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彩色多普勒超声对颈动脉狭窄支架成形术疗效及术后残余狭窄的评估价值

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[摘要] 目的: 探讨彩色多普勒超声对颈动脉狭窄支架成形术(carotid artery stenting, CAS)患者疗效及术后残余狭窄的评估价值。方法: 前瞻性选取2018年1月至2020年9月在池州市人民医院神经外科治疗的110例CAS患者, 对比手术前后超声相关测量指标。依据数字减影血管造影(digital subtraction angiography, DSA)检查统计术后残余狭窄发生率, 并分为残余狭窄组与正常组(未发生残余狭窄)。比较两组临床资料和超声相关指标, 并分析CAS术后残余狭窄发生的影响因素。结果: CAS术后狭窄部位狭窄程度 $[(26.51 \pm 5.78)\%]$ 低于术前 $[(83.57 \pm 10.20)\%]$, 术后颈动脉近中端、颈动脉远端的收缩期血流峰值流速(peak systolic velocity, PSV)、舒张期末流速(end diastolic velocity, EDV)也均较术前显著下降, 差异有统计学意义($P < 0.05$)。CAS术后残余狭窄发生率为22.73%。残余狭窄组CAS术后颈动脉近中端PSV $[(131.48 \pm 11.92) \text{ cm/s}]$ 、EDV $[(47.20 \pm 5.24) \text{ cm/s}]$ 均高于正常组 $[(98.86 \pm 10.26) \text{ cm/s}$ 、 $(38.14 \pm 5.06) \text{ cm/s}]$, 斑块形态不规则(76.00%)、斑块钙化(72.00%)均明显高于正常组(38.82%、61.18%), 差异有统计学意义($P < 0.05$)。多因素Logistic回归分析显示: 斑块形态不规则(OR=1.572, 95%CI: 1.021~2.256)、斑块钙化(OR=2.380, 95%CI: 1.364~3.527)均是CAS患者发生术后残余狭窄的独立危险因素($P < 0.05$)。结论: 彩色多普勒超声能有效评估CAS血管再通的疗效和观察有无残余狭窄, 斑块形态不规则和斑块钙化是CAS术后残余狭窄发生的危险因素。

[关键词] 颈动脉狭窄支架成形术; 彩色多普勒超声; 疗效; 术后残余狭窄; 评估价值

Evaluation of the effect of color Doppler ultrasound in stent forming of carotid stenosis and the residual stenosis after operation

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Abstract **Objective:** To investigate the value of color Doppler ultrasound in evaluating the efficacy of carotid artery stenting (CAS) and residual stenosis after operation. **Methods:** A total of 110 CAS patients treated in the neurosurgery department of Chizhou People's Hospital from January 2018 to September 2020 were prospectively selected, and the relevant measurement indexes of ultrasound before and after operation were compared. According to

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digital subtraction angiography (DSA), the incidence of postoperative residual stenosis was analyzed and divided into residual stenosis group and normal group (no residual stenosis). The clinical data and ultrasound related indexes were compared between the two groups, and the influencing factors of residual stenosis after CAS were analyzed. **Results:** The stenosis degree of stenosis site after CAS was $(26.51 \pm 5.78)\%$, which was lower than that before $[(83.57 \pm 10.20)\%]$. The peak systolic velocity (PSV) and end diastolic velocity (EDV) of proximal and distal carotid artery after CAS were significantly lower than those before CAS ($P < 0.05$). DSA confirmed that the incidence of residual stenosis was 22.73%. PSV $[(131.48 \pm 11.92) \text{ cm/s}]$ and EDV $[(47.20 \pm 5.24) \text{ cm/s}]$ in the residual stenosis group were significantly higher than those in the normal group $[(98.86 \pm 10.26) \text{ cm/s}]$ and $[(38.14 \pm 5.06) \text{ cm/s}]$. The plaque morphology was irregular (76.00%) and plaque calcification (72.00%) in the residual stenosis group were significantly higher than those in the normal group (38.82% and 61.18%) ($P < 0.05$). Multivariate logistic regression analysis showed that irregular plaque shape (OR=1.572, 95%CI: 1.021–2.256) and plaque calcification (OR=2.380, 95%CI: 1.364–3.527) were independent risk factors for postoperative residual stenosis in patients with CAS ($P < 0.05$). **Conclusion:** Color Doppler ultrasound can effectively evaluate the effect of CAS recanalization and observe whether there is residual stenosis. Irregular plaque shape and plaque calcification are the risk factors of residual stenosis after CAS.

Keywords carotid artery stenosis stenting; color Doppler ultrasound; curative effect; postoperative residual stenosis; evaluation value

颈动脉狭窄是临床较为常见疾病, 动脉粥样硬化是本病的主要病因, 多发于中老年人, 男性多于女性, 且随年龄增长, 发病率呈升高趋势。据报道^[1], ≥ 80 岁男性群体颈动脉狭窄比较多见, 其中中重度狭窄(狭窄程度 $\geq 50\%$)发生率达10%以上。颈动脉狭窄需积极接受规范治疗, 缓解症状体征, 降低缺血性脑卒中发生风险。CAS作为颈动脉内膜剥脱术(carotid endarterectomy, CEA)治疗中重度颈动脉狭窄的重要补充疗法, 具有操作微创、安全和心血管并发症少等优点, 随着CAS逐渐推广开展, 不断完善CAS的疗效评估工作显得尤为重要。同时术后残余狭窄作为CAS常见的并发症, 是导致支架内再狭窄和远期疗效不佳的主要原因^[2], 围绕术后残余狭窄进行相关探究具有重要意义。颈动脉血管彩色多普勒超声技术的推广应用为临床了解颈动脉责任血管的血流参数、狭窄程度和斑块特征等信息提供可靠手段, 其在CAS疗效监测评估和相关并发症研究的作用日益凸显, 引起了相关学科工作者的浓厚兴趣。本研究在此背景下开展, 探讨彩色多普勒超声在CAS疗效及术后残余狭窄的评估价值。

1 对象与方法

1.1 对象

病例入选标准: 1)入院接受彩色多普勒超声

筛查和DSA证实颈动脉狭窄程度 $\geq 70\%$; 2)经医患沟通后, 在患者及家属知情同意前提下, 接受CAS治疗, 均为单侧CAS, 且均参与配合本次研究。排除标准: 1)颈动脉完全闭塞; 2)拟接受颈动脉内膜切除术或药物治疗; 3)年龄 > 80 岁; 4)术前存在严重脏器功能障碍; 5)大动脉炎、外伤、血管先天肌纤维发育不良等所致颈动脉狭窄。按上述病例筛选标准, 本研究共选取2018年1月至2020年9月池州市人民医院神经外科接受CAS治疗的患者110例, 其中男98例(89.09%), 女12例(10.91%); 年龄43~80(67.08 ± 9.74)岁。本研究分组方法: 根据术后有无残余狭窄进行分组, 分为残余狭窄组与正常组(无残余狭窄)。本研究获池州市人民医院医学伦理委员会批准。

1.2 方法

1.2.1 CAS及分组方法

CAS均由同组经验丰富的手术团队操作, 术中常规预置脑保护伞于颈动脉狭窄处的远端, 然后将合适大小的颈动脉金属支架植入狭窄的颈动脉内, 支撑狭窄部位。CAS术后抗血小板聚集、调脂等常规治疗谨遵医嘱。支架植入完毕后, 即刻进行全脑DSA检查, 术后残余狭窄判定标准^[3]: DAS检查显示狭窄程度 $\geq 30\%$ 。观察术后残余狭窄发生率。

1.2.2 彩色多普勒超声检查方法

由2名丰富颈动脉血管超声检查经验的超声科医师采用彩色多普勒超声诊断仪(荷兰PHILIPS公司IE33型)进行操作, 观察手术前后狭窄处的血流充盈情况, 测量颈动脉狭窄部位血管内径的狭窄程度及血流参数, 血流参数包括颈动脉狭窄部位近中端和远端的PSV、EDV, 同时观察并记录责任斑块的超声影像学特征, 包括斑块形态(规则、不规则)以及钙化情况等, 其中规则型斑块如扁平斑块, 基底较宽, 表面纤维帽光滑, 不规则型斑块如溃疡斑块, 表面光滑度较差, 局部缺损, 常有“火山口”样缺口。彩超检查显示高密度影或强回声, 判定为斑块钙化。

1.3 观察指标

比较CAS患者手术前后超声相关测量指标; 观察本研究入选患者术后残余狭窄的发生率, 并收集残余狭窄组和正常组的一般资料和相关超声指标, 包括性别、年龄、BMI、合并基础疾病(高血压、高血糖、高血脂、冠心病)、吸烟史、饮酒史、植入支架类型、术前狭窄程度、斑块影像学特征以及手术前后超声测量指标等。并分析CAS患者术后残余狭窄发生的影响因素。

1.4 统计学处理

使用SPSS 22.0统计学软件进行数据分析, 计数资料以“例(%)”表示, 采用 χ^2 检验; BMI、颈动脉狭窄程度、超声测量指标等计量资料, 经检验均满足正态分布, 以均数 \pm 标准差($\bar{x}\pm s$)表示, 采用组间 t 检验, 组内术前术后比较, 行配对 t 检验; CAS患者术后残余狭窄的影

响因素采用多因素logistic回归分析。 $P<0.05$ 为差异有统计学意义。

2 结果

2.1 CAS 手术疗效评估

CAS术后患者颈动脉狭窄部位狭窄程度由术前的(83.57 \pm 10.20)%下降至(26.51 \pm 5.78)%, 差异有统计学意义($t=55.918$, $P<0.05$), 术后超声检查提示颈动脉血流充盈状况明显改善, 血流速度减缓, 斑块数量减少。超声测量显示: 颈内动脉近中端、远端PSV、EDV较术前明显下降, 差异有统计学意义($P<0.05$, 表1)。

2.2 CAS 术后残余狭窄发生率及一般资料分析

CAS术后DSA检查证实残余狭窄发生率为22.73%(25/110), 其中轻度狭窄($<50\%$)占88.00%(22/25), 中度狭窄(50%~69%)占12.00%(3/25)。残余狭窄组与正常组性别、年龄、BMI、高血压、高血糖、高脂血症、冠心病、吸烟史、饮酒史以及植入支架类型比较, 差异无统计学意义($P>0.05$, 表2)。

典型病例见图1、2。其中图1为CAS术后再通效果良好患者, 图1A为术后支架处彩色多普勒超声检查, 可见血流充盈良好; 图1B为颈动脉狭窄部位近端, EDV测量值为42.2 cm/s, 流速正常。图2为CAS术后残余狭窄患者, 狭窄程度约62%, 图2A为颈总动脉膨大部延伸至颈内起始部支架处彩色多普勒超声, 支架处显示血流颜色为亮黄色, 提示此处残余狭窄; 图2B为支架处频谱多普勒超声, 显示为花色血流, 流速明显异常。

表1 CAS手术前后颈动脉血流参数超声测量比较($n=110$)

Table 1 Comparison of ultrasound measurement of carotid blood flow parameters before and after CAS ($n=110$)

时点	颈动脉近中端/($\text{cm}\cdot\text{s}^{-1}$)		颈动脉远端/($\text{cm}\cdot\text{s}^{-1}$)	
	PSV	EDV	PSV	EDV
术前	182.36 \pm 21.40	117.57 \pm 16.34	159.36 \pm 18.76	105.29 \pm 15.83
术后	106.27 \pm 12.08	44.38 \pm 7.58	100.27 \pm 11.48	42.06 \pm 7.23
t	32.475	42.616	28.178	38.106
P	<0.001	<0.001	<0.001	<0.001

表2 CAS术后残余狭窄组和正常组一般资料比较

Table 2 Comparison of general information between residual stenosis group and normal group after CAS

一般资料	残余狭窄组(n=25)	正常组(n=85)	χ^2/t	P
性别/[例(%)]			0.318	0.573
男	21 (84.00)	77 (90.59)		
女	4 (16.00)	8 (9.41)		
年龄/岁	67.54 ± 8.90	66.94 ± 9.13	0.290	0.772
BMI/(kg·m ⁻²)	25.42 ± 2.16	25.38 ± 2.13	0.082	0.935
合并基础疾病/[例(%)]				
高血压	7 (28.00)	17 (20.00)	0.725	0.395
高血糖	5 (20.00)	15 (17.65)	0.001	0.979
高血脂	9 (36.00)	21 (24.71)	1.242	0.265
冠心病	8 (32.00)	22 (25.88)	0.365	0.547
吸烟史	14 (56.00)	50 (58.82)	0.063	0.801
饮酒史	12 (48.00)	46 (54.12)	0.290	0.590
术前狭窄程度/[例(%)]			0.090	0.764
70%~80%	19 (76.00)	67 (78.82)		
>80%	6 (24.00)	18 (21.18)		
植入支架类型/[例(%)]			0.063	0.801
闭环支架	11 (44.00)	35 (41.18)		
开环支架	14 (56.00)	50 (58.82)		

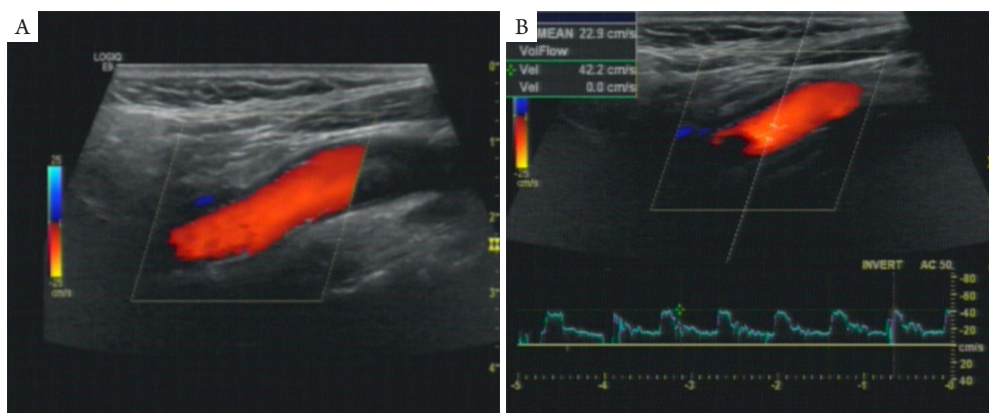


图1 CAS术后无残余狭窄患者超声影像图

Figure 1 Ultrasound image of patients without residual stenosis after CAS

(A)为术后支架处彩色多普勒超声检查,可见血流充盈良好;(B)为颈动脉狭窄部位近端,EDV测量值为42.2 cm/s,流速正常。

(A) Postoperative color Doppler ultrasound examination of the stent showed good blood flow filling; (B) Proximal to the site of carotid artery stenosis, EDV was 42.2 cm/s, and flow rate was normal.

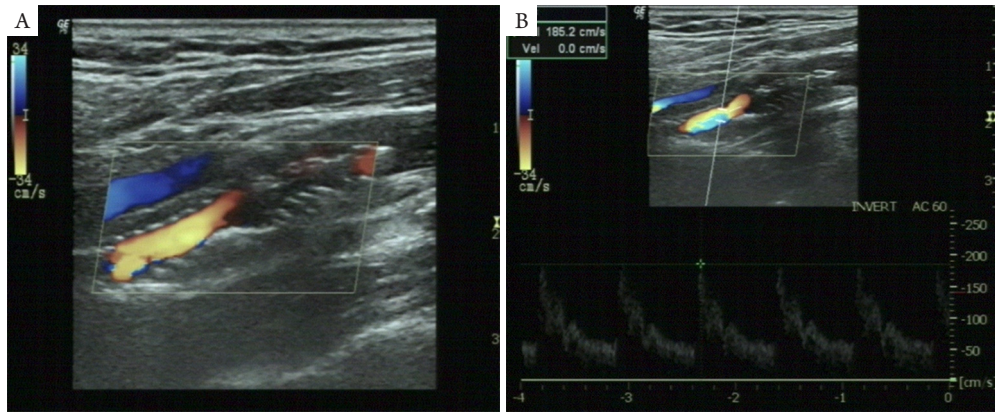


图2 CAS术后残余狭窄患者超声影像图

Figure 2 Ultrasonic imaging of residual stenosis after CAS

(A)为颈总动脉膨大部延伸至颈内起始部支架处彩色多普勒超声，支架处显示血流颜色为亮黄色，提示此处残余狭窄；(B)为支架处频谱多普勒超声，显示为花色血流，流速明显异常。

(A) Color Doppler ultrasound was performed at the stent from the enlarged part of the common carotid artery extending to the initial part of the internal neck, and the blood flow at the stent was bright yellow, suggesting residual stenosis here; (B) Spectrum Doppler ultrasonography at the stent, showing color blood flow and obviously abnormal velocity.

2.3 CAS 术后残余狭窄组和正常组超声相关指标比较

与正常组比较，残余狭窄组颈动脉近中端PSV、EDV明显较高，不规则斑块形态和斑块钙化所占比重显著较高，植入闭环支架占比显著较低，差异有统计学意义($P < 0.05$)，两组颈动脉远端PSV、EDV比较，差异无统计学意义($P > 0.05$)，表3。

2.4 CAS 术后残余狭窄发生的影响因素分析

以CAS患者术后残余狭窄发生为因变量，将表2、3的单因素分析中有统计学意义的因素作为自变量，多因素logistic回归分析显示：斑块形态不规则、斑块钙化是CAS患者术后残余狭窄发生的独立危险因素($P < 0.05$)，表4。

表3 CAS术后残余狭窄组和正常组超声相关指标比较

Table 3 Comparison of ultrasound related indexes between residual stenosis group and normal group after CAS

组别	n	颈动脉近中端/($\text{cm}\cdot\text{s}^{-1}$)		颈动脉远端/($\text{cm}\cdot\text{s}^{-1}$)		斑块形态特征/[例(%)]		斑块钙化情况/[例(%)]	
		PSV	EDV	PSV	EDV	不规则	规则	钙化	无钙化
残余狭窄组	25	131.48 ± 11.92	47.20 ± 5.24	102.13 ± 11.37	42.02 ± 5.38	19 (76.00)	6 (24.00)	18 (72.00)	7 (28.00)
正常组	85	98.86 ± 10.26	38.14 ± 5.06	99.74 ± 10.53	41.04 ± 5.10	33 (38.82)	52 (61.18)	32 (37.65)	53 (62.35)
χ^2/t		13.461	7.807	0.980	0.834	10.712		9.195	
P		<0.001	<0.001	0.329	0.406	<0.001		0.002	

表4 CAS术后残余狭窄发生的logistic回归分析

Table 4 Logistic regression analysis of residual stenosis after CAS

因素	β	SE	Wald χ^2	P	OR	95%CI
斑块形态不规则	0.539	0.162	11.068	0.006	1.572	1.021~2.256
斑块钙化	1.146	0.471	5.920	0.012	2.380	1.364~3.527

3 讨论

本研究纳入患者责任血管狭窄程度 $\geq 70\%$,属于重度颈动脉狭窄,单纯抗血小板聚集、调脂等药物治疗存在明显局限,需接受介入疗法或CEA,对预防脑卒中和一过性脑缺血发作(transient cerebral ischemia attack, TIA)发生尤为重要。据报道^[4],颈动脉狭窄所致脑卒中占脑卒中人群的比重高达30%以上。CAS作为目前比较成熟的血管再通治疗手段,在肾动脉、冠状动脉等血管类型疾病应用广泛,在颈动脉狭窄领域,相对起步较晚,多中心、大规模的前瞻性临床研究缺乏。近些年随着脑保护装置逐渐应用,大大降低术中脑栓塞的发生率,CAS安全性得到提高^[5-6]。而且与CEA相比,CAS手术耐受性更佳,尤其适合老年重度颈动脉狭窄患者。但CAS术后不仅需加强动态监测评估疗效,而且术后残余狭窄仍是不可忽视的并发症难题。受限于CAS开展起步较晚,CAS的远期疗效报道缺乏,但术后残余狭窄作为影响CAS疗效的独立危险因素已成为临床共识,尽早评估诊断和寻找其发生的影响因素,对临床降低术后残余狭窄发生率、改善远期疗效提供参考依据。

颈动脉狭窄的影像学检查手段较多,彩色多普勒超声能了解责任血管狭窄程度、僵硬程度、斑块形态学特征及性质,对疾病诊断、病情严重程度评估以及心脑血管事件风险预测有指导价值。本研究结果显示:CAS术后狭窄部位狭窄程度由 $(83.57\pm 10.20)\%$ 下降至 $(26.51\pm 5.78)\%$,而且颈动脉近中端、远端的PSV、EDV也较术前明显减缓,血流参数变化反映CAS术后责任血管有效管径和血流灌注量明显增大,颈动脉血供得到改善。此外虽然计算机断层血管造影(computed tomography angiography, CTA)、磁共振血管造影(magnetic resonance angiography, MRA)也可用于颈动脉狭窄的临床评估,但CTA检查斑块钙化特征明显的患者时易产生伪影,可能影响结果的精确性^[7]。Arous等^[8]也指出:CT血管造影面积狭窄计算可能会高估颈动脉狭窄程度。此外CTA造影剂的使用可能对肾脏造成损害,MRA存在费用昂贵、操作技能要求较高等问题^[9]。上述不足限制了二者的临床应用。相较而言,彩色多普勒超声成本低廉、操作简单和安全性好,临床应用价值显著。

CAS术后残余狭窄的发生率尚无权威报道,本研究术后残余狭窄发生率为22.73%,与Mazurek等^[10]报道的发生率相接近,但二者均存在样本量偏少、单中心等不足。本研究结果显示:与CAS术

后无残余狭窄发生的正常组比较,残余狭窄组颈动脉近中端PSV、EDV均明显较高,原因为CAS术后残余狭窄患者责任血管的有效内径仍较小,血流灌注并未得到有效改善,直接影响局部血流动力学,此类患者发生支架内狭窄风险较高^[11-12]。多因素logistic分析结果显示:斑块形态不规则、斑块钙化是CAS术后残余狭窄的独立危险因素,与斑块形态规则、斑块无钙化患者比较,术后残余狭窄发生风险分别增加了1.572倍、2.380倍,二者均可造成植入支架腔内扩张不充分,或与管腔壁的贴覆不良,直接影响责任血管的血管再通程度和CAG疗效。有报道^[13]指出:颈动脉狭窄的斑块钙化积分和CT值与心脑血管事件风险及介入治疗后再狭窄率存在紧密关联。临床研究^[14-15]也发现:术前血管彩超提示钙化斑块的CAG患者术后残余狭窄发生率比较突出,支架植入后扩展效果欠佳,因此对此类患者的临床治疗需谨慎考量,应依据术前血管彩超信息、病情程度、手术耐受情况和患者个人意愿,制定合理的治疗方案,必要时仍应选择CEA进行血运重建治疗。

本研究仍存在一些不足:科室收治的CAS病例较少,样本量不足;颈动脉血管彩超检查均由2名超声科医师完成,可能受操作者水平、经验等主观性因素影响检查的准确性,对研究造成一定干扰和偏倚。

综上所述,随着CAS的推广应用,采用彩色多普勒超声对CAS患者进行术前和术后动态监测检查,对临床评估CAS疗效和术后残余狭窄有重要意义,斑块形态不规则、钙化斑块会明显增加术后残余狭窄的发生风险,此类患者需结合临床具体情况,综合制定最适宜的治疗方案,努力让患者更充分获益。

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