

· 论 著 ·

DSA 容积成像对支架进行精细显影在
神经介入治疗中的应用

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【摘要】目的 探讨 DSA 容积成像对支架进行精细显影在神经介入治疗中的应用效果。方法 回顾性分析 2021 年 4 月至 2022 年 6 月支架植入术治疗的 68 例脑血管病的临床资料。在支架释放过程中或完全释放后,应用 DSA 容积成像对支架进行小视野扫描,然后对影像进行去金属伪影等后处理并三维重建,评价支架显影效果及释放后状态,其中支架精细结构显示清晰评定为显影效果优,可明确识别支架轮廓,但不能清晰显示支架精细结构评定为显影效果良,不能明确识别支架轮廓评定为显影效果差,并反馈术者对支架治疗方法进行调整改进。结果 68 例共使用 71 枚支架,其中 Enterprise 支架 48 枚、Neuroform EZ 支架 1 枚、Neuroform Atlas 支架 8 枚、Lvis 支架 5 枚、Leo 支架 1 枚、Tubridge 支架 8 枚;显影效果优 55 枚,显影效果良 12 枚,显影效果差 4 枚;优良率为 94.4%。DSA 容积成像可清晰显示 Enterprise 支架、Neuroform EZ 支架、Neuroform Atlas 支架、Lvis 支架、Leo 支架等精细结构。由于 Tubridge 支架的编曲网眼细、密及编织丝相互的伪影干扰,DSA 容积成像不能清晰显示其精细网眼结构,但对其可显影金属丝的重建效果良好,可清晰显示支架全程轮廓。导致支架精细显影效果差的最主要因素是弹簧圈的金属伪影。结论 在使用支架治疗脑血管病时,DSA 容积成像可精准判断支架植入后张开、贴壁、打折等状态,对低可视性支架也有良好显示效果,是评价治疗效果的重要依据。

【关键词】脑血管病;介入治疗;DSA 容积成像;支架精细显影

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Application of DSA volumetric imaging technology in achieving high-precision visualization of stents in neurointerventional treatment

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【Abstract】Objective To investigate the application efficacy of DSA volumetric imaging technology in achieving high-precision visualization of stents during neurointerventional treatment. Methods A retrospective analysis was performed on the clinical data of 68 patients with cerebrovascular diseases who underwent stent implantation from April 2021 to June 2022. During or after the complete release of the stents, DSA volumetric imaging technology was employed for small-field scanning, and post-processing such as metal artifact removal and three-dimensional reconstruction were conducted on the images to evaluate the visualization effect of the stents and their post-release status. The specific evaluation criteria were as follows: clear display of the fine structure of the stent was rated as excellent in visualization effect; clear identification of the stent contour but not the fine structure was rated as good in visualization effect; inability to clearly identify the stent contour was rated as poor in visualization effect. The visualization results were fed back to the neurosurgeons to facilitate the adjustment and improvement of the stent treatment methods. Results A total of 71 stents were utilized, including 48 Enterprise stents, 1 Neuroform EZ stent, 8 Neuroform Atlas stents, 5 Lvis stents, 1 Leo stent, and 8 Tubridge stents. Among them, 55 stents had excellent visualization effects, 12 had good visualization effects, and 4 had poor visualization effects, with an excellent and good rate of 94.4%. DSA volumetric imaging could clearly display the fine structures of Enterprise, Neuroform EZ, Neuroform Atlas, Lvis, and Leo stents. However, due to the fine mesh and mutual interference of the braided wires of the Tubridge stent, its fine mesh structure could not be clearly displayed, but the reconstruction effect of its metal wires was favorable, and the entire contour of the stent could be clearly displayed. The main factor contributing to the poor fine visualization of the stent was the metal artifact of the

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coils. **Conclusion** When using stents to treat cerebrovascular diseases, DSA volumetric imaging technology can precisely determine the states such as opening, wall-adhering, and folding of the stents after implantation, and has a favorable display effect on low-visibility stents. It serves as an important basis for evaluating the treatment effect.

[Key words] Cerebrovascular disease; Interventional therapy; DSA volumetric imaging; Fine stent visualization

血管内支架植入术被广泛用于治疗出血性脑血管疾病及缺血性脑血管疾病^[1-4]。由于颅内支架结构精细,常规 X 线摄影方式往往显示不清,因此,目前缺少颅内支架植入术后直接的影像学评价资料^[5,6]。我们应用 DSA 容积成像对支架进行精细显影,获得满意效果,现报道如下。

1 资料与方法

1.1 一般资料 回顾性分析 2021 年 4 月至 2022 年 6 月采用支架植入术治疗的 68 例脑血管疾病的临床资料,其中男性 14 例,女性 54 例;年龄 39~80 岁,平均(60.9±18.7)岁。颈内动脉瘤 47 例(眼动脉段 16 例,后交通段 31 例),前交通动脉瘤 4 例,胼周动脉瘤 3 例,大脑中动脉瘤 1 例,大脑后动脉瘤 1 例,基底动脉夹层 2 例,椎动脉 V4 段夹层 3 例,基底动脉瘤 4 例,大脑中动脉重度狭窄 3 例;共置入颅内支架 71 枚,其中 Enterprise 支架 48 枚,Neuroform EZ 支架 1 枚,Neuroform Atlas 支架 8 枚,Lvis 支架 5 枚,Leo 支架 1 枚,Tubridge 支架 8 枚。支架辅助弹簧圈栓塞动脉瘤 59 例(61 枚支架),单纯支架置入术 9 例(10 枚支架)。

1.2 影像检查方法 DSA 机器行 Dyna CT 容积扫描,将获得的三维影像运用系统 Smart 去金属伪影软件,应用容积再现(volume reconstruction, VR)技术重建支架局部影像,并裁剪支架外多余组织,同时行最大密度投影(maximum intensity projection, MIP)技术重建,调整合适窗宽、窗位, MIP 重建影像调整合适层厚,显示支架整体和局部形态。

1.3 影像资料分析 根据重建影像对支架精细显影效果进行分级评价,其中,支架精细结构清晰评定为显影效果优;可明确识别支架轮廓,但不能清晰显示支架精细结构评定为显影效果良;不能明确识别支架轮廓评定为显影效果差。

2 结果

71 枚支架均行支架精细显影重建,显影效果优 55 枚,显影效果良 12 枚,显影效果差 4 枚;总体优良率为 94.4%(表 1)。DSA 容积成像可清晰显示 Enterprise 支架、Neuroform EZ 支架、Neuroform Atlas 支架、Lvis 支架、Leo 支架等精细结构;Tubridge 支架,由于编曲网眼细、密及编织丝相互的伪影干扰,不能清晰显示其精细网眼结构,但对其可显影金属丝的重建效果良好,可清晰显示支架全程轮廓(图 1)。重建显影效果差的病例均为支架辅助弹簧圈栓塞的动脉瘤。在各类支架中,导致支架精细显影效果差的最主要因素是弹簧圈的金属伪影。

3 讨论

脑血管疾病已成为我国病死率第一位的疾病,且患病率及发病率呈逐年增高的趋势。随着介入技术和材料的进步,越来越多的脑血管疾病采用介入治疗,而支架是广泛应用于出血性和缺血性脑血管疾病的重要材料。由于脑血管具有血管直径小、走行迂曲、血管壁薄、缺乏其他组织支撑等特点,因而应用于脑血管疾病治疗的支架须具备尺寸小、柔顺性高的特点,而这类支架往往可视程度低,特别是一

表 1 DSA 容积成像对颅内支架进行精细显影的效果

Table 1 Efficacy of DSA volumetric imaging technology for high-precision visualization of intracranial stents

支架类型	数量(枚)	精细显影效果(枚)			优良率
		优	良	差	
Enterprise 支架	48	42	3	3	93.7%
Neuroform EZ 支架	1	1	0	0	100%
Neuroform Atlas 支架	8	6	1	1	87.5%
Lvis 支架	5	5	0	0	100%
Leo 支架	1	1	0	0	100%
Tubridge 支架	8	0	8	0	100%
合计	71	55	12	4	94.4%

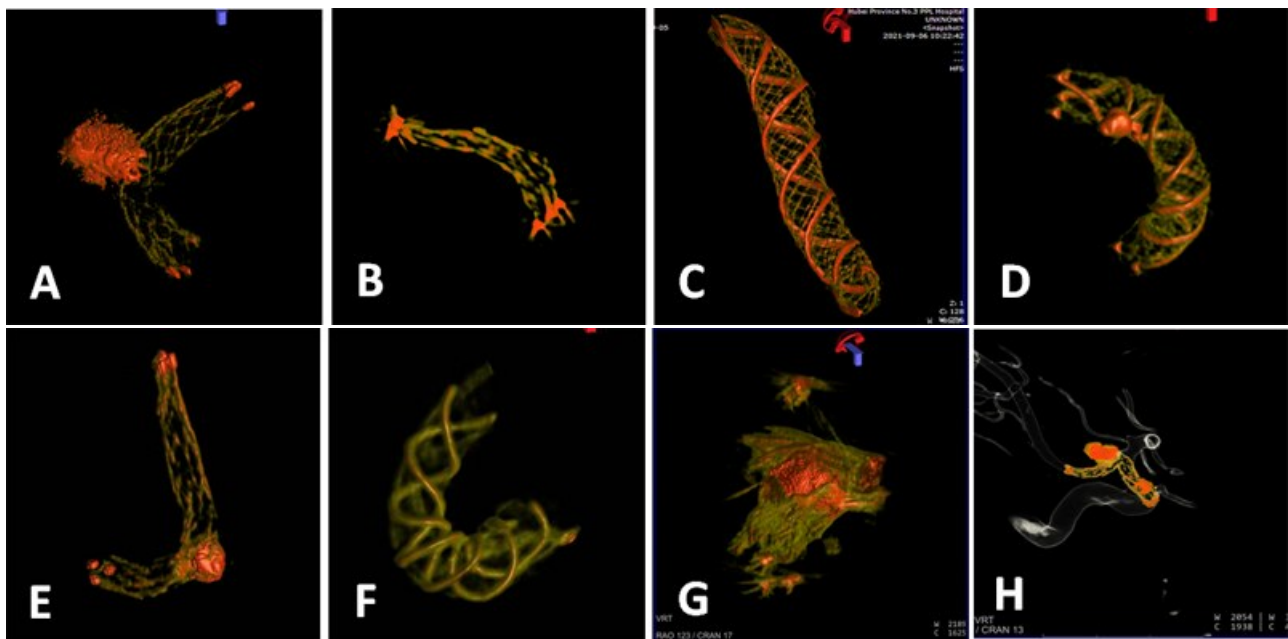


图1 DSA容积成像对颅内支架进行精细显影的效果

A~E. 分别为重建后的 Enterprise 支架、Neuroform EZ 支架、Leo 支架、Lvis 支架、Neuroform Atlas 支架, 支架的精细结构清晰可见, 判定为显影效果优; F. 重建后的 Tubridge 支架, 支架轮廓清晰, 但不能显示支架的网眼, 判定为显影效果良; G. 重建后的 Neuroform Atlas 支架, 可见弹簧圈及支架头、尾端产生的大量放射状金属伪影, 不能完全显示支架轮廓, 判定为显影效果差; H. 轮廓清晰的支架与血管的影像整合, 可以清晰显示支架释放后贴壁情况

Figure 1 Efficacy of high-precision visualization of intracranial stents by DSA volumetric imaging

A~E: They are the reconstructed Enterprise stent, Neuroform EZ stent, Leo stent, Lvis stent and Neuroform Atlas stent, respectively; their fine structures are clearly visible and are judged as having excellent visualization effects. F: The reconstructed Tubridge stent; although the stent contour is clear, the mesh structure cannot be displayed and is judged as having a good visualization effect. G: The reconstructed Neuroform Atlas stent; due to a large number of radial metal artifacts generated by the coils and the head and tail ends of the stent, the stent contour cannot be completely displayed and is judged as having a poor visualization effect. H: After the fusion of the stent and vascular images, the wall-adhering condition of the stent after release can be clearly displayed with a clear contour.

些激光雕刻支架,应用普通显影方式只可见支架头、尾两端的 Mark 标识点,无法清晰显示支架的精细结构。在应用此类支架治疗后,对支架释放后的工作状态不能作出准备判断,造成治疗不确定性^[7-9]。既往 Vaso CT^[10]、Xper CT^[11,12]等技术对支架精细结构有一定显示作用,但需要使用稀释造影剂,且不同支架所需的造影剂浓度不一致,在没有双筒高压注射器的条件下,还须要对高压注射器针筒进行更换,且造影剂总用量大,术中实现极为不便,故临床难以推广。

我们在支架释放过程中或全释放后,用平板 DSA 的 VR 方法对支架进行小视野扫描,然后对影像进行去金属伪影等后处理三维重建,从而显示支架的精细结构,可显示 Enterprise、Neuroform EZ、Neuroform Atlas、Lvis、Leo 多种类型支架的精细结构,对低可视性支架也有良好显示效果。该方法具有操作简便、成像快、显示清晰等特点,可在术中实时进行评价,易于在临床推广。

应用支架精细显影技术重建时,应同时进行

MIP 重建,调整合适的三维轴方向,从支架长轴、短轴及横断位的三维平面上观察支架各部位的形态,一方面从总体上清晰显示支架的精细结构,另一方面通过 VR 三维影像与 MIP 像的局部对照了解支架释放后各部位细节,从而使术者掌握支架全程打开情况,结合影像融合技术可了解支架各部位的贴壁情况,为术中决策和术后管理提供影像学依据;也有助于术者了解各类支架的性能,还可以反馈指导术者改进支架释放技术及习惯,有极高的临床应用价值。

DSA 容积扫描支架精细显影技术需要机器装配有去金属伪影功能方可实现。另外,重建效果会受到弹簧圈、局部血管钙化等因素。本文显示效果差的病例均为受到弹簧圈金属放射状伪影干扰所致,是否能通过调节管电压等其他方法改善仍需进一步研究。

总之,在使用支架治疗脑血管病时,DSA 容积成像可精准判断支架植入后张开、贴壁、打折等状态,对低可视性支架也有良好显示效果,是评价治疗效

果的重要依据。

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