·临床研究·

急性颈内动脉狭窄性串联病变颅内动脉机械取栓后急诊颈动脉支架成形术疗效分析

徐娜 易婷玉 王则托 吴燕敏 林定来 陈文伙

【摘要】 **目的** 探讨急性颈内动脉狭窄性串联病变颅内动脉机械取栓术同期行急诊颈动脉支架成形术(CAS)的有效性和安全性。**方法** 选择2015年1月至2019年12月福建医科大学附属漳州市医院收治的79例急性颈内动脉狭窄性串联病变患者,均采用"半前向法"伴或不伴保护技术行血管内治疗,根据是否急诊行颈动脉支架成形术分为CAS组(47例)和无CAS组(32例),对比分析两组手术相关指标[包括术前Alberta脑卒中计划早期CT评分(ASPECTS)、串联病变部位、侧支代偿、血流再灌注、穿刺至血管再通时间、C型臂CT渗出表现、异位栓塞]以及临床预后指标(包括出血性转化、责任血管再闭塞、术后90 d预后良好率和病死率),单因素和多因素前进法Logistic回归分析筛查急性颈内动脉狭窄性串联病变患者术后90 d预后不良影响因素。**结果** 共计79例患者术后即刻改良脑梗死溶栓血流分级≥2b级,血管再通率达100%,CAS组与无CAS组术前ASPECTS评分(t = -0.170, P = 0.865)、串联病变部位(Z = 5.907, P = 0.091)、侧支代偿(t = -0.900, P = 0.368)、穿刺至血管再通时间(t = 0.182, P = 0.856)、C型臂CT有渗出表现(Z = -0.171, P = 0.864)、异位栓塞发生率(χ^2 = 0.872, P = 0.350),以及出血性转化(χ^2 = 1.670, P = 0.434)、责任血管再闭塞(χ^2 = 0.000, P = 1.000)、术后90 d预后良好率(χ^2 = 2.149, P = 0.143)和病死率(χ^2 = 0.150, P = 0.699)组间差异均无统计学意义。Logistic回归分析显示,年龄增大(OR = 1.078, 95%CI:1.011~1.148; P = 0.021)和C型臂CT有渗出表现(OR = 5.163, 95%CI:1.633~16.326; P = 0.005)是急性颈内动脉狭窄性串联病变患者术后90 d预后不良的危险因素。**结论** 急性颈内动脉狭窄性串联病变采用"半前向法"伴或不伴保护技术在机械取栓后根据责任颈内动脉狭窄程度和C型臂CT脑实质渗出情况决策是否急诊行颈动脉支架成形术安全、可行,值得临床推广。

【关键词】 颈动脉狭窄; 血栓切除术; 支架; 危险因素; Logistic模型

Efficacy of emergent internal carotid artery stenting after intracranial thrombectomy for acute internal carotid artery stenosis related tandem lesions

XU Na[1], YI Ting-yu[2], WANG Ze-tuo[1], WU Yan-min[2], LIN Ding-lai[2], CHEN Wen-huo[2]

[1]*Department of Neurology, The Second Affiliated Hospital of Xiamen Medical College, Xiamen 361021, Fujian, China*

[2]*Department of Neurology Cerebrovascular Intervention, Zhangzhou Affiliated Hospital of Fujian Medical University, Zhangzhou 363000, Fujian, China*

XU Na and YI Ting-yu contributed equally to the article

Corresponding author: CHEN Wen-huo (Email: 13806906089@126.com)

【Abstract】 **Objective** To investigate the efficacy and safety of emergent carotid artery stenting (CAS) after intracranial artery mechanical thrombectomy for acute internal carotid artery (ICA) stenosis related tandem lesions. **Methods** A total of 79 patients with acute ICA stenosis related tandem lesions admitted to the Advanced Stroke Center of Zhangzhou Hospital affiliated to Fujian Medical University from January 2015 to December 2019 were selected. All patients underwent urgent endovascular therapy with

doi:10.3969/j.issn.1672-6731.2022.08.013

基金项目:福建医科大学启航基金资助项目(项目编号:2016QH088)

作者单位:361021 厦门医学院附属第二医院神经内科(徐娜,王则托);363000 福建医科大学附属漳州市医院脑血管病介入科(易婷玉,吴燕敏,林定来,陈文伙)

徐娜与易婷玉对本文有同等贡献

通讯作者:陈文伙,Email:13806906089@126.com

"half" anterograde approach with or without usage of embolic prevention device (EPD) technology, and divided into CAS group (n = 47) and non-CAS group (n = 32) according to whether CAS was performed in emergency. Compared and analysed the 2 groups of surgical related indexes [including the preoperative Alberta Stroke Program Early CT Score (ASPECTS), the occlusion site of tandem lesions, the American Society of Interventional and Therapeutic Neuroradiology/Society of Interventional Radiology Collateral Flow Grading System (ASITN/SIR ACG), puncture-to-reperfusion time, leakage on C-arm CT, incidence of distal embolism], and the clinical prognostic indicators [including the incidence of symptomatic intracranial hemorrhage (sICH), culprit artery reocclusion rate, postoperative 90-d favorable outcome rate and mortality]. Univariate and multivariate forward Logistic regression were used to analysis the influencing factors of postoperative 90-d poor prognosis in acute ICA stenosis related tanchem lesions. **Results** All 79 patients had immediate postoperative mTICI grading ≥ 2b, the vascular recanalization rate was 100%. There was no statistically significant differences in the preoperative ASPECTS (t = -0.170, P = 0.865), the occlusion site of tandem lesions (Z = 5.907, P = 0.091), the ASITN/SIR ACG (t = -0.900, P = 0.368), puncture-to-reperfusion time (t = 0.182, P = 0.856), leakage on C-arm CT (Z = -0.171, P = 0.864), incidence of distal embolism (χ^2 = 0.872, P = 0.350), the incidence of sICH (χ^2 = 1.670, P = 0.434), the culprit artery re-occlusion rate (χ^2 = 0.000, P = 1.000), postoperative 90-d favorable outcome rate (χ^2 = 2.149, P = 0.143) and the mortality (χ^2 = 0.150, P = 0.699) between CAS group and non-CAS group. Logistic regression analysis showed that increasing age (OR = 1.078, 95%CI: 1.011-1.148; P = 0.021), leakage on C-arm CT (OR = 5.163, 95%CI: 1.633-16.326; P = 0.005) were risk factors for postoperaive 90-d poor outcomes of the patients with acute carotid atherosclerotic stenosis related tandem lesions. **Conclusions** For patients with acute ICA stenosis related tandem lesions used "half" anterograde approach with or without usage of EPD technology, the decision of emergent CAS after mechanical thrombectomy was made according to the stenosis degree of ICA and leakage on C-arm CT. This strategy is safe and feasible, and has the potential of clinical promotion.

【Key words】 Carotid stenosis; Thrombectomy; Stents; Risk factors; Logistic models

This study was supported by Startup Fund for Scientific Research of Fujian Medical University (No. 2016QH088).

Conflicts of interest: none declared

急性颈内动脉(ICA)狭窄串联病变系指前循环闭塞合并同侧颈内动脉重度狭窄或闭塞导致的急性缺血性卒中,占大血管闭塞致急性缺血性卒中的10%~15%[1],病残率和病死率较高[2-3],血管内治疗(EVT)可以改善临床预后[4-6],但理想的血管内治疗方案尚不明确,颅内动脉机械取栓后是否同期行急诊颈动脉支架成形术(CAS)仍存争议。有学者认为,颈动脉支架成形术后即刻或迟发性支架内血栓形成导致责任血管再闭塞的概率为5%~28%[7-9];亦有研究显示,急性颈内动脉狭窄串联病变颅内动脉机械取栓后急诊行颈动脉支架成形术的再灌注率较高、责任血管再闭塞率较低[10-12],还可减少择期二次手术的负担。因此,二者在何种条件下同期进行方可安全、有效且使获益最大化值得讨论。本研究探讨急性颈内动脉狭窄串联病变颅内动脉机械取栓后同期行颈动脉支架成形术的有效性和安全性,以为临床制定手术策略提供参考。

资料与方法

一、临床资料

1.纳入标准 (1)经CTA或DSA明确责任血管病变为颈内动脉颅外段狭窄性闭塞伴颅内动脉闭塞[1]。(2)年龄>18岁。(3)发病前改良Rankin量表(mRS)评分≤2分。(4)入院时美国国立卫生研究院卒中量表(NIHSS)评分≥6分。(5)均行颅内动脉机械取栓术。(6)发病至动脉穿刺时间≤6 h,或者发病至动脉穿刺时间>6 h但多模态影像学检查符合DAWN(DWI or CTP Assessment with Clinical Mismatch in the Triage of Wake Up and Late Presenting Strokes Undergoing Neurointervention with Trevo)研究[13]或DEFUSE3(Endovascular Therapy Following Imaging Evaluation for Ischemic Stroke 3)研究[14]的入组标准。(7)随访资料完整。(8)所有患者及其家属均对手术方案知情并签属知情同意书。

2.排除标准 (1)颈内动脉起始部或颅内动脉闭塞再通失败。(2)DSA显示责任血管病变为栓塞性或夹层性闭塞。(3)严重心、肺、肝、肾功能障碍。(4)术前评估无法耐受抗栓治疗。

3.一般资料 选择2015年1月至2019年12月福建医科大学附属漳州市医院高级卒中中心收治的颈内动脉狭窄串联病变患者共79例,男性71例,

表1　CAS组与无CAS组患者基线资料的比较

Table 1.　Comparison of baseline data between CAS group and non-CAS group

观察指标	无CAS组（n=32）	CAS组（n=47）	统计量值	*P*值
性别[例(%)]			0.000*	1.000
男性	29(90.63)	42(89.36)		
女性	3(9.38)	5(10.64)		
年龄($\bar{x}\pm s$,岁)	68.94±8.29	72.36±9.42	-1.663	0.100
高血压[例(%)]	25(78.13)	29(61.70)	2.374	0.123
糖尿病[例(%)]	5(15.63)	15(31.91)	2.672	0.102
高脂血症[例(%)]	4(12.50)	10(21.28)	1.006	0.316
房颤或风湿性心脏病[例(%)]	2(6.25)	2(4.26)	0.000*	1.000
吸烟史[例(%)]	20(62.50)	25(53.19)	0.673	0.412
发病至入院时间[$M(P_{25},P_{75})$,h]	4.08（2.52, 5.24）	3.87（2.58, 8.93）	-0.749	0.454
发病至动脉穿刺时间[$M(P_{25},P_{75})$,h]	5.06（3.43, 6.52）	5.42（4.02, 9.33）	-1.288	0.198
入院时NIHSS评分[$M(P_{25},P_{75})$,分]	17.00（14.00,20.00）	16.00（12.00,20.00）	-1.210	0.225
桥接静脉溶栓[例(%)]	6(18.75)	6(12.77)	0.167*	0.683

*adjusted χ^2 value，校正χ^2值。Two-independent-sample *t* test for comparison of age, Mann-Whitney *U* test for comparison of oneset-to-admission time, oneset-to-puncture time and NIHSS at admission, and χ^2 test for comparison of others，年龄的比较行两独立样本的*t*检验，发病至入院时间、发病至动脉穿刺时间和入院时NIHSS评分的比较行Mann-Whitney *U*检验，其余指标的比较行χ^2检验。CAS, carotid artery stenting，颈动脉支架成形术；NIHSS, National Institutes of Health Stroke Scale，美国国立卫生研究院卒中量表

女性8例；年龄45～90岁，平均（71±9）岁；发病至入院时间1.33～21.33 h，中位时间3.87（2.58，5.92）h；发病至动脉穿刺时间0.13～15.32 h，中位时间5.25（3.75，7.33）h；合并高血压54例占68.35%、糖尿病20例占25.32%、高脂血症14例占17.72%、房颤或风湿性心脏病4例占5.06%，吸烟史45例占56.96%；入院时NIHSS评分6～26分，中位评分16（12，20）分；发病前mRS评分均为零；急诊均行颅内动脉机械取栓术，其中12例（15.19%）为桥接静脉溶栓。据机械取栓后是否急诊行颈动脉支架成形术分为CAS组（47例）和无CAS组（32例），两组患者一般资料差异无统计学意义（均$P>0.05$，表1），均衡可比。

二、研究方法

1. 血管内治疗及围手术期管理　所有患者均接受“半前向法”伴或不伴保护技术的血管内治疗。“半前向法”伴保护技术为保护（protect）-扩张（expand）-抽吸（aspiration）-颅内血管再通（revascularization）-颈动脉支架植入（stenting），即PEARS技术[15]。患者仰卧位，于局部或全身麻醉下经股动脉置入8F动脉鞘（日本Terumo公司），以椎动脉管行诊断性脑血管造影。若颈内动脉起始部完全闭塞（图1a），采取以下步骤：（1）微导管、微导丝通过闭塞段近端。将6F/8F导引导管（美国Johnson & Johnson公司）置于颈内动脉狭窄性闭塞段近端，以0.014 in微导丝（长度300 mm，Synchro，美国Stryker公司）在微导管（Rebar 18，美国EV3公司；Headway 21，美国MicroVention公司）辅助下穿过闭塞段近端，微导管在微导丝引导下通过闭塞段，退出微导丝，微导管“冒烟”证实微导管在真腔，远端血管通畅（图1b）。（2）释放保护伞。再次送入微导丝，利用交换技术退出微导管，沿微导丝送入保护伞（直径5 mm，Spider，美国EV3公司）至颈内动脉颈段远端（图1c）。（3）行颈内动脉起始部球囊扩张。选择合适球囊（Aviators 4～5 mm×30～40 mm，美国Johnson & Johnson公司；Sterling 4～5 mm×30～40 mm，美国Stryker公司）对颈内动脉狭窄性闭塞段进行扩张（图1d）。（4）导引导管通过近端闭塞段。在球囊泄气的同时，将导引导管通过狭窄段至颈内动脉颈段中远端（图1e），回撤球囊，以50 ml注射器通过导引导管对颈内动脉颈段、岩骨段进行抽吸，回收保护伞（图1f），导引导管负压回抽血流通畅，导引导管“冒烟”再次确定颅内动脉闭塞情况，若颅内动脉仍闭塞，则行支架取栓术。（5）颅内动脉取栓。微导管在微导丝辅助下穿过颅内动脉闭塞部位，通过微导管“冒烟”证实通过闭塞段，再将取栓支架（Solitaire 4～6 mm×20～30 mm，美国Medtronic公司）通过微导管送入颅内动脉闭塞段完全覆盖闭塞段后释放，支架停留至少3 min后一起回撤支架和微导管，回撤过程中以50 ml注射器保持导引导管连续抽吸完成取栓，实现颅内闭塞动脉再通（图1g）。（6）退导引导管至颈总动脉。再次将保护伞清洗干净后输送至颈内动脉起始部远端（图1h），回撤导引导管至颈总动脉（图1i），通过导引导管行脑血管造影，观察颈内动脉狭窄段情况以及脑灌注情况至少5 min，同时术中采用DSA行C型臂CT检查以监测脑实质渗出情况，行颈动脉支架成形术。决策标准为：颈内动脉狭窄率<50%，不予急诊颈动脉支架成形术处理；颈内动脉狭窄率≥50%，C型臂CT提示无皮质广泛渗出，则急诊行颈动脉支架成形术，C型臂CT提示皮质广泛渗出，则观察颈内动脉及脑灌注情况，改良脑梗死溶栓血流分级（mTICI）≥2b级，

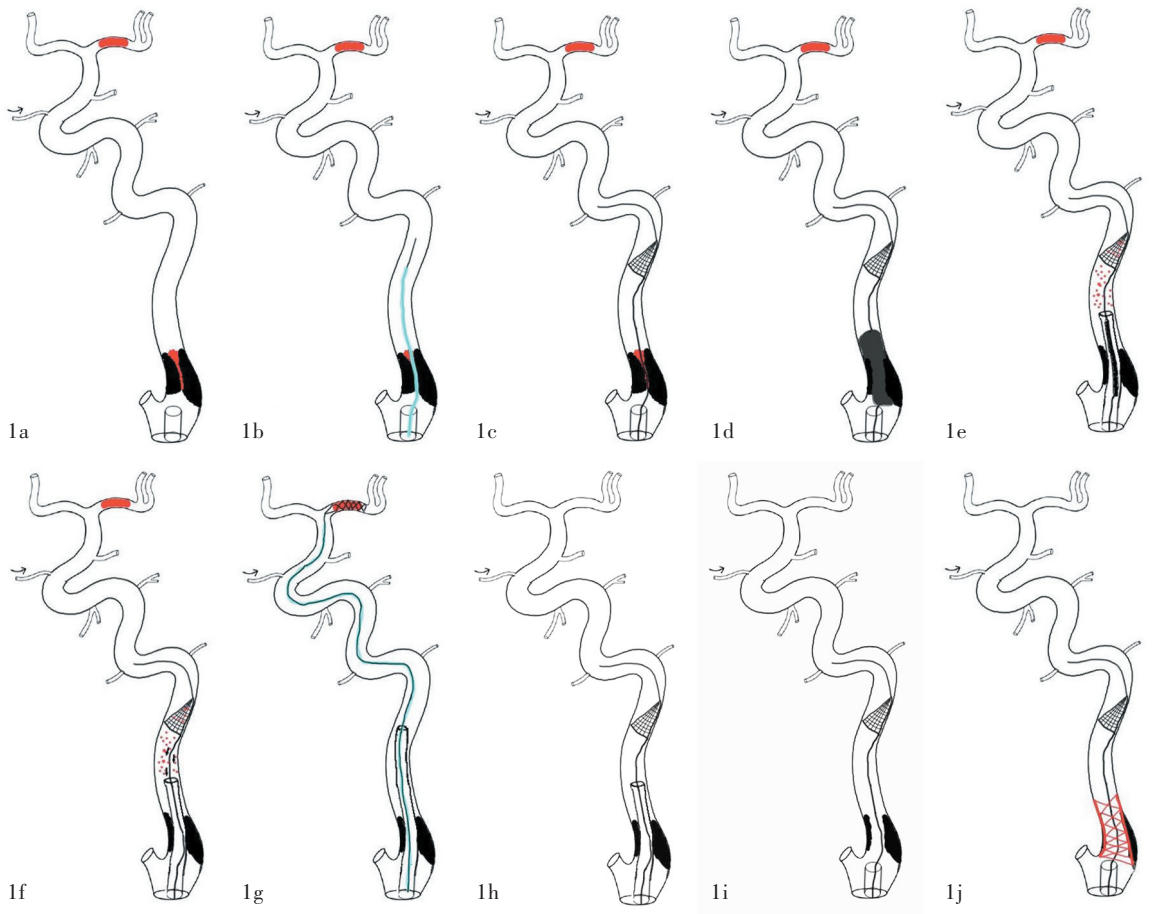

图1 PEARS技术操作示意图 1a 颈内动脉起始部完全闭塞伴大脑中动脉闭塞 1b 导引导管置于颈内动脉闭塞段近端，微导管在微导丝引导下通过颈内动脉闭塞段 1c 沿微导丝输送保护伞至颈内动脉颈段远端 1d 选择合适球囊对颈内动脉闭塞段进行扩张 1e 在球囊泄气的同时，将导引导管通过狭窄段至颈内动脉颈段中远端，回撤球囊 1f 以50 ml注射器通过导引导管对颈内动脉颈段、岩骨段进行抽吸，回收保护伞 1g 微导管在微导丝辅助下穿过颅内动脉闭塞段，通过取栓支架完成取栓，实现颅内闭塞动脉再通 1h 再次将保护伞清洗干净后输送至颈内动脉起始部远端 1i 回撤导引导管至颈总动脉 1j 颈内动脉起始部植入支架

Figure 1 Schematic diagram of the PEARS technique Initial segment occlusion of the ICA with MCA occlusion (Panel 1a). A guidingcatheter was placed to the occluded sgement of the ICA, a microcatheter travelled through the occlusion site with the assistance of a microwire (Panel 1b). An embolic protection device (EPD) was advanced into the distal cervical segment of the ICA over the microwire (Panel 1c). Emergent angioplasty of the initial ICA segment via a balloon (Panel 1d). A guiding catheter was advanced through the occlusion site over the deflated balloon system (Panel 1e). The EPD and deflated balloon were withdrawn together with continuous suction from the guiding catheter achieved with a 50 ml syringe (Panel 1f). A microcatheter travelled through the occlusion site of the intracranial artery with the assistance of a microwire, thrombectomy was performed with a thrombectomy stent, the occlusion recanalized (Panel 1g). The EPD was introduced into the distal cervical segment of the ICA (Panel 1h). The guiding catheter was retrieved back to the arteria carotis communis (Panel 1i). Stent implantation was performed in the initial ICA segment (Panel 1j).

不予急诊颈动脉支架成形术处理，mTICI < 2b级，则急诊行颈动脉支架成形术，同时减少抗血小板药物剂量或停药。(7)沿保护伞导丝送入颈内动脉支架(Wallstent支架，美国Boston Scientific公司；Acculink/Xact支架，美国Abbott Laboratories公司；Precise支架，美国Johnson & Johnson公司；Proteage支架，美国EV3公司)至颈内动脉狭窄处释放(图1j)。最后行责任侧脑血管造影，若颈内动脉起始部及颅内动脉血流通畅，mTICI ≥ 2b级，则结束手术；若DSA观察到CAS组有急性支架内血栓形成征象，无CAS组责任颈内动脉有血栓征象，则局部动脉注射或增加静脉注射替罗非班等抗血小板药物剂量，或利用导引导管对局部血栓进行抽吸处理，直至颈内动脉起始部及颅内动脉血流通畅，mTICI ≥ 2b级，则结束手术。“半前向”不伴保护技术，省略“半前向”伴保护技术中的(2)，在(6)中采用取栓支架半释放于颈内动脉眼动脉段进行保护，若回撤导引导管至颈总动脉过程中未发生栓子脱落，则回收取栓

支架，改为送入0.014 in微导丝，行颈内动脉支架成形术，若回撤导引导管至颈总动脉过程中发生栓子脱落，则行支架取栓术，其余步骤同“半前向”伴保护技术。术后根据具体情况采用联合抗血小板治疗[15]及常规管理。

2.手术相关指标 （1）预期疗效评估：术前采用Alberta脑卒中计划早期CT评分（ASPECTS）[16]评估血管内治疗预期效果及远期预后，该评分将大脑中动脉（MCA）供血区分为10个区域，总评分为10分，任何一个区域有早期缺血改变减1分，评分越低、预期疗效越差。（2）病变部位：术中行全脑血管造影明确串联病变部位并定位分类，近端病变定位于颈内动脉起始部（C1），远端病变定位于颈内动脉颅内段（包括颈内动脉T部和L部[17]）、大脑中动脉M1段和M2段、大脑前动脉（ACA）。（3）侧支代偿评估：术中采用美国介入和治疗性神经放射学学会（ASITN）/美国介入放射学学会（SIR）侧支循环分级系统（ACG）评估侧支代偿[17]，0级，无代偿；1级，缺血区周围有缓慢逆流的血流灌注但始终有逆流灌注缺损；2级，缺血区周围有快速逆流的血流灌注但有部分区域无逆流灌注；3级，静脉晚期代偿倒灌整个病变区，无逆流灌注缺乏区；4级，有完全快速逆流的血流灌注至整个病变区。（4）再灌注评估：术后即刻复查全脑血管造影，采用mTICI分级评估再灌注，再灌注成功为mTICI≥2b级[17]。（5）穿刺至血管再通时间：股动脉穿刺成功至成功再灌注时间。（6）C型臂CT渗出表现：术后即刻行C型臂CT检查，若术前CT无高密度影而术后出现高密度影，则提示有颅内渗出表现，若渗出累及≥2个脑叶，则定义为有广泛颅内渗出表现[18]。（7）异位栓塞：指术后即刻复查脑血管造影显示术前血流通畅血管出现闭塞。

3.临床结局指标 （1）出血性转化：于术后24 h内复查头部CT判断有无出血性转化，包括症状性颅内出血（sICH）和无症状性颅内出血（asICH），sICH定义为新增颅内出血且NIHSS评分增加＞4分[19]。（2）责任血管再闭塞：术后3个月内经CTA、MRA、经颅彩色多普勒超声（TCCD）评估颈内动脉病变部位血流通畅情况，若CTA提示责任颈内动脉起始部无对比剂充盈、MRA提示责任颈内动脉血流信号丢失、TCCD提示责任颈内动脉病变部位无血流，为责任血管再闭塞。（3）术后90 d预后：术后90 d采用mRS量表评估神经功能预后，mRS评分≤2分为预后良好、＞2分为预后不良。（4）术后90 d病死率：记录术后90 d内死亡病例数。

4.统计分析方法 采用SPSS 23.0统计软件进行数据处理与分析。计数资料以相对数构成比（%）或率（%）表示，行χ^2检验。呈正态分布的计量资料以均数±标准差（$\bar{x}\pm s$）表示，采用两独立样本的t检验；呈非正态分布的计量资料以中位数和四分位数间距[$M(P_{25},P_{75})$]表示，采用Mann-Whitney U检验。等级资料的比较采用Mann-Whitney U检验。急性颈内动脉狭窄性串联病变预后不良影响因素的筛查采用采用单因素和多因素前进法Logistic回归分析（$\alpha_{入}=0.05$，$\alpha_{出}=0.10$）。以$P\leq0.05$为差异具有统计学意义。

结 果

两组患者手术相关指标比较，术后即刻mTICI≥2b级，血管再通率达100%；CAS组与无CAS组术前ASPECTS评分、串联病变分布、ASITN/SIR ACG分级、穿刺至血管再通时间、C型臂CT渗出表现、异位栓塞发生率差异均无统计学意义（$P>0.05$，表2）。

两组患者临床结局指标比较，CAS组与无CAS组出血性转化、责任血管再闭塞、术后90 d预后良好率和病死率差异均无统计学意义（$P>0.05$，表3）。

根据临床经验及文献资料[20]，以性别、年龄、高血压、糖尿病、房颤或风湿性心脏病、吸烟史、入院时NIHSS评分、行颈动脉支架成形术、穿刺至血管再通时间、C型臂CT有渗出表现、异位栓塞、sICH为自变量，以术后90 d预后为因变量。单因素Logistic回归分析显示，年龄增大（$P=0.040$）、C臂CT有渗出表现（$P=0.008$）是术后90 d预后不良的影响因素（表4，5）。根据纳入与剔除变量的标准，将年龄增大、C型臂CT有渗出表现、异位栓塞、sICH纳入多因素Logistic回归方程，结果显示，年龄增大（$OR=1.078$，95%CI：1.011～1.148；$P=0.021$）和C型臂CT有渗出表现（$OR=5.163$，95%CI：1.633～16.326；$P=0.005$）是急性颈内动脉狭窄性串联病变患者术后90 d预后不良的危险因素（表6）。

讨 论

颈内动脉串联病变即颅内大动脉[包括颈内动脉末段、大脑中动脉M1段和（或）M2段]闭塞，同时合并颈内动脉起始部闭塞或重度狭窄[美国症状性颈内动脉内膜剥脱术试验（NASCET）狭窄率＞

表2 CSA组与无CAS组患者手术相关指标的比较

Table 2. Comparison of surgical related indexes between CAS group and non-CAS group

观察指标	无CAS组(n=32)	CAS组(n=47)	统计量值	*P*值
术前ASPECTS评分[$M(P_{25},P_{75})$,评分]	10.00(9.00,10.00)	10.00(9.00,10.00)	-0.170	0.865
串联病变部位[例(%)]			6.152*	0.079
C1+颈内动脉颅内段	14(43.75)	9(19.15)		
C1+大脑中动脉	15(46.88)	29(61.70)		
C1+M2	3(9.38)	8(17.02)		
C1+多支血管远端	0(0.00)	1(2.13)		
ASITN/SIR ACG分级[例(%)]	31	38	-0.900	0.368
0级	0(0.00)	1(2.63)		
1级	7(22.58)	3(7.89)		
2级	20(64.52)	29(76.31)		
3级	4(12.90)	5(13.16)		
4级	0(0.00)	0(0.00)		
mTICI≥2b级[例(%)]	32(100.00)	47(100.00)	0.000	1.000
穿刺至血管再通时间($\bar{x}\pm s$,min)	90.59±32.46	89.10±37.78	0.182	0.856
C型臂CT渗出表现[例(%)]			-0.171	0.864
无渗出	9(28.13)	17(36.17)		
有渗出	16(50.00)	17(36.17)		
脑实质广泛渗出	7(21.87)	13(27.66)		
异位栓塞[例(%)]	9(28.13)	9(19.15)	0.872	0.350

*Fisher's exact probability, Fisher确切概率法。Two-independent-sample *t* test for comparison of puncture-to-reperfusion time, Mann-Whitney *U* test for comparison of preoperative ASPECT, ASITN/SIR ACG grading and leakage on C-arm CT, and χ^2 test for comparison of others, 穿刺至血管再通时间的比较采用两独立样本的*t*检验,术前ASPECT评分、ASITN/SIR ACG分级、C型臂CT渗出表现的比较采用Mann-Whitney *U*检验,其余指标的比较采用χ^2检验。CAS, carotid artery stenting, 颈动脉支架成形术; ASPECTS, Alberta Stroke Program Early CT Score, Alberta脑卒中计划早期CT评分; ASITN/SIR ACG, American Society of Interventional and Therapeutic Neuroradiology/Society of Interventional Radiology Collateral Flow Grading System, 美国介入和治疗性神经放射学学会/美国介入放射学学会侧支循环分级系统; mTICI, modified Thrombolysisin Cerebral Infarction, 改良脑梗死溶栓血流分级

表3 CSA组与无CAS组患者临床结局指标的比较[例(%)]

Table 3. Comparison of clinical outcomes between CAS group and non-CAS group [case (%)]

组别	例数	出血性转化			责任血管再闭塞	术后90 d良好预后	术后90 d死亡
		无	asICH	sICH			
无CAS组	32	11(34.40)	17(53.10)	4(12.50)	0(0.00)	11(34.38)	8(25.00)
CAS组	47	23(48.49)	19(40.40)	5(10.64)	0(0.00)	24(51.06)	10(21.28)
χ^2值			1.670		0.000	2.149	0.150
*P*值			0.434		1.000	0.143	0.699

CAS, carotid artery stenting, 颈动脉支架成形术; asICH, asymptomatic intracranial hemorrhage, 无症状性颅内出血; sICH, symptomatic intracranial hemorrhage, 症状性颅内出血

90%][21]。串联病变中颈内动脉起始部病变主要病因为动脉粥样硬化(51%~55%)、房颤栓塞(14%~19%)、动脉夹层(10%~13%)等[22]。血管内治疗是急性颈内动脉串联病变的有效治疗方式[23],主要分为两种方法,即"前向法"(先行颈动脉支架成形术后行颅内动脉机械取栓术)和"逆向法"(先行颅内动脉机械取栓术后行颈动脉支架成形术)。"前向法"可以确保颅内动脉取栓通路稳定,但颈动脉支架成形术延长血管再通时间,且术后颈内动脉恢复前向血流有可能导致血栓向远端逃逸,增加颅内血管再通难度[24-25];"逆向法"先行颅内动脉机械取栓术,缩短血管再通时间,且颈内动脉起始部未经处理,减少取栓过程中异位栓塞的风险,但是由于未预处理颈内动脉病变,导引导管或中间导管通过颈

表4 急性颈内动脉狭窄性串联病变术后90 d预后不良影响因素的变量赋值表

Table 4. Variable assignment of prognostic factors in patients with acute ICA stenosis related tandem lesions

变量	赋值	
	0	1
术后90 d预后	良好	不良
性别	女性	男性
高血压	无	有
糖尿病	无	有
房颤或风湿病心脏病	无	有
吸烟史	无	有
CAS	无	有
C型臂CT渗出表现	无	有
异位栓塞	无	有
sICH	无	有

CAS, carotid artery stenting, 颈动脉支架成形术; sICH, symptomatic intracranial hemorrhage, 症状性颅内出血

表5 急性颈内动脉狭窄性串联病变术后90 d预后不良影响因素的单因素Logistic回归分析

Table 5. Univariate Logistic regression analysis of prognostic factors for patients with acute ICA stenosis related tandem lesions

变量	*b*	*SE*	Wald χ^2	*P*值	*OR*值	*OR* 95%CI
男性	1.861	1.095	2.889	0.089	6.432	0.752～55.023
年龄增大	-0.055	0.027	4.215	0.040	0.946	0.897～0.977
高血压	0.362	0.502	0.521	0.471	1.437	0.537～3.845
糖尿病	0.118	0.528	0.050	0.823	1.125	0.400～3.166
房颤或风湿性心脏病	0.272	1.027	0.070	0.791	1.312	0.175～9.827
吸烟史	0.780	0.477	2.672	0.102	2.182	0.856～5.560
入院时NIHSS评分升高	-0.030	0.047	0.412	0.521	0.970	0.884～1.064
CAS	0.689	0.473	2.124	0.145	1.992	0.788～5.034
穿刺至血管再通时间	0.008	0.007	1.513	0.219	1.008	0.995～1.021
C型臂CT有渗出表现	-1.386	0.520	7.096	0.008	0.250	0.090～0.693
异位栓塞	-0.595	0.562	1.120	0.290	0.552	0.183～1.660
sICH	-2.050	1.088	3.554	0.059	0.129	0.015～1.085

NIHSS, National Institutes of Health Stroke Scale, 美国国立卫生研究院卒中量表; CAS, carotid artery stenting, 颈动脉支架成形术; sICH, symptomatic intracranial hemorrhage, 症状性颅内出血

内动脉病变的难度较大[26]。鉴于此,本研究采用第3种方法,即“半前向法”伴或不伴保护技术,该方法确保颅内动脉机械取栓通路的建立,亦不过分延长血管再通时间,同时又可控制颈内动脉前向血流量,并对所有颈内动脉病变均行球囊扩张(球囊直径为4或5 mm),从而有效改善颈内动脉狭窄程度,提高血管再通率,降低异位栓塞发生率[15]。本研究采用“半前向法”伴或不伴保护技术,在行血管内机械取栓术的同时,根据责任颈内动脉狭窄程度是否超过50%和C型臂CT皮质是否有广泛渗出表现来决定是否行颈动脉支架成形术,取得较好疗效,同期行颈动脉支架成形术,术后即刻mTICI≥2b级,术后血管再通率达100%,其他手术相关评价指标包括术前ASPECTS评分、串联病变分布、ASITN/SIR ACG分级、穿刺至血管再通时间、C型臂CT渗出表现、异位栓塞发生率,以及出血性转化、责任血管再闭塞、术后90天预后良好率和病死率等临床结局指标,均与单纯行急诊机械取栓术的患者无明显差异;进一步行Logistic回归分析,同期行颈动脉支架成形术并未增加术后90天预后不良风险,提示急性颈内动脉狭窄性串联病变患者行血管内机械取栓术的同期行颈动脉支架成形术安全、可行,避免择期二次手术的负担。

本研究CAS组与无CAS组患者均实现血管再通,术后影像学随访均未发现责任血管再闭塞,分析原因可能与本研究颈内动脉支架成形术的处理方式有关:(1)机械取栓术后对所有颈内动脉病变狭窄程度和颅内血流灌注情况均进行至少5分钟的观察。若颈内动脉狭窄率<50%,发生血管再闭塞可能性较小[7-8],可不行颈动脉支架成形术;若颈内动脉狭窄率≥50%,且颅内血流灌注无法维持mTICI≥2b级,血管再闭塞概率增加[7-8],则急诊行颈动脉支架成形术。(2)本研究植入的颈内动脉支架类型48.94%(23/47)是闭环支架(Wallstent支架),与开环支架(Precise支架,Proteage支架)相比,闭环支架网眼较密,金属覆盖率高,不过度挤压斑块,不易引起颅内动脉栓塞事件及支架内血栓形成[9]。(3)本研究机械取栓后行C型臂CT观察脑实质渗出情况,若有脑实质广泛渗出表现,则不予颈动脉支架成形术。这是由于机械取栓术后C型臂CT有渗出表现,提示病变部位血-脑屏障破坏,其出血性转化可能性较高,临床预后不良[19],因此急性颈内动脉狭窄性串联病变机械取栓后根据颈内动脉狭窄率达50%、C型臂CT发现脑实质广泛渗出作为是否行颈内动脉支架成形术的决策标准并选择闭环支架是有效、可行的。

Meta分析显示,接受血管内治疗的串联病变sICH发生率为7%[1]。本研究sICH发生率为

表6 急性颈内动脉狭窄性串联病变术后90 d预后不良影响因素的多因素前进法Logistic回归分析

Table 6. Multivariate forward Logistic regression analysis of influencing factors in patients with acute ICA stenosis related tandem lesions

变量	*b*	*SE*	Wald χ^2	*P*值	*OR*值	*OR* 95%CI
年龄增大	0.075	0.032	5.326	0.021	1.078	1.011～1.148
C型臂CT有渗出表现	1.641	0.587	7.809	0.005	5.163	1.633～16.326
异位栓塞	0.153	0.651	0.055	0.814	1.165	0.325～4.173
sICH	1.823	1.183	2.372	0.124	6.188	0.608～62.926
常数项	-5.195	2.825	3.382	0.066		

sICH, symptomatic intracranial hemorrhage, 症状性颅内出血

11.39%(9/79), 与THRACE研究(THRombectomie des Artères CErébrales)的13%相近[27], 究其原因可能为所纳入患者病情较重(入院时NIHSS评分平均16分), 年龄偏大[平均为(71±9)岁]。急性颈内动脉狭窄性串联病变血管内治疗可能导致斑块破裂、内膜暴露引起局部血小板聚集致血栓形成而需抗血小板治疗[28], 而颈动脉支架成形术后更需联合积极的抗血小板治疗以避免支架内再狭窄[29], 但亦可能造成sICH发生率升高[7]。本研究CAS组与无CAS组出血性转化发生率无显著差异, 主要是由于以机械取栓术后C型臂CT是否有广泛渗出作为行颈内动脉支架成形术的决策标准。此外, 本研究Logistic回归分析也显示, C型臂CT有渗出表现是术后90天预后不良的危险因素, 亦表明根据C型臂CT脑实质有广泛渗出表现决定是否急诊行颈内动脉支架成形术是安全的。

本研究的局限性有以下几方面:(1)为单中心回顾性研究, 研究结果不可避免地存在选择偏倚。但本研究在血管内治疗方法和抗栓治疗方案的执行方面有很好的统一性, 也在一定程度上减少了主观因素的影响。(2)机械取栓后根据颈内动脉狭窄程度、颅内血流再灌注情况、C臂CT脑实质渗出等多种因素决定是否急诊行颈动脉支架成形术, 无法做到有统一标准的绝对随机对照。(3)样本量较少, 尚待大样本数据进一步验证急诊行颈动脉支架成形术的有效性及安全性。

综上所述, 采用"半前向法"伴或不伴保护技术在血管内机械取栓术后根据责任颈内动脉狭窄程度是否超过50%和C型臂CT是否有脑实质广泛渗出表现来决策是否急诊行颈动脉支架成形术安全、可行, 值得临床推广。

利益冲突 无

参 考 文 献

[1] Sivan-Hoffmann R, Gory B, Armoiry X, Goyal M, Riva R, Labeyrie PE, Lukaszewicz AC, Lehot JJ, Derex L, Turjman F. Stent-retriever thrombectomy for acute anterior ischemic stroke with tandem occlusion: a systematic review and meta-analysis[J]. Eur Radiol, 2017, 27:247-254.

[2] Rubiera M, Ribo M, Delgado-Mederos R, Santamarina E, Delgado P, Montaner J, Alvarez-Sabín J, Molina CA. Tandem internal carotid artery/middle cerebral artery occlusion: an independent predictor of poor outcome after systemic thrombolysis[J]. Stroke, 2006, 37:2301-2305.

[3] Kim YS, Garami Z, Mikulik R, Molina CA, Alexandrov AV; CLOTBUST Collaborators. Early recanalization rates and clinical outcomes in patients with tandem internal carotid artery/middle cerebral artery occlusion and isolated middle cerebral artery occlusion[J]. Stroke, 2005, 36:869-871.

[4] Sadeh-Gonik U, Tau N, Friehmann T, Bracard S, Anxionnat R, Derelle AL, Tonnelet R, Liao L, Richard S, Armoiry X, Gory B. Thrombectomy outcomes for acute stroke patients with anterior circulation tandem lesions: a clinical registry and an update of a systematic review with meta-analysis[J]. Eur J Neurol, 2018, 25:693-700.

[5] Lockau H, Liebig T, Henning T, Neuschmelting V, Stetefeld H, Kabbasch C, Dorn F. Mechanical thrombectomy in tandem occlusion: procedural considerations and clinical results[J]. Neuroradiology, 2015, 57:589-598.

[6] Powers WJ, Rabinstein AA, Ackerson T, Adeoye OM, Bambakidis NC, Becker K, Biller J, Brown M, Demaerschalk BM, Hoh B, Jauch EC, Kidwell CS, Leslie-Mazwi TM, Ovbiagele B, Scott PA, Sheth KN, Southerland AM, Summers DV, Tirschwell DL; American Heart Association Stroke Council. 2018 Guidelines for the early management of patients with acute ischemic stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association[J]. Stroke, 2018, 49:e46-110.

[7] Heck DV, Brown MD. Carotid stenting and intracranial thrombectomy for treatment of acute stroke due to tandem occlusions with aggressive antiplatelet therapy may be associated with a high incidence of intracranial hemorrhage[J]. J Neurointerv Surg, 2015, 7:170-175.

[8] Steglich-Arnholm H, Holtmannspötter M, Kondziella D, Wagner A, Stavngaard T, Cronqvist ME, Hansen K, Højgaard J, Taudorf S, Krieger DW. Thrombectomy assisted by carotid stenting in acute ischemic stroke management: benefits and harms[J]. J Neurol, 2015, 262:2668-2675.

[9] Pop R, Zinchenko I, Quenardelle V, Mihoc D, Manisor M, Richter JS, Severac F, Simu M, Chibbaro S, Rouyer O, Wolff V, Beaujeux R. Predictors and clinical impact of delayed stent thrombosis after thrombectomy for acute stroke with tandem lesions[J]. AJNR Am J Neuroradiol, 2019, 40:533-539.

[10] Kim B, Kim BM, Bang OY, Baek JH, Heo JH, Nam HS, Kim YD, Yoo J, Kim DJ, Jeon P, Baik SK, Suh SH, Lee KY, Kwak HS, Roh HG, Lee YJ, Kim SH, Ryu CW, Ihn YK, Jeon HJ, Kim JW, Byun JS, Suh S, Park JJ, Lee WJ, Roh J, Shin BS. Carotid artery stenting and intracranial thrombectomy for tandem cervical and intracranial artery occlusions[J]. Neurosurgery, 2020, 86:213-220.

[11] Soize S, Kadziolka K, Estrade L, Serre I, Barbe C, Pierot L. Outcome after mechanical thrombectomy using a stent retriever under conscious sedation: comparison between tandem and

single occlusion of the anterior circulation[J]. J Neuroradiol, 2014, 41:136-142.

[12] Jadhav AP, Zaidat OO, Liebeskind DS, Yavagal DR, Haussen DC, Hellinger FR Jr, Jahan R, Jumaa MA, Szeder V, Nogueira RG, Jovin TG. Emergent management of tandem lesions in acute ischemic stroke[J]. Stroke, 2019, 50:428-433.

[13] Nogueira RG, Jadhav AP, Haussen DC, Bonafe A, Budzik RF, Bhuva P, Yavagal DR, Ribo M, Cognard C, Hanel RA, Sila CA, Hassan AE, Millan M, Levy EI, Mitchell P, Chen M, English JD, Shah QA, Silver FL, Pereira VM, Mehta BP, Baxter BW, Abraham MG, Cardona P, Veznedaroglu E, Hellinger FR, Feng L, Kirmani JF, Lopes DK, Jankowitz BT, Frankel MR, Costalat V, Vora NA, Yoo AJ, Malik AM, Furlan AJ, Rubiera M, Aghaebrahim A, Olivot JM, Tekle WG, Shields R, Graves T, Lewis RJ, Smith WS, Liebeskind DS, Saver JL, Jovin TG; DAWN Trial Investigators. Thrombectomy 6 to 24 hours after stroke with a mismatch between deficit and infarct[J]. N Engl J Med, 2018, 378:11-21.

[14] Albers GW, Marks MP, Kemp S, Christensen S, Tsai JP, Ortega-Gutierrez S, McTaggart RA, Torbey MT, Kim-Tenser M, Leslie-Mazwi T, Sarraj A, Kasner SE, Ansari SA, Yeatts SD, Hamilton S, Mlynash M, Heit JJ, Zaharchuk G, Kim S, Carrozzella J, Palesch YY, Demchuk AM, Bammer R, Lavori PW, Broderick JP, Lansberg MG; DEFUSE 3 Investigators. Thrombectomy for stroke at 6 to 16 hours with selection by perfusion imaging[J]. N Engl J Med, 2018, 378:708-718.

[15] Yi TY, Chen WH, Wu YM, Zhang MF, Lin DL, Lin XH. Another endovascular therapy strategy for acute tandem occlusion: Protect - Expand - Aspiration - Revascularization - Stent (PEARS) technique[J]. World Neurosurg, 2018, 113:e431-438.

[16] Barber PA, Demchuk AM, Zhang J, Buchan AM; ASPECTS Study Group. Validity and reliability of a quantitative computed tomography score in predicting outcome of hyperacute stroke before thombolytic therapy[J]. Lancet, 2000, 355:1670-1674.

[17] Zaidat OO, Yoo AJ, Khatri P, Tomsick TA, von Kummer R, Saver JL, Marks MP, Prabhakaran S, Kallmes DF, Fitzsimmons BF, Mocco J, Wardlaw JM, Barnwell SL, Jovin TG, Linfante I, Siddiqui AH, Alexander MJ, Hirsch JA, Wintermark M, Albers G, Woo HH, Heck DV, Lev M, Aviv R, Hacke W, Warach S, Broderick J, Derdeyn CP, Furlan A, Nogueira RG, Yavagal DR, Goyal M, Demchuk AM, Bendszus M, Liebeskind DS; Cerebral Angiographic Revascularization Grading (CARG) Collaborators; STIR Revascularization Working Group; STIR Thrombolysis in Cerebral Infarction (TICI) Task Force. Recommendations on angiographic revascularization grading standards for acute ischemic stroke: a consensus statement[J]. Stroke, 2013, 44: 2650-2663.

[18] Chen WH, Yi TY, Wu YM, Zhang MF, Lin DL, Lin XH. Parenchymal hyperdensity on C - arm CT images after endovascular therapy for acute ischaemic stroke predicts a poor prognosis[J]. Clin Radiol, 2019, 74:399-404.

[19] Wahlgren N, Ahmed N, Eriksson N, Aichner F, Bluhmki E, Dávalos A, Erilä T, Ford GA, Grond M, Hacke W, Hennerici MG, Kaste M, Köhrmann M, Larrue V, Lees KR, Machnig T, Roine RO, Toni D, Vanhooren G; Safe Implementation of Thrombolysis in Stroke - Monitoring Study Investigators. Multivariable analysis of outcome predictors and adjustment of main outcome results to baseline data profile in randomized controlled trials: Safe Implementation of Thrombolysis in Stroke-MOnitoring STudy (SITS - MOST)[J]. Stroke, 2008, 39: 3316 - 3322.

[20] Zhu F, Bracard S, Anxionnat R, Derelle AL, Tonnelet R, Liao L, Mione G, Humbertjean L, Lacour JC, Hossu G, Anadani M, Richard S, Gory B. Impact of emergent cervical carotid stenting in tandem occlusion strokes treated by thrombectomy: a review of the TITAN collaboration[J]. Front Neurol, 2019, 10:206.

[21] Gory B, Haussen DC, Piotin M, Steglich - Arnholm H, Holtmannspötter M, Labreuche J, Kyheng M, Taschner C, Eiden S, Nogueira RG, Papanagiotou P, Boutchakova M, Siddiqui AH, Lapergue B, Dorn F, Cognard C, Killer M, Mangiafico S, Ribo M, Psychogios MN, Spiotta AM, Labeyrie MA, Biondi A, Mazighi M, Turjman F; Thrombectomy In Tandem lesions (TITAN) Investigators. Impact of intravenous thrombolysis and emergent carotid stenting on reperfusion and clinical outcomes in patients with acute stroke with tandem lesion treated with thrombectomy: a collaborative pooled analysis[J]. Eur J Neurol, 2018, 25:1115-1120.

[22] Malhotra K, Goyal N, Tsivgoulis G. Internal carotid artery occlusion: pathophysiology, diagnosis, and management[J]. Curr Atheroscler Rep, 2017, 19:41.

[23] Goyal M, Menon BK, van Zwam WH, Dippel DW, Mitchell PJ, Demchuk AM, Dávalos A, Majoie CB, van der Lugt A, de Miquel MA, Donnan GA, Roos YB, Bonafe A, Jahan R, Diener HC, van den Berg LA, Levy EI, Berkhemer OA, Pereira VM, Rempel J, Millán M, Davis SM, Roy D, Thornton J, Román LS, Ribó M, Beumer D, Stouch B, Brown S, Campbell BC, van Oostenbrugge RJ, Saver JL, Hill MD, Jovin TG; HERMES Collaborators. Endovascular thrombectomy after large - vessel ischaemic stroke: a meta-analysis of individual patient data from five randomised trials[J]. Lancet, 2016, 387:1723-1731.

[24] Spiotta AM, Lena J, Vargas J, Hawk H, Turner RD, Chaudry MI, Turk AS. Proximal to distal approach in the treatment of tandem occlusions causing an acute stroke[J]. J Neurointerv Surg, 2015, 7:164-169.

[25] Son S, Choi DS, Oh MK, Kim SK, Kang H, Park KJ, Choi NC, Kwon OY, Lim BH. Emergency carotid artery stenting in patients with acute ischemic stroke due to occlusion or stenosis of the proximal internal carotid artery: a single-center experience[J]. J Neurointerv Surg, 2015, 7:238-244.

[26] Kang DH, Kim YW, Hwang YH, Kim YS. Endovascular recanalization of acute tandem cervical carotid and intracranial occlusions: efficacy of cervical balloon angioplasty alone then intracranial target recanalization strategy[J]. World Neurosurg, 2019, 126:e1268-1275.

[27] Bracard S, Ducrocq X, Mas JL, Soudant M, Oppenheim C, Moulin T, Guillemin F; THRACE Investigators. Mechanical thrombectomy after intravenous alteplase versus alteplase alone after stroke (THRACE): a randomised controlled trial[J]. Lancet Neurol, 2016, 15:1138-1147.

[28] Zhu F, Anadani M, Labreuche J, Spiotta A, Turjman F, Piotin M, Steglich-Arnholm H, Holtmannspötter M, Taschner C, Eiden S, Haussen DC, Nogueira RG, Papanagiotou P, Boutchakova M, Siddiqui AH, Lapergue B, Dorn F, Cognard C, Killer - Oberpfalzer M, Mangiafico S, Ribo M, Psychogios MN, Labeyrie MA, Mazighi M, Biondi A, Anxionnat R, Bracard S, Richard S, Gory B; TITAN Investigators. Impact of antiplatelet therapy during endovascular therapy for tandem occlusions: a collaborative pooled analysis[J]. Stroke, 2020, 51:1522-1529.

[29] Kastrup A, Gröschel K, Krapf H, Brehm BR, Dichgans J, Schulz JB. Early outcome of carotid angioplasty and stenting with and without cerebral protection devices: a systematic review of the literature[J]. Stroke, 2003, 34:813-819.

（收稿日期：2022-07-29）

（本文编辑：袁云）