·急性大血管闭塞血管内治疗·

改良SWIM技术在急性缺血性卒中血管内机械取栓术中的应用

崔接门 叶斌 宫鑫 张红艳 孙瑄

【摘要】 **目的** 探讨改良SWIM技术机械取栓术治疗急性缺血性卒中的有效性和安全性。**方法** 纳入2021年1月至2024年1月在安徽省蚌埠市第三人民医院行血管内机械取栓术的114例急性缺血性卒中患者，分别予以改良SWIM技术（改良取栓组，57例）和常规SWIM技术（常规取栓组，57例），记录首次取栓血管再通率、总体血管再通率、取栓次数、穿刺至再灌注时间，近期神经功能缺损[术后14 d美国国立卫生研究院卒中量表（NIHSS）]和远期神经功能预后[术后90 d改良Rankin量表（mRS）]，以及症状性颅内出血发生率和病死率。**结果** 改良取栓组首次取栓血管再通率高于常规取栓组（$\chi^2=5.054$，$P=0.025$），取栓次数少于（$Z=2.014$，$P=0.044$）、穿刺至再灌注时间短于（$Z=2.630$，$P=0.009$）常规取栓组。改良取栓组与常规取栓组手术前后NIHSS评分差异有统计学意义（$F=5.185$，$P=0.025$），两组入院时与术后14 d NIHSS评分差异亦有统计学意义（$F=133.705$，$P=0.000$），但处理因素与测量时间之间无交互作用（$F=3.148$，$P=0.079$），其中术后14 d改良取栓组NIHSS评分低于常规取栓组（$t=2.969$，$P=0.004$），改良取栓组（$t=10.286$，$P=0.000$）和常规取栓组（$t=6.428$，$P=0.000$）术后14 d NIHSS评分均低于入院时。改良取栓组与常规取栓组手术前后mRS评分差异有统计学意义（$F=7.581$，$P=0.007$），两组患者入院时与术后90 d mRS评分差异亦有统计学意义（$F=277.328$，$P=0.000$），且处理因素与测量时间之间存在交互作用（$F=10.471$，$P=0.002$），改良SWIM技术的效果更佳。改良取栓组术后90 d预后良好（mRS评分≤2分）率高于常规取栓组（$\chi^2=4.267$，$P=0.039$），而两组术后症状性颅内出血发生率（$\chi^2=0.077$，$P=0.782$）和病死率（$\chi^2=0.101$，$P=0.751$）差异均无统计学意义。**结论** 机械取栓术中应用改良SWIM技术较常规SWIM技术具有更好的疗效且安全性相当，值得临床推广。

【关键词】 缺血性卒中； 血栓切除术； 支架； 预后

Application of modified SWIM technique in mechanical thrombectomy of acute ischemic stroke

CUI Jie-men[1], YE Bin[1], GONG Xin[1], ZHANG Hong-yan[1], SUN Xuan[2]

[1]*Department of Neurology, The Third the People's Hospital of Bengbu; Central Hospital of Bengbu, Bengbu 233000, Anhui, China*

[2]*Department of Interventional Neuroradiology, Beijing Tiantan Hospital, Capital Medical University, Beijing 100070, China*

Corresponding author: SUN Xuan (Email: 13810926284@163.com)

【**Abstract**】 **Objective** To investigate the efficacy and safety of modified SWIM technique for mechanical thrombectomy in patients with acute ischemic stroke. **Methods** Total 114 patients with acute ischemic stroke who underwent mechanical thrombectomy in The Third the People's Hospital of Bengbu from January 2021 to January 2024 were included. Modified SWIM technique (modified thrombectomy group, n = 57) and conventional SWIM technique (conventional thrombectomy group, n = 57) were given respectively. Vascular recanalization rate of the first thrombectomy, overall vascular recanalization rate, the number of thrombectomy, puncture-to-reperfusion time, near-term neurological deficits [National Institutes of

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作者单位：233000 安徽省蚌埠市第三人民医院 安徽省蚌埠市中心医院神经内科（崔接门，叶斌，宫鑫，张红艳）；100070 首都医科大学附属北京天坛医院神经病学中心介入神经病学科（孙瑄）

通讯作者：孙瑄，Email：13810926284@163.com

Health Stroke Scale (NIHSS) at 14 d postoperatively] and long-term neurological prognosis [modified Rankin Scale (mRS) at 90 d postoperatively] were recorded, as well as symptomatic intracranial hemorrhage (sICH) rate and mortality. **Results** The vascular recanalization rate of the first thrombectomy in modified thrombectomy group was higher than that in conventional thrombectomy group (χ^2 = 5.054, P = 0.025), the number of thrombectomy was less than (Z = 2.014, P = 0.044), and puncture-to-reperfusion time was shorter than (Z = 2.630, P = 0.009) conventional thrombectomy group. There was a statistically significant difference in NIHSS score between modified thrombectomy group and conventional thrombectomy group before and after surgery (F = 5.185, P = 0.025), and there was also a statistically significant difference in NIHSS score between the 2 groups at admission and 14 d after surgery (F = 133.705, P = 0.000). There was not an interaction between treatment factors and measurement times (F = 3.148, P = 0.079). The NIHSS score 14 d after surgery in modified thrombectomy group was lower than that in conventional thrombectomy group (t = 2.969, P = 0.004). The NIHSS score of modified thrombectomy group (t = 10.286, P = 0.000) and conventional thrombectomy group (t = 6.428, P = 0.000) were lower at 14 d after surgery than those at admission. There was a statistically significant difference in mRS score between modified thrombectomy group and conventional thrombectomy group before and after surgery (F = 7.581, P = 0.007), and there was also a statistically significant difference in mRS score between the 2 groups at admission and 90 d after surgery (F = 277.328, P = 0.000). There was an interaction between treatment factors and measurement times (F = 10.471, P = 0.002), and the effect of modified SWIM technique was better. Modified thrombectomy group had a better prognosis (mRS score ≤ 2) at 90 d after surgery than conventional thrombectomy group (χ^2 = 4.267, P = 0.039). There were no significant differences in the incidence of postoperative sICH rate (χ^2 = 0.077, P = 0.782) and the mortality (χ^2 = 0.101, P = 0.751) between 2 groups. **Conclusions** The application of modified SWIM technique in mechanical thrombectomy has better efficacy and safety than conventional SWIM technique, and is worthy of clinical promotion.

【Key words】 Ischemic stroke; Thrombectomy; Stents; Prognosis

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Conflicts of interest: none declared

急性缺血性卒中是威胁人类健康的主要疾病之一，其治疗关键在于尽早开通闭塞血管，挽救缺血半暗带[1]，早期血管再通方法主要为阿替普酶静脉溶栓[2-4]，但血管再通率较低[5]。2015年，5项国际临床研究——MR CLEAN（Multicenter Randomized CLinical Trials of Endovascular Treatment for Acute Ischemic Stroke in the Netherlands）[6]、ESCAPE（Endovascular Treatment for Small Core and Anterior Circulation Proximal Occlusion with Emphasis on Minimizing CT to Recanalization Times）[7]、SWIFT PRIME（Solitaire with the Intention for Thrombectomy as Primary Endovascular Treatment）[8]、REVASCAT（Randomized Trial of Revascularization with Solitaire FR Device versus Best Medical Therapy in the Treatment of Acute Stroke Due to Anterior Circulation Large Vessel Occlusion Presenting within Eight Hours of Symptom Onset）[9]、EXTEND - IA（Extending the Time for Thrombolysis in Emergency Neurological Deficits-Intra-Arterial）[10]均证实机械取栓术治疗急性前循环大血管闭塞性缺血性卒中的效果优于单纯静脉溶栓，90 d后预后良好率显著增加。2018年，DAWN（DWI or CTP Assessment with Clinical Mismatch in the Triage of Wake - Up and Late Presenting Strokes Undergoing Neurointervention with Trevo）研究[11]和DEFUSE 3（Endovascular Therapy Following Imaging Evaluation for Ischemic Stroke 3）研究[12]将机械取栓术的治疗“时间窗”拓宽至发病24小时内。2022年，ATTENTION（the Endovascular Treatment for Acute Basilar-Artery Occlusion）研究进一步明确机械取栓术是急性基底动脉（BA）闭塞性缺血性卒中的首选治疗方法[13]。机械取栓术存在多种术式，根据手术技术策略，分为单纯支架取栓、直接抽吸取栓、支架结合抽吸的抽拉结合取栓3种术式；根据是否应用球囊导引导管（BGC），分为予近端血流阻断和不予近端血流阻断术式；同时包括多种技术组合，如SWIM技术（Solitaire FR With Intracranial support catheter for Mechanical thrombectomy）、Solumbra技术（Solitaire + Penumbra）、ARTS技术（Aspiration - Retriever Technique for Stroke）、SAVE技术（Stent retriever Assisted Vacuum - locked Extraction）、

ADAPT技术（A Direct Aspiration first - Pass Thrombectomy）、BADDASS技术（BAlloon guide with large bore Distal access catheter with Dual Aspiration with Stent-retriever as Standard approach）等，其中SWIM技术是临床最常用的技术之一，即颅内支撑导管辅助支架取栓+抽吸取栓，是一种抽拉结合的综合技术。安徽省蚌埠市第三人民医院在常规SWIM技术的基础上，增加释放支架时的推拉释放技术（PFT）和中间导管负压抽吸时的裸导丝技术（BWT）两个技术细节，称为改良SWIM技术。本研究以我院近3年收治的114例急性缺血性卒中患者为研究对象，分别行改良SWIM技术和常规SWIM技术机械取栓术，探讨改良SWIM技术的临床疗效和安全性，以为急性缺血性卒中的机械取栓术提供更佳的方案选择。

对象与方法

一、研究对象

1.纳入标准 （1）均符合《中国急性缺血性脑卒中早期血管内介入诊疗指南2018》的标准[14]。（2）经影像学证实为颅内大血管闭塞。（3）年龄＞18岁。（4）发病至手术时间为，前循环闭塞＜6 h（如果6～24 h须经严格的影像学筛选），后循环闭塞＜24 h。（5）入院时美国国立卫生研究院卒中量表（NIHSS）评分≥6分。（6）入院时改良Rankin量表（mRS）评分≥3分。（7）本研究经安徽省蚌埠市第三人民医院医学伦理委员会审核批准（审批号：伦科批字[2024]第k49号）。（8）所有患者及其家属均对手术方案和风险知情并签署知情同意书。

2.排除标准 （1）颅内动脉夹层、烟雾病或血管炎。（2）CT提示颅内出血、蛛网膜下腔出血。（3）活动性出血或已知有明显出血倾向。（4）合并严重心、肝、肾功能障碍。（5）临床资料不完整。

3.一般资料 选择2021年1月至2024年1月在安徽省蚌埠市第三人民医院神经内科行机械取栓术的急性缺血性卒中患者114例，男性67例，女性47例；年龄28～90岁，平均（66.54±13.15）岁；既往有高血压占72.81%（83/114）、房颤占36.84%（42/114）、糖尿病占41.23%（47/114）、高脂血症占45.61%（52/114），吸烟占47.37%（54/114）、饮酒占44.74%（51/114）；其中64例（56.14%）既往有脑卒中病史。入院时NIHSS评分6～36分，平均（17.46±5.74）分；入院时mRS评分3～5分，中位评分为4（4，5）分；33例（28.95%）静脉溶栓桥接机械取栓；发病至动脉穿刺时间85～940 min，中位时间307.50（214.00，430.00）min。根据患者意愿及术中具体情况，分别予以常规SWIM技术机械取栓术（常规取栓组，57例）和改良SWIM技术机械取栓术（改良取栓组，57例），两组患者一般资料比较，差异无统计学意义（均$P>0.05$，表1），均衡可比。

表1 改良取栓组与常规取栓组一般资料的比较

Table 1. Comparison of general data between the modified thrombectomy group and the conventional thrombectomy group

观察指标	常规取栓组（n=57）	改良取栓组（n=57）	统计量值	P值
性别[例(%)]			1.774	0.183
男性	30(52.63)	37(64.91)		
女性	27(47.37)	20(35.09)		
年龄($\bar{x}\pm s$，岁)	67.26±12.92	65.81±13.46	0.589	0.557
高血压[例(%)]	40(70.18)	43(75.44)	0.399	0.528
房颤[例(%)]	20(35.09)	22(38.60)	0.151	0.698
糖尿病[例(%)]	23(40.35)	24(42.11)	0.036	0.849
高脂血症[例(%)]	24(42.11)	28(49.12)	0.566	0.452
吸烟[例(%)]	23(40.35)	31(54.39)	2.252	0.133
饮酒[例(%)]	26(45.61)	25(43.86)	0.035	0.851
既往脑卒中病史[例(%)]	35(61.40)	29(50.88)	1.283	0.257
入院时NIHSS（$\bar{x}\pm s$，评分）	17.91± 6.75	17.00± 4.53	0.847	0.399
入院时mRS[$M(P_{25},P_{75})$，评分]	4.00（4.00，5.00）	4.00（4.00，5.00）	0.458	0.796
静脉溶栓[例(%)]	15(26.32)	18(31.58)	0.384	0.536
发病至动脉穿刺时间[$M(P_{25},P_{75})$，min]	285.00（215.00，430.00）	318.00（213.00，439.00）	0.666	0.505

Two-independent-sample t test for comparison of age and NIHSS on admission, Mann-Whitney U test for comparison of mRS on admission and onset-to-puncture time, and χ^2 test for comparison of others，年龄和入院时NIHSS评分的比较行两独立样本的t检验，入院时mRS评分和发病至动脉穿刺时间的比较行Mann-Whitney U检验，其余指标的比较行χ^2检验。NIHSS，National Institutes of Health Stroke Scale，美国国立卫生研究院卒中量表；mRS，modified Rankin Scale，改良Rankin量表

二、研究方法

1.机械取栓术 患者平卧位，全身麻醉，采用Seldinger技术经右股动脉穿刺，置入8F动脉鞘（日本Terumo株式会社），脑血管造影明确闭塞部位和侧支代偿情况，将6F Neuron Max长鞘（美国Penumbra公司）内套5F MPA1多功能导管（长度125 cm，美国Cordis公司）于泥鳅导丝（日本Terumo株式会社）导引下送至颈内动脉（ICA）C1段远端（前

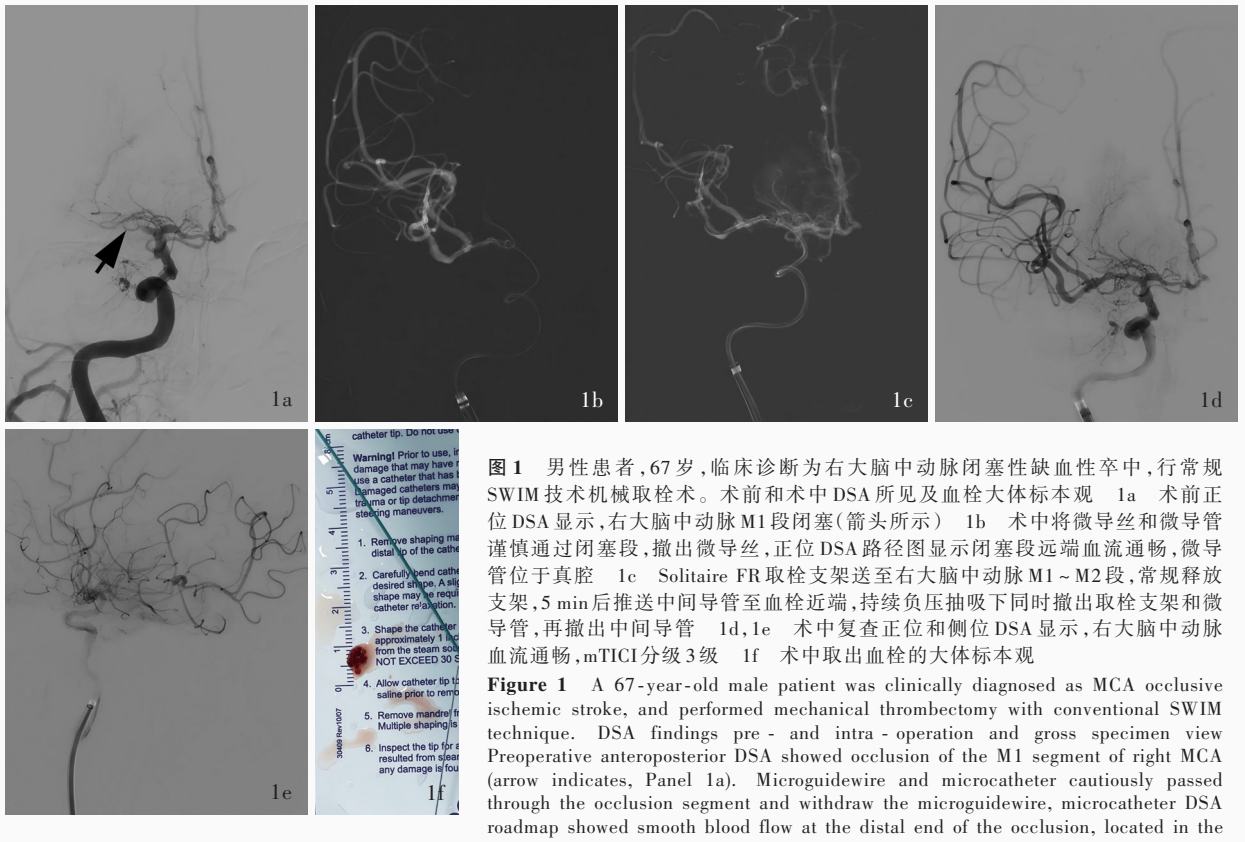

图1 男性患者，67岁，临床诊断为右大脑中动脉闭塞性缺血性卒中，行常规SWIM技术机械取栓术。术前和术中DSA所见及血栓大体标本观 1a 术前正位DSA显示，右大脑中动脉M1段闭塞（箭头所示） 1b 术中将微导丝和微导管谨慎通过闭塞段，撤出微导丝，正位DSA路径图显示闭塞段远端血流通畅，微导管位于真腔 1c Solitaire FR取栓支架送至右大脑中动脉M1～M2段，常规释放支架，5 min后推送中间导管至血栓近端，持续负压抽吸下同时撤出取栓支架和微导管，再撤出中间导管 1d，1e 术中复查正位和侧位DSA显示，右大脑中动脉血流通畅，mTICI分级3级 1f 术中取出血栓的大体标本观

Figure 1 A 67-year-old male patient was clinically diagnosed as MCA occlusive ischemic stroke, and performed mechanical thrombectomy with conventional SWIM technique. DSA findings pre- and intra-operation and gross specimen view Preoperative anteroposterior DSA showed occlusion of the M1 segment of right MCA (arrow indicates, Panel 1a). Microguidewire and microcatheter cautiously passed through the occlusion segment and withdraw the microguidewire, microcatheter DSA roadmap showed smooth blood flow at the distal end of the occlusion, located in the true cavity (Panel 1b). During operation, the Solitaire FR thrombectomy stent was sent to the M1-M2 segment of right MCA, and the stent was released routinely. After 5 min, the intermediate catheter followed up to the proximal end of the thrombus, and under continuous negative pressure aspiration, firstly withdraw the thrombectomy stent and microcather, and then withdraw the intermediate catheter (Panel 1c). Intraoperative anteroposterior (Panel 1d) and lateral (Panel 1e) DSA showed smooth blood flow in the right MCA, and mTICI was grade 3. Gross specimen view of thrombus removal (Panel 1f).

循环）或椎动脉（VA）V2段（后循环），在长鞘内送入中间导管（Navien，美国Medtronic公司；AXS Catalyst，美国Stryker公司；SOFIA，美国MicroVention公司；通桥银蛇DA远端通路导管，通桥医疗科技有限公司），于Synchro微导丝（0.014 in，美国Stryker公司）、Rebar微导管（美国Medtronic公司）辅助下将中间导管送至目标血管闭塞段近端，微导丝携带微导管谨慎通过闭塞段，微导管达闭塞段远端后撤出微导丝，经微导管造影确认闭塞段远端血流通畅且微导管位于真腔；在微导管内送入取栓支架（Solitaire FR，美国Medtronic公司；Solitaire AB，美国Medtronic公司；Trevo ProVue，美国Stryker公司；通桥蛟龙取栓支架，通桥医疗科技有限公司）。（1）常规SWIM技术：支架达微导管头端后回撤微导管并释放取栓支架，观察5 min，待血栓与支架紧密结合后，推送中间导管至血栓近端，持续负压抽吸下同时撤出取栓支架和微导管，再撤出中间导管，即刻复查脑血管造影观察血管再通情况（图1）。（2）改良SWIM技术：支架达微导管头端后采用推拉释放技术（图2）释放支架，观察5 min，待血栓与支架紧密结合后保留支架，先撤出微导管，推送中间导管至血栓近端，采用裸导丝技术（图3）在中间导管持续负压抽吸下依次撤出取栓支架和中间导管，即刻复查脑血管造影观察血管再通情况（图4）。必要时重复上述取栓操作，但一般不超过3次。（3）静脉溶栓桥接机械取栓：发病≤4.50 h的急性缺血性卒中患者先予阿替普酶0.90 mg/kg静脉溶栓，最大剂量90 mg，先将10%于1 min内静脉注射，余90%于1 h内持续静脉泵入，同时完善影像学检查（CTA或MRA），提示大血管闭塞者桥接机械取栓术。

2. 疗效和安全性评价 （1）记录首次取栓血管再通率、总血管再通率、取栓次数以及穿刺至再灌注时间，其中血管再通率的评价采用改良脑梗死溶栓血流分级（mTICI），共分为5级，0级，无血流灌注；

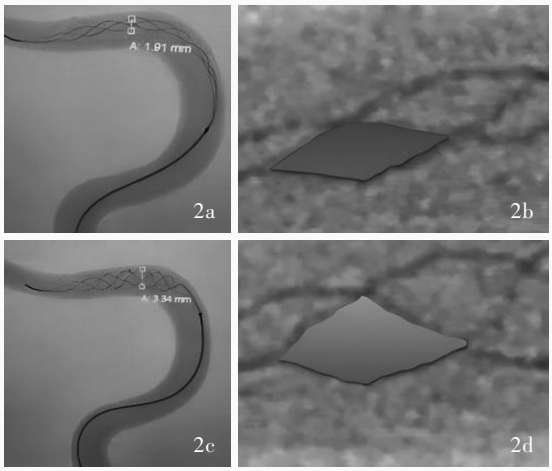

图2　推拉释放技术示意图　2a　回撤输送微导管同时释放支架的脱鞘方式，支架直径约1.91 mm　2b　常规释放支架的网孔　2c　标准脱鞘技术释放支架前段，使支架锚定后主动向前推送支架送入微导丝，微导管因张力作用同时自动后退，直至支架完全释放，改变取栓支架形态，支架直径约3.34 mm，增加75%　2d　推拉释放技术释放支架后网孔面积增加51%，支架直径和网孔面积的增加使之与血管贴壁更佳，更完整地结合血栓

Figure 2　Schematic diagram of PFT　The unsheathed method of retracting the delivery microcatheter and meanwhile releasing the stent, the diameter of the stent is about 1.91 mm (Panel 2a). Mesh of conventional release stent (Panel 2b). Standard unsheathed technology releases the front section of the stent, so that the stent is anchored and actively pushed the stent forward to deliver microguidewire. The microcatheter automatically retreats due to tension until the stent is completely released, changing the shape of the thrombectomy stent. The diameter of the stent is about 3.34 mm, an increase of 75% (Panel 2c). After the stent is released by PFT, the mesh area increases by 51%, the diameter and the mesh area of the stent increase, which can better adhere to the wall of the blood vessel, so as to combine the thrombus more completely (Panel 2d).

图3　裸导丝技术示意图　3a　常规释放支架后，保留输送微导管，回撤支架的同时进行中间导管抽吸　3b　利用支架锚定作用，保留支架送入微导丝，撤出微导管，回撤支架的同时进行中间导管抽吸，中间导管内仅保留支架送入导丝，增加中间导管内腔面积，经中间导管抽吸可获得更大的负压抽吸力，提高取栓成功率

Figure 3　Schematic diagram of BWT　After routine stent release, the delivery microcatheter is retained, and intermediate catheter aspiration is performed while the stent is withdrawn (Panel 3a). Using the anchoring effect of the stent, the stent delivery microguidewire is retained, the microcatheter is withdrawn, and then intermediate catheter aspiration is performed while the stent is withdrawn. Only the stent delivery guide wire is retained in the intermediate catheter, which increases the lumen area of the intermediate catheter. Greater negative pressure suction force can be obtained by pumping through the intermediate catheter to improve the success rate of thrombectomy (Panel 3b).

1级，仅有微量血流通过闭塞段；2a级，远端缺血区有部分血流灌注（<50%）；2b级，远端缺血区有血流灌注（>50%）；3级，完全恢复血流灌注，并将mTICI分级≥2b级定为血管再通[15]。(2)近期预后：于术后14 d采用NIHSS量表评价近期神经功能缺损程度，该量表包括意识水平（3分）、意识水平提问（2分）、意识水平指令（2分）、凝视（2分）、视野（3分）、面瘫（3分）、左上肢运动（4分）、右上肢运动（4分）、左下肢运动（4分）、右下肢运动（4分）、共济失调（2分）、感觉（2分）、语言（3分）、构音（2分）、忽视（2分）共15项内容，总评分42分，评分越高，神经功能缺损越严重[16]。(3)远期预后：于术后90 d采用mRS量表评价远期神经功能预后，mRS评分≤2分为预后良好、3～5分为预后不良[17]。(4)手术相关并发症：记录术后14 d症状性颅内出血（sICH）发生率和病死率，其中症状性颅内出血定义为NIHSS评分增加≥4分，且归因于脑实质血肿、蛛网膜下腔出血或脑室内出血导致的临床恶化[18]。

3.统计分析方法　采用SPSS 26.0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，采用χ^2检验。采用Shapiro-Wilk检验验证数据是否符合正态分布，呈正态分布的计量资料以均数±标准差（$\bar{x}\pm s$）表示，行两独立样本的t检验；手术前后NIHSS和mRS评分的比较采用前后测量设计的方差分析，两两比较行LSD-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。以$P\leq0.05$为差异具有统计学意义。

结　果

改良取栓组患者首次取栓血管再通率高于常规取栓组（$P=0.025$），取栓次数少于（$P=0.044$）、穿刺至再灌注时间短于（$P=0.009$）常规取栓组；而总体血管再通率比较，组间差异无统计学意义（$P=0.542$，表2）。

改良取栓组与常规取栓组手术前后NIHSS评分差异有统计学意义（$P=0.025$），两组入院时与术后14 d NIHSS评分差异亦有统计学意义（$P=0.000$），但处理因素与测量时间之间无交互作用（$P=0.079$），提示改良取栓组与常规取栓组手术前后NIHSS评分的下降幅度相同（表3，4）；进一步两两比较，术后14 d改良取栓组NIHSS评分低于常规

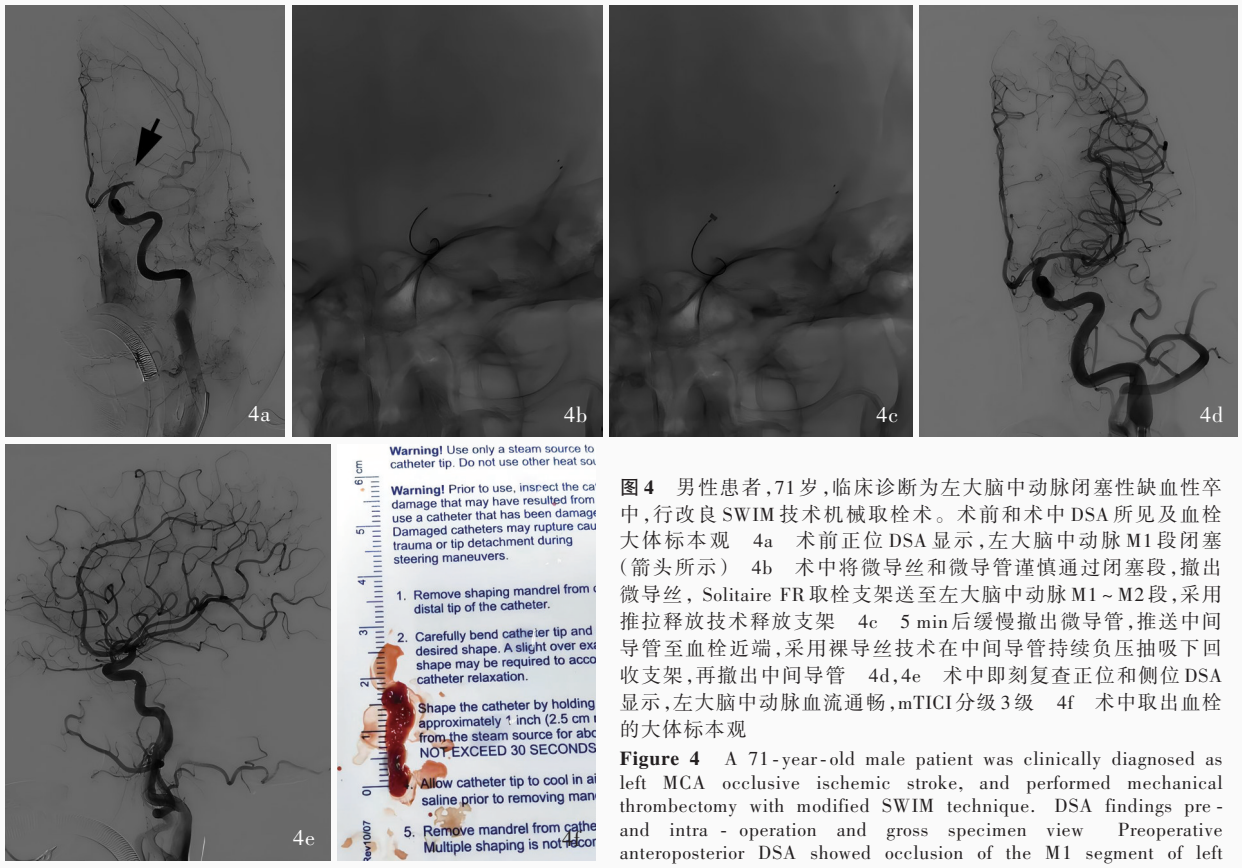

图4 男性患者，71岁，临床诊断为左大脑中动脉闭塞性缺血性卒中，行改良SWIM技术机械取栓术。术前和术中DSA所见及血栓大体标本观 4a 术前正位DSA显示，左大脑中动脉M1段闭塞（箭头所示） 4b 术中将微导丝和微导管谨慎通过闭塞段，撤出微导丝，Solitaire FR取栓支架送至左大脑中动脉M1～M2段，采用推拉释放技术释放支架 4c 5 min后缓慢撤出微导管，推送中间导管至血栓近端，采用裸导丝技术在中间导管持续负压抽吸下回收支架，再撤出中间导管 4d，4e 术中即刻复查正位和侧位DSA显示，左大脑中动脉血流通畅，mTICI分级3级 4f 术中取出血栓的大体标本观

Figure 4 A 71-year-old male patient was clinically diagnosed as left MCA occlusive ischemic stroke, and performed mechanical thrombectomy with modified SWIM technique. DSA findings pre- and intra - operation and gross specimen view Preoperative anteroposterior DSA showed occlusion of the M1 segment of left MCA (arrow indicates, Panel 4a). During surgery, the microguidewire and microcatheter were discreetly passed through the occlusion segment, withdraw the microguidewire, Solitaire FR thrombectomy stent delivered to the M1-M2 segment of left MCA, using PFT to release the stent (Panel 4b). Slowly withdraw the microcatheter after 5 min, follow up with the intermediate catheter to the proximal end of the thrombus, using BWT to recover the stent under continuous negative pressure aspiration in the intermediate catheter, then withdraw the intermediate catheter (Panel 4c). Intraoperative anteroposterior (Panel 4d) and lateral (Panel 4e) DSA showed left MCA had smooth blood flow, and mTICI was grade 3. Gross specimen view of thrombus removal (Panel 4f).

取栓组（$t=2.969$，$P=0.004$），而入院时两组NIHSS评分差异无统计学意义（$t=0.847$，$P=0.399$）；改良取栓组（$t=10.286$，$P=0.000$）和常规取栓组（$t=6.428$，$P=0.000$）术后14 d NIHSS评分均低于入院时。改良取栓组与常规取栓组手术前后mRS评分差异有统计学意义（$P=0.007$），两组患者入院时与术后90 d mRS评分差异亦有统计学意义（$P=0.000$），且处理因素与测量时间之间存在交互作用（$P=0.002$），表明改良取栓组与常规取栓组手术前后mRS评分下降幅度不同，改良取栓组平均mRS评分由4.33分降至2.12分，平均减少2.21分；常规取栓组平均mRS评分由4.35分降至2.86分，平均减少1.49分，故认为改良SWIM技术的效果更佳（表3，4）。术后90 d，改良取栓组有32例（56.14%）预后良好（mRS评分≤2分），常规取栓组有21例（36.84%）预后良好，组间差异有统计学意义（$\chi^2=4.267$，$P=0.039$）。改良取栓组有7例（12.28%）术后发生症状性颅内出血，常规取栓组有8例（14.04%）术后发生症状性颅内出血，组间差异无统计学意义（$\chi^2=0.077$，$P=0.782$）；改良取栓组病死率为8.77%（5/57），常规取栓组为10.53%（6/57），组间差异亦无统计学意义（$\chi^2=0.101$，$P=0.751$）。

讨 论

本研究采用的改良SWIM技术属于支架取栓联合抽吸取栓技术，在常规SWIM技术的基础上，增加推拉释放技术和裸导丝技术两个技术细节。取栓支架的常规释放技术是回撤输送微导管同时释放支架的脱鞘方式，而本研究采用的推拉释放技术首先以标准脱鞘技术释放支架前段，使支架锚定后主动向前推送支架输送微导丝，微导管因张力作用同时自动后退，直至支架完全释放，推拉释放技术改

表2 改良取栓组与常规取栓组患者血管再通率、取栓次数和穿刺至再灌注时间的比较

Table 2. Comparison of vascular recanalization rate, number of thrombectomy and puncture-to-reperfusion time between the modified thrombectomy group and the conventional thrombectomy group

组别	例数	首次取栓血管再通率[例(%)]	总体血管再通率[例(%)]
常规取栓组	57	22(38.60)	50(87.72)
改良取栓组	57	34(59.65)	52(91.23)
χ^2或Z值		5.054	0.373
P值		0.025	0.542

组别	例数	取栓次数[$M(P_{25},P_{75})$,次]	穿刺至再灌注时间[$M(P_{25},P_{75})$,min]
常规取栓组	57	2.00(1.00,3.00)	60.00(40.50,82.50)
改良取栓组	57	1.00(1.00,2.00)	45.00(31.50,66.50)
χ^2或Z值		2.014	2.630
P值		0.044	0.009

χ^2 test for comparison of vascular recanalization rate of the first thrombectomy and overall vascular recanalization rate, Mann-Whitney U test for comparison of the number of thrombectomy and puncture-to-reperfusion time,首次取栓血管再通率和总体血管再通率的比较采用χ^2检验,取栓次数和穿刺至再灌注时间的比较采用Mann-Whitney U检验

表3 改良取栓组与常规取栓组患者手术前后NIHSS和mRS评分的比较($\bar{x}\pm s$,评分)

Table 3. Comparison of NIHSS and mRS scores before and after operation between the modified thrombectomy group and the conventional thrombectomy group ($\bar{x}\pm s$, score)

组别	例数	NIHSS		mRS	
		入院时	术后14 d	入院时	术后90 d
常规取栓组	57	17.91±6.75	12.11±5.77	4.35±0.52	2.86±1.23
改良取栓组	57	17.00±4.53	9.09±5.07	4.33±0.48	2.12±1.24

NIHSS, National Institutes of Health Stroke Scale,美国国立卫生研究院卒中量表;mRS, modified Rankin Scale,改良Rankin量表。The same for Table 4

表4 改良取栓组与常规取栓组患者手术前后NIHSS和mRS评分的前后测量设计的方差分析表

Table 4. ANOVA of premeasure-postmeasure design of NIHSS and mRS scores before and after surgery between the modified thrombectomy group and the conventional thrombectomy group

变异来源	*SS*	*df*	*MS*	*F*值	*P*值
NIHSS					
处理因素	220.070	1	220.070	5.185	0.025
测量时间	2682.123	1	2682.123	133.705	0.000
处理因素×测量时间	63.158	1	63.158	3.148	0.079
组间误差	4753.772	112	42.444		
组内误差	2246.719	112	20.060		
mRS					
处理因素	8.110	1	8.110	7.581	0.007
测量时间	195.268	1	195.268	277.328	0.000
处理因素×测量时间	7.373	1	7.373	10.471	0.002
组间误差	119.807	112	1.070		
组内误差	78.860	112	0.704		

变取栓支架的形态,使支架长度减少25%,但支架直径增加75%、网孔面积增加51%,支架直径和网孔面积增加,使之与血管贴壁更好,更完整地结合血栓,有助于增加首次取栓血管再通率、减少取栓次数、获得更高的血管再通率[19]。此外,释放支架后回收支架和中间导管抽吸时,采用裸导丝技术,利用支架锚定作用,保留支架输送微导丝,撤出微导管,中间导管内仅保留支架输送微导丝,增加中间导管内腔面积,经中间导管抽吸可以获得更大的负压抽吸力,提高取栓成功率[20]。

改良SWIM技术一方面利用推拉释放支架改变取栓支架形态,使支架与血管贴壁更好,更完整地结合血栓;另一方面回收支架和负压抽吸时,裸导丝技术增加中间导管内腔面积,获得更大的负压抽吸力,从而形成局部逆向血流,避免细碎的血栓逃逸至远端栓塞毛细血管,影响脑灌注,导致神经功能缺损[21]。然而仍存在取栓失败的可能,临床常见的多次取栓或取栓失败多为血栓与支架结合不完全或血栓逃逸致再栓塞,尤其是质地较硬、负荷较大的血栓,易导致支架抓取不完全、中间导管抽吸不完全。取栓过程中受管壁摩擦、前向血流冲击等原因,血栓易脱落、碎裂,最终导致取栓次数增多、取栓时间延长甚至取栓失败。随着材料学的发展,取栓支架的改良和中间导管的更新可一定程度上增加取栓成功率,与此同时,手术方式的改良同样重要。研究显示,取栓支架在中间导管的持续负压抽吸下可以保持系统内真空,闭塞血管再通快速且有效[22]。远端通路导管联合取栓支架可以降低前向血流对血栓破碎和血栓逃逸的影响[23]。但也有研究结果提示,支架取栓联合抽吸取栓相较单纯支架取栓并不能增加血管再通率[24]。

本研究发现,改良SWIM技术和常规SWIM技术的总体血管再通率分别为91.23%(52/57)和87.72%(50/57),组间无明显差异,表明两种手术方式均具有良好的血管再通效果。良好的再灌注状态是急性缺血性卒中患者预后良好的预测因素[25],再灌注时间同样重要,本研究改良SWIM技术的首

次取栓血管再通率高于常规SWIM技术，取栓次数少于、穿刺至再灌注时间短于常规SWIM技术，预后良好（mRS评分≤2分）率高于常规SWIM技术，表明应用推拉释放技术和裸导丝技术后取栓次数减少，一方面可以提高取栓效率，另一方面可以减少血管内取栓操作，进而减轻导管、导丝、支架对血管的刺激和损伤，可能减少术后并发症，提高患者预后良好率；而且发病至再灌注时间缩短使缺血缺氧的脑组织尽早恢复灌注，对改善预后至关重要[26-27]。改良取栓组与常规取栓组手术前后NIHSS和mRS评分差异有统计学意义，特别是改良取栓组术后14天NIHSS评分和术后90天mRS评分均低于常规取栓组；两组患者入院时与术后14天NIHSS评分和入院时与术后90天mRS评分差异亦有统计学意义，改良取栓组和常规取栓组术后14天NIHSS评分和术后90天mRS评分均低于入院时。推测是由于推拉释放支架技术可以增加血栓与支架的结合率，裸导丝技术可以增大中间导管内腔面积、增加负压抽吸力，通过缩短血管再通时间、减少取栓次数以提高取栓效率，减少缺血半暗带面积，最终减少核心梗死面积，减轻神经功能缺损，改善预后。

机械取栓术后并发症同样值得关注，颅内出血最为常见，根据神经功能缺损严重程度，分为无症状性颅内出血和症状性颅内出血，症状性颅内出血定义为颅内出血与临床症状恶化具有时间相关性，术后14天内NIHSS评分增加≥4分。研究显示，急性缺血性卒中患者行机械取栓术术后症状性颅内出血发生率约为16%[28]，症状性颅内出血可以引发脑疝，甚至导致死亡。颅内出血的原因之一是血管渗透性改变，缺血性卒中导致脑组织缺血、缺氧，引起氧自由基、炎性因子等增多，损伤血管内皮细胞和血管壁完整性[29]；此外，多次取栓、血管再通时间延长、侧支循环较差等均可增加机械取栓术后颅内出血发生率[28]，取栓过程中微导管、微导丝、取栓支架也可能损伤血管内膜、牵拉分支，增加颅内出血风险[30]。美国555家脑卒中中心的观察性队列登记研究GWTG-Stroke（Get With The Guidelines-Stroke）显示，静脉溶栓桥接机械取栓可增加症状性颅内出血风险[31]。国内相关研究显示，大血管闭塞性缺血性卒中患者直接机械取栓的疗效与静脉溶栓桥接机械取栓相当[32-33]，而颈内动脉或大脑中动脉（MCA）M1段闭塞致急性缺血性卒中患者以及脑卒中发作后4.5小时内患者直接机械取栓疗效并不优于静脉溶栓桥接机械取栓[34-37]。然而，对于超静脉溶栓“时间窗”的急性缺血性卒中患者，急诊机械取栓“时间窗”更长，适应证更广，对于发病＞6 h的急性缺血性卒中患者，机械取栓术仍有效[38]；对于发病6～24小时的急性前循环大血管闭塞性缺血性卒中患者，若CTA提示存在侧支循环，超“时间窗”机械取栓术仍安全、有效[39]。因此关于能否越过静脉溶栓而直接机械取栓，目前尚无定论，有待进一步深入研究。

本研究改良SWIM技术的症状性颅内出血发生率为12.28%（7/57）、病死率为8.77%（5/57），常规SWIM技术为14.04%（8/57）和10.53%（6/57），两种手术方式无明显差异，表明与常规SWIM技术相比，改良SWIM技术并未增加症状性颅内出血发生率和病死率，证明该项技术相对安全。尽管改良SWIM技术增加推拉释放技术和裸导丝技术，使支架更好地与血栓结合，同时增大抽吸导管负压抽吸力，提高取栓效率，但本研究并未发现该项技术可以降低症状性颅内出血发生率，究其原因，除反复多次取栓、损伤血管内膜、支架多次牵拉分支外，还可能与暴力操作、大范围核心梗死区、侧支循环差、再灌注损伤等相关。

综上所述，增加推拉释放技术和裸导丝技术的改良SWIM技术不仅增加首次取栓血管再通率、减少取栓次数、缩短血管再通时间，更有效改善患者神经功能及预后，且安全性良好，值得临床推广。但本研究为单中心回顾性研究，具有一定的局限性：样本量较小，样本代表性不足，存在回忆偏倚，数据准确性不够，同时缺乏标准化数据收集，混杂因素控制困难等，尚待多中心、大样本、前瞻性研究进一步证实。

利益冲突 无

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《中国现代神经疾病杂志》2025年广告征订启事

《中国现代神经疾病杂志》（ISSN 1672-6731，CN 12-1363/R）是国家卫生健康委员会主管，中国医师协会、天津市科学技术协会、天津市神经科学学会、天津市环湖医院主办的神经病学专业学术期刊。月刊，国内外公开发行。目前我刊已入编北京大学图书馆《中文核心期刊要目总览》2017年版（即第8版）、2020年版（即第9版）和2023年版（即第10版）的核心期刊，中国科技论文统计源期刊（中国科技核心期刊）和RCCSE中国核心学术期刊，并已被WJCI（2020、2021、2022和2023科技版）、EMBASE/SCOPUS、CA、DOAJ、EBSCO*host*、JSTChina等国际知名检索机构收录。

我刊订阅用户遍及全国各级医疗单位、高等医学院校、各级医学院校图书馆、科研单位和个人。为加强本刊与神经内外科医学科研、医药、医疗器械行业的合作，共同宣传推广新药、新器械和新技术，促进互惠双赢，现诚邀广告合作方。现将刊登广告注意事项告知：

1. 严格遵守《中华人民共和国广告法》，刊登广告单位必须经国家级或所在省级食品药品监督管理局审核批准，并在广告发布地的省级医疗药品和医疗器械行政监督管理部门备案。

2. 刊登广告单位必须附有国家食品药品监督管理总局核发的《药品广告审查表》和《医疗器械广告审查表》。广告内容应与医疗药品和医疗器械广告批准文号同时发布。广告审查批准文号有效期1年。

3. 广告文字简练，图片清晰、规范、必须以大16开本为基准进行设计，广告图稿原图或资料请于广告发布前1个月发送至编辑部邮箱（xdsjjbzz@263.net.cn）。

4. 凡刊登广告者，须与编辑部提前签订广告发布合同，根据合同具体内容执行。

联系地址：天津市津南区吉兆路6号天津市环湖医院C座二楼。邮政编码：300350。联系人：陈雪。联系电话：（022）59065612。Email：xdsjjbzz@263.net.cn。