·论著 临床诊治·

TCD对单侧颈内动脉重度狭窄或闭塞后颅内侧支循环的诊断和预后评价

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【摘要】 **目的** 探讨TCD对单侧颈内动脉重度狭窄或闭塞后颅内侧支循环的诊断和预后评价的价值。**方法** 收集超声诊断为一侧颈内动脉重度狭窄或闭塞同时行TCD检查评价颅内侧支循环的病例共22例。根据患侧大脑中动脉（MCA）平均血流速度分组，同时根据磁共振和CT病变侧脑梗死范围大小将病例分为4级。分析侧支循环出现率以及侧支循环与MCA平均血流速度、脑梗死范围的关系。**结果** 所有病例均检测到侧支循环开放，16例（73%）前交通动脉开放，16例（73%）后交通动脉开放，13例（59%）眼动脉开放。患侧MCA平均血流速度正常组5例，偏下限组7例，减低组9例，明显减低组1例。病变侧脑梗死范围1级3例，2级7例，3级6例，4级6例。前交通动脉开放者的患侧MCA平均血流速度[（47.4±11.7）cm/s]明显高于无前交通动脉开放者[（35.8±5.0）cm/s，Z=－2.559，P=0.010]。前交通动脉开放者的梗死范围级别（2.4±1.0）明显低于无前交通动脉开放者（3.5±0.5，Z=－2.598，P=0.022）。**结论** TCD在评价单侧颈内动脉重度狭窄或闭塞后颅内侧支循环方面起重要作用，且前交通动脉侧支开放对于评估其预后有较高价值。

【关键词】 经颅多普勒超声；单侧颈内动脉；重度狭窄；闭塞；颅内侧支循环

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Transcranial Doppler in the diagnosis and prognostic evaluation of cranial collateral circulation after severe stenosis or occlusion of unilateral internal carotid artery

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【**Abstract**】 **Objective** To investigate the value of transcranial Doppler（TCD）in the diagnosis and prognosis of cranial collateral circulation after severe stenosis or occlusion of unilateral internal carotid artery. **Methods** A total of 22 cases with severe stenosis or occlusion of one side of internal carotid artery diagnosed by ultrasound and TCD were collected. The patients were grouped according to the average flow velocity of the affected middle cerebral artery（MCA）. At the same time，the cases were divided into four grades according to the scope of cerebral infarction on the lesion side of MRI and CT. The incidence of collateral circulation was analyzed，and the relationship between collateral circulation and MCA average flow velocity/the range of cerebral infarction was analyzed. **Results** Collateral circulation was detected in all cases，16 cases（73%）showed opening of anterior communicating artery，16 cases（73%）showed opening of posterior communicating artery，and

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13 cases (59%) showed opening of ophthalmic artery. The average flow velocity of MCA on the affected side was normal in 5 cases, normal low limit in 7 cases, decreased in 9 cases and significantly decreased in 1 case. The range of cerebral infarction on the lesion side was 3 cases in grade 1, 7 cases in grade 2, 6 cases in grade 3 and 6 cases in grade 4. The mean velocity of MCA ((47.4±11.7) cm/s) in patients with anterior communicating artery opening was significantly higher than that ((35.8±5.0) cm/s) in patients without anterior communicating artery opening (Z=−2.559, P=0.010). The grade of infarct size (2.4±1.0)in patients with anterior communicating artery opening was significantly lower than that (3.5±0.5) in patients without anterior communicating artery opening (Z=−2.598, P=0.022). **Conclusion** TCD plays an important role in evaluating the cranial collateral circulation after severe stenosis or occlusion of the unilateral internal carotid artery. At the same time, the opening of the anterior communicating artery is of high value in improving prognosis.

【Key words】 Transcranial Doppler; Unilateral internal carotid artery; Severe stenosis; Occlusion; Cranial collateral circulation

缺血脑组织在闭塞动脉开通前主要依赖侧支血管的血供代偿而存活，因此颅内侧支循环的状态一定程度上反映可挽救脑组织的程度，不仅显著影响梗死进程，且与功能预后密切相关[1-11]。经颅多普勒超声（transcranial Doppler，TCD）检查具有实时、无创、操作简单且可重复检查等优点，是检测脑血流动力学的主要手段[12-17]。TCD可以直接检测并获取脑血流动力学各个参数，通过定量分析评估颅内外血管及其周围侧支循环情况。本文应用TCD评价单侧颈内动脉重度狭窄或闭塞后颅内侧支循环开放情况，讨论其在评估预后中的价值。

1 对象与方法

1.1 研究对象 收集苏州市立医院北区2017-02—2021-03超声诊断为一侧颈内动脉重度狭窄或闭塞同时行TCD检查评价颅内侧支循环的病例共22例，男21例，女1例，平均年龄67岁（26～83岁）。纳入标准：超声诊断为一侧颈内动脉重度狭窄或闭塞，同时行TCD检查评价颅内侧支循环。排除标准：（1）两侧颈内动脉重度狭窄或闭塞；（2）未行TCD检查评价颅内侧支循环。

1.2 方法

1.2.1 TCD检查：TCD检查设备采用德力凯公司的EMS-9PB经颅多普勒超声诊断仪，4 MHz连续波探头探测颈内动脉、颈外动脉、颈总动脉，2 MHz脉冲波探头探测大脑中动脉（middle cerebral artery，MCA）、颈内动脉终末段、大脑前动脉、大脑后动脉以及椎基底动脉。

1.2.2 颅内侧支循环开放的评价标准[18]：（1）前交通动脉（一级侧支）开放：患者平卧，探头置于颞窗进行探测检查。TCD可以检测到患侧大脑前动脉Al段的血流方向逆转，同时对侧大脑前动脉A1段血流速度代偿性升高，其血流频谱形态相对正常；如果压迫对侧颈总动脉，可以检测到患侧大脑中动脉M1段或反向的大脑前动脉A1段血流速度减低。（2）后交通动脉（一级侧支）开放：患者平卧，探头置于颞窗进行探查。TCD可以检测到患侧大脑后动脉P1段血流速度升高，高于同侧大脑中动脉M1段，侧支代偿血流方向朝向探头；基底动脉、两侧椎动脉血流速度代偿性升高，也提示后交通动脉开放。（3）眼动脉即颈内-外侧支动脉（二级侧支）开放：患者平卧，闭目，探头轻置于眼睑上进行探查。TCD可以检测到患侧眼动脉血流方向逆转或呈双向，且血流频谱形态颅内化改变，呈相对低搏动性代偿血流频谱。正常情况下眼动脉血流应朝向探头，呈高阻型血流频谱。

1.2.3 根据患侧大脑中动脉平均血流速度分组：根据患侧MCA平均血流速度将病例分为4组，50 cm/s以上为正常组，＞40～50 cm/s为偏下限组，30～40 cm/s为减低组，30 cm/s以下为明显减低组。

1.2.4 根据磁共振和CT图像评价病变侧脑梗死范围分组：根据磁共振和CT图像评价病变侧脑梗死范围将病例分为4级：1级，仅见脑萎缩，未见明确梗死灶；2级，梗死范围＜2 cm×2 cm；3级，梗死范围＜4 cm×4 cm；4级，梗死范围＞4 cm×4 cm。

1.3 统计学处理 采用SPSS 20.0统计学软件进行数据处理和分析，计数资料的组间比较用χ^2检验，计量资料用均数±标准差表示，2组间比较采用Mann-Whitney U检验，3组间比较采用Kruskai-Wallis H检验。以P<0.05为差异有统计学意义。

2 结果

所有病例均检测到侧支循环开放，其中16例（73%）前交通动脉开放（图1），16例（73%）后交通动脉开放（图2），13例（59%）眼动脉开放（图3）。6例（27%）3支侧支动脉开放（眼动脉、前交通和后交通动脉）；11例（50%）2支侧支动脉开放，其中眼动脉+前交通动脉同时开放2例（9%），眼动脉+后交通动脉同时开放3例（23%），前交通+后交通动脉同时开放6

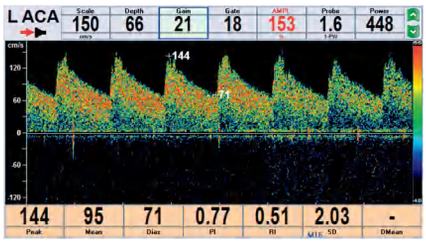

图1 男，51岁，TCD诊断左侧颈内动脉重度狭窄或闭塞。TCD检测到前交通动脉开放，表现为患侧大脑前动脉A1段血流速度升高，血流方向逆转

Figure 1 A-51-years-man with severe left internal carotid artery stenosis or occlusion diagnosed by TCD. TCD found the opening of anterior communicating artery showing an increased flow velocity with reversed direction at the A1 segment of the anterior cerebral artery on the affected side

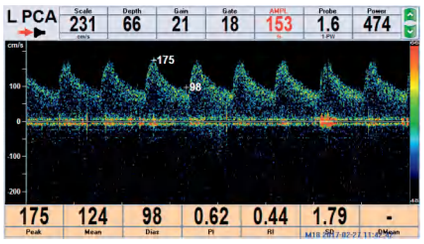

图2 男，61岁，TCD诊断左侧颈内动脉重度狭窄或闭塞。TCD检测到左侧后交通动脉开放，表现为患侧大脑后动脉P1段血流速度明显升高，且高于同侧大脑中动脉M1段血流速度

Figure 2 A-61-years-man with severe left internal carotid artery stenosis or occlusion diagnosed by TCD. TCD found the opening of posterior communicating artery showing a significant increased flow velocity at the P1 segment of the posterior cerebral artery on the affected side, which was higher than that at the M1 segment of the ipsilateral middle cerebral artery

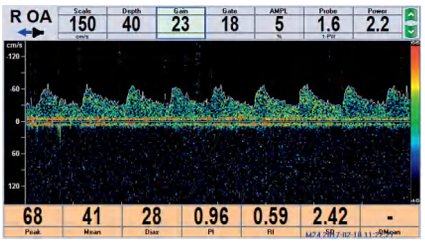

图3 男，59岁，TCD诊断右侧颈内动脉重度狭窄或闭塞。TCD检测到眼动脉侧支开放，表现为患侧眼动脉血流方向逆转，血流频谱颅内化改变

Figure 3 A-59-years-man with severe right internal carotid artery stenosis or occlusion diagnosed by TCD. TCD found the opening of ophthalmic artery showing intracranial blood flow spectrum with reversed direction at the affected ophthalmic artery

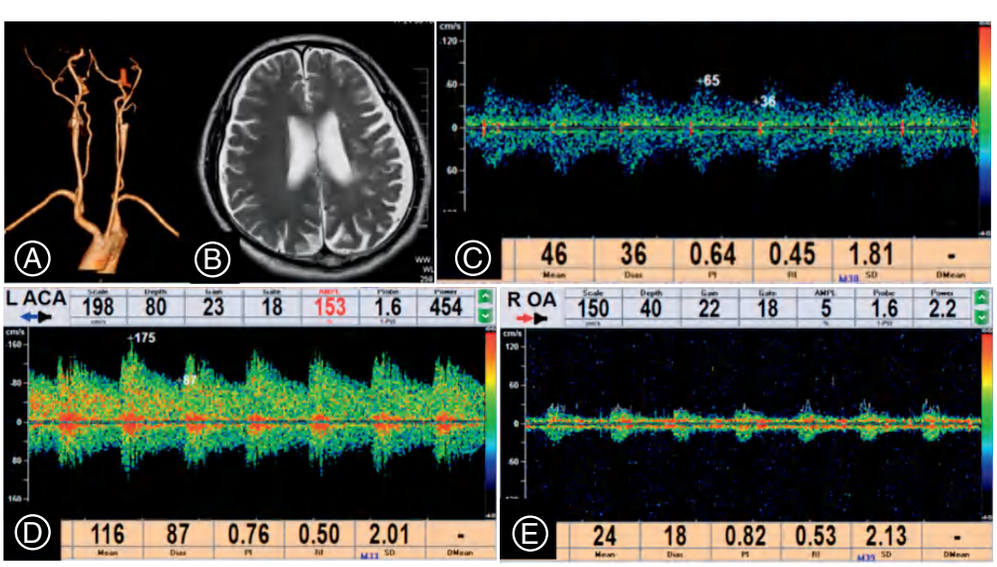

图4 男，68岁，TCD诊断左侧颈内动脉重度狭窄或闭塞，前交通动脉、两侧眼动脉侧支开放。CTA示左侧颈内动脉闭塞（A），磁共振示左侧额叶及侧脑室旁小片缺血灶（B），TCD示左侧大脑中动脉血流速度偏下限，呈相对低搏动性代偿血流频谱（C），两侧大脑前动脉血流速度稍高，且左侧血流方向逆转（D），两侧眼动脉均测及双向低阻型血流频谱（E）

Figure 4 A-68-years-man with severe stenosis or occlusion of left internal carotid artery, opening of anterior communicating artery and bilateral ophthalmic arteries diagnosed by TCD. CTA showed the occlusion of left internal carotid artery (A). Magnetic resonance imaging showed small ischemic foci in left frontal lobe and paraventricular area (B). TCD showed relatively low pulsatile compensatory flow spectrum and normal-low-limit flow velocity at left middle cerebral artery (C). The flow velocity of bilateral anterior cerebral arteries slightly increased, with reversed direction at left anterior cerebral artery (D). Bilateral ophthalmic arteries showing bidirectional intracranial blood flow spectrum (E)

例（27%）；5例（23%）仅有1支侧支动脉开放，其中单独眼动脉开放2例（9%），单独前交通动脉开放2例（9%），单独后交通动脉开放1例（5%）。

患侧MCA平均流速为44 cm/s，正常组5例，偏下限组7例，减低组9例，明显减低组1例。病变侧脑梗死范围1级为3例，2级为7例，3级为6例，4级为6例。单侧颈内动脉重度狭窄或闭塞后颅内侧支开放情况与患侧MCA平均流速、病变侧脑梗死范围分级的关系（见表1），其中有前交通动脉开放者的患侧MCA平均流速为（47.4 ± 11.7）cm/s，明显高于无前交通动脉开放者

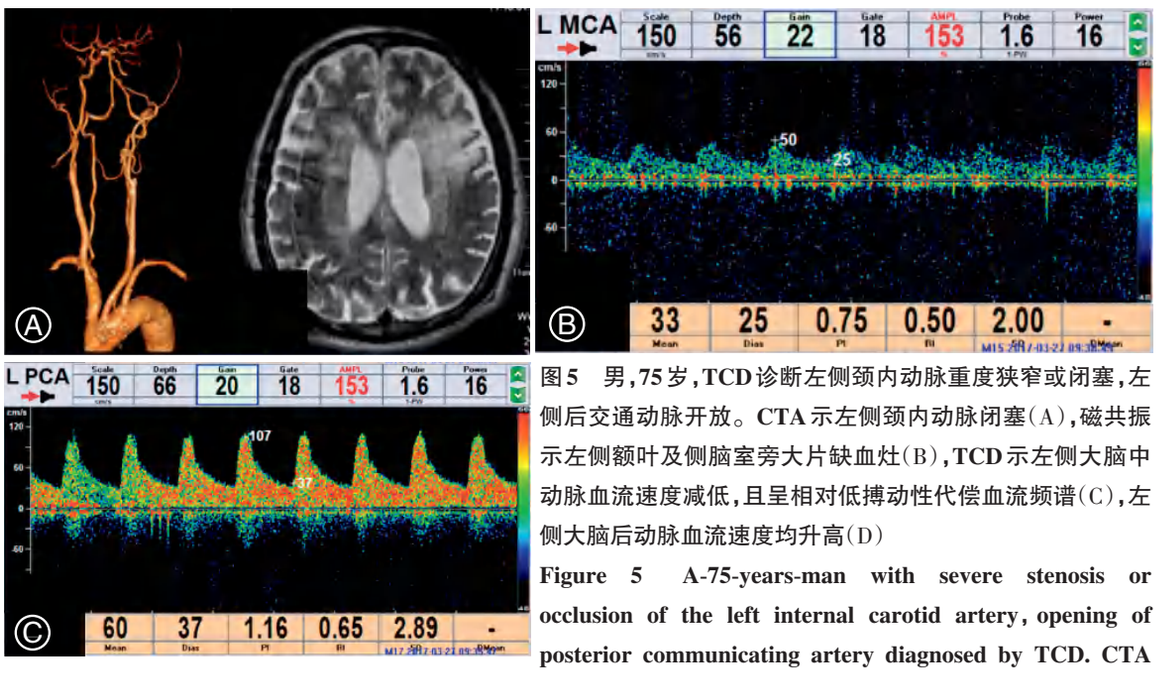

图5 男，75岁，TCD诊断左侧颈内动脉重度狭窄或闭塞，左侧后交通动脉开放。CTA示左侧颈内动脉闭塞（A），磁共振示左侧额叶及侧脑室旁大片缺血灶（B），TCD示左侧大脑中动脉血流速度减低，且呈相对低搏动性代偿血流频谱（C），左侧大脑后动脉血流速度均升高（D）

Figure 5 A-75-years-man with severe stenosis or occlusion of the left internal carotid artery, opening of posterior communicating artery diagnosed by TCD. CTA showed the occlusion of left internal carotid artery (A). Magnetic resonance imaging showed large ischemic foci in left frontal lobe and paraventricular area (B). TCD showed relatively low pulsatile compensatory flow spectrum and normal-low-limit flow velocity at left middle cerebral artery (C). The flow velocity of left posterior cerebral artery increased (D)

表1 单侧颈内动脉重度狭窄或闭塞后颅内侧支开放情况与患侧MCA平均血流速度、病变侧脑梗死分级的关系

Table 1 Relationship between collateral circulation and MCA average flow velocity/the range of cerebral infarction after severe stenosis or occlusion of unilateral internal carotid artery

侧支开放情况	MCA平均血流/cm·s^{-1}	检验值	P值	梗死范围分级	检验值	P值
侧支开放1支	36.8±3.7			3.4±0.9		
侧支开放2支	45.3±11.8	χ^2=3.305	0.192	2.45±1.1	χ^2=3.063	0.216
侧支开放3支	48.5±13.5			2.5±0.8		
前交通动脉开放	47.4±11.7	Z=—2.559	0.010	2.4±1.0	Z=—2.598	0.022
无前交通动脉开放	35.8±5.0			3.5±0.5		
后交通动脉开放	45.1±12.8	Z=—0.148	0.914	2.69±0.9	Z=—0.068	0.969
无后交通动脉开放	41.8±7.3			2.67±1.2		
眼动脉开放	44.1±11.3	Z=—0.067	0.946	2.7±1.0	Z=0.000	1.000
无眼动脉开放	44.4±12.3			2.7±1.2		
眼动脉、前交通动脉、后交通动脉同时开放	48.5±13.5	Z=—0.964	0.335	2.5±0.8	Z=—0.613	0.540
无眼动脉、前交通动脉、后交通动脉同时开放	42.6±10.6			2.8±1.1		
前交通动脉、后交通动脉同时开放	48.0±13.7	Z=—1.076	0.282	2.3±1.2	Z=—0.881	0.378
无前交通动脉、后交通动脉同时开放	42.8±10.6			2.8±1.0		
眼动脉、前交通动脉同时开放	50.0±5.7	Z=—1.264	0.206	1.5±0.7	Z=—1.661	0.139
无眼动脉、前交通动脉同时开放	43.7±11.8			2.8±1.0		
眼动脉、后交通动脉同时开放	36.7±7.7	Z=—1.540	0.123	3.3±0.6	Z=—1.193	0.223
无眼动脉、后交通动脉同时开放	45.4±11.6			2.6±1.1		

[(35.8±5.0) cm/s，Z=—2.559，P=0.010]（图4～5），前交通动脉开放者的梗死范围级别（2.4±1.0）明显低于无前交通动脉开放者（3.5±0.5，Z=—2.598，P=0.022）。

3 讨论

3.1 TCD在评价侧支循环中的价值 既往文献[19]报道，前交通动脉开放是最常见的侧支，发生率为81%，眼动脉为63%，后交通动脉为53%。本研究显

示，所有病例均检测到侧支循环的开放，73%前交通动脉开放，59%眼动脉开放，略低于文献[19]报道，68%检测到后交通动脉开放，略高于文献[19]报道。关于侧支显示率的报道目前并不一致[19-20]，可能与大脑 Willis 环仅在 30%的老年人中较完整有关。有研究认为，在颈内动脉闭塞时前交通动脉开放较后交通动脉开放更加重要[21-22]，但本研究显示前、后交通动脉开放的发生率近似。

既往文献[19]报道，26%的病人有 3 支侧支开放，55%有 2 支侧支开放，15%有 1 支侧支开放。本研究显示，27%有 3 支侧支开放，50%有 2 支侧支开放，23%有 1 支侧支开放，与文献报道相仿。

3.2 TCD 在评估预后中的价值 单侧颈内动脉重度狭窄或闭塞时，患侧的 MCA 平均血流速度主要取决于侧支动脉的血供情况，而 TCD 测量的患侧 MCA 平均血流速度能反映侧支动脉的供血量和代偿情况[19]。既往研究认为，侧支动脉开放的数量与患侧 MCA 平均血流速度及梗死范围分级无相关性[19]。虽然本研究呈现侧支数量越多，患侧 MCA 平均血流速度越高，梗死范围级别越低的趋势，但各组间比较差异无统计学意义。本研究显示，前交通动脉开放者的患侧 MCA 平均血流速度明显高于无前交通动脉开放者，前交通动脉开放者的梗死范围级别明显低于无前交通动脉开放者。单侧颈内动脉重度狭窄或闭塞时，前交通动脉侧支开放对于血供代偿有十分重要的意义[19,23-24]，且与其预后相关。

既往有文献认为，眼动脉开放时提示侧支供应相对较好[19,25-28]，但本研究显示，眼动脉是否开放与患侧 MCA 的平均血流速度、梗死范围级别无关，眼动脉侧支开放的价值还需要进一步研究。TCD 在评价单侧颈内动脉重度狭窄或闭塞后颅内侧支循环方面起重要作用，同时前交通动脉侧支开放对于评估其预后改善有较高价值[29-40]。

4 参考文献

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