与支架固定,其余部分游离,顺应性强,较易通过迂曲的血管。Liu 等<sup>[44]</sup>利用 Willis 支架治疗 14 例血泡样动脉瘤患者,术后即刻造影显示所有肿瘤均完全不显影,仅 8 例出现无症状性血管痉挛,随访时 2 例轻度复发,12 例完全闭塞,闭塞率为 12/14。而 Fang 等<sup>[45]</sup>报告 13 例血泡样动脉瘤患者经 Willis 支架治疗后,12 例动脉瘤即刻闭塞、1 例近端轻度内漏,随访时影像学检查闭塞率为 100%。应用覆膜支架常见问题主要是邻近动脉分支闭塞和内漏。血泡样动脉瘤常发生于颈内动脉床突上段,邻近眼动脉及脉络膜前动脉等分支,其中,眼动脉闭塞,其主要分支视网膜中央动脉往往可由颈外动脉吻合代偿,不至于出现失明等并发症;而脉络膜前动脉闭塞,则可引起偏瘫、偏盲、偏身感觉障碍等。Fang 等<sup>[45]</sup>治疗的患者中,眼动脉闭塞 2 例、脉络膜前动脉闭塞 1 例,均无相关神经功能障碍。脉络膜前动脉闭塞无功能障碍考虑是由于脉络膜后动脉代偿供血。内漏表现为在支架与管壁之间的持续血流灌注,可能原因包括动脉瘤远端和近端载瘤管径差别大、动脉瘤靠近虹吸弯、覆膜贴壁不良、支架移位覆盖不全、侧支血管逆流等;内漏是造成动脉瘤复发的主要原因<sup>[46]</sup>。为避免内漏应注意:(1)仔细测量载瘤动脉直径,若远端和近端管径差别大,避免应用覆膜支架;同时测量动脉瘤颈的长度,选择合适的支架。(2)释放支架时尽量在平直段,以利于支架的打开和贴壁。(3)选择较强支撑力的支撑系统、扩张球囊前充分释放支架的张力以及缓慢扩张球囊可避免支架移位。(4)发现内漏,尤其是近端内漏,首先判断原因,如果是支架局部贴壁不良所致,可通过再次球囊扩张成形消除内漏,如果是瘤颈覆盖不全,则需用另一枚支架覆盖瘤颈以消除内漏<sup>[47-48]</sup>。此外,覆膜支架治疗还可发生支架内再狭窄。因此应根据覆膜支架本身的特点,合理谨慎地选择病

例,尤其是近端血管高度迂曲及存在侧支循环的病例,应避免应用覆膜支架。

综上所述,由于血泡样动脉瘤解剖学结构的特异性,无论显微外科手术还是血管内介入治疗,均具有一定的挑战。显微外科手术可以获得较高的动脉瘤闭塞率,但手术创伤较大且技术要求较高;血管内介入治疗具有微创性,手术时间较短,患者恢复迅速等特点,但动脉瘤闭塞率较显微外科手术低,因此临床医师应准确评估患者的病情和血管条件,为不同患者选择个体化治疗方案。

利益冲突 无

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## · 小词典 ·

## 中英文对照名词词汇(六)

- 西奈山脑库 Mount Sinai Brain Bank(MSBB)
- 系统性红斑狼疮 systemic lupus erythematosus(SLE)
- B细胞淋巴瘤/白血病-2 B cell lymphoma/leukemia-2(Bcl-2)
- 小动脉闭塞 small artery occlusion(SAO)
- 效应型记忆T细胞 effector memory T cells(TEM)
- CD4<sup>+</sup>效应型记忆T细胞  
CD4<sup>+</sup> effector memory T cells(CD4<sup>+</sup>TEM)
- 心肺复苏 cardiopulmonary resuscitation(CPR)
- 心源性栓塞 cardioembolism(CE)
- 新生儿肾上腺脑白质营养不良  
neonatal adrenoleukodystrophy(NALD)
- 嗅球 olfactory bulb(OB)
- 血管内大B细胞淋巴瘤  
intravascular large B cell lymphoma(IVLBCL)
- 血管内皮生长因子  
vascular endothelial growth factor(VEGF)
- 血泡样动脉瘤 blood blister-like aneurysm(BBA)
- 液相色谱-串联质谱  
liquid chromatography tandem mass spectrometry  
(LC-MS/MS)
- N-乙酰天冬氨酸 N-acetyl-aspartate(NAA)
- 异柠檬酸脱氢酶 isocitrate dehydrogenase(IDH)
- Beck抑郁量表 Beck Depression Inventory(BDI)
- 吲哚菁绿荧光血管造影术  
indocyanine green angiography(ICGA)
- 英国牛津郡社区卒中项目  
Oxfordshire Community Stroke Project(OCSP)
- 婴儿型Refsum综合征 infantile Refsum syndrome(IRS)
- 荧光原位杂交 fluorescence in situ hybridization(FISH)
- 预先指示 advance directives(ADs)
- 原发性中枢神经系统血管炎  
primary angiitis of the central nervous system(PACNS)
- 在线人类孟德尔遗传数据库  
Online Mendelian Inheritance in Man(OMIM)
- 造血干细胞移植  
hematopoietic stem cell transplantation(HSCT)
- 正压通气 positive pressure ventilation(PPV)
- 症状性颅内出血  
symptomatic intracranial hemorrhage(SICH)
- 中脑星形胶质细胞源性神经营养因子  
mesencephalic astrocyte-derived neurotrophic factor(MANF)
- 中位生存期 median survival time(MST)
- 中央型记忆T细胞 central memory T cells(TCM)
- Zellweger综合征 Zellweger syndrome(ZS)
- 总胆固醇 total cholesterol(TC)
- CC族趋化因子受体7 CC-chemokine receptor 7(CCR7)
- 左旋多巴等效剂量 levodopa equivalent dose(LED)