

## . 综 述 .

## 外视镜在神经外科手术中的应用进展

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【摘要】手术显微镜和神经内镜的应用显著提升了神经外科手术的疗效。然而,由于设备本身固有的一些特点,使它们在临床应用方面仍然有一定的局限。鉴于手术显微镜和神经内镜的不足之处,加之数字成像、WiFi 网络连接、屏幕技术和光学技术的进步,作为手术显微镜和神经内镜的桥梁,外视镜系统应运而生。外视镜具有良好的图像质量和手术视野,更好的人体工程学姿势、教学有效性以及更高效的手术团队参与,应用效果与手术显微镜类似。目前,文献主要报道外视镜在景深、视野、焦距及操作等技术设备层面与手术显微镜的差别,缺乏外视镜在神经外科手术具体应用和手术效果的总结分析。因此,我们总结近年来外视镜在神经外科手术中的应用报道,分析其在临床实践中的优势和局限性,为临床提供参考。

【关键词】神经外科手术;外视镜;临床应用

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### Progress of application of exoscopes in neurosurgical procedures

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【Abstract】The application of surgical microscopes and neuroendoscopes has notably enhanced the efficacy of neurosurgical procedures. Nevertheless, owing to some inherent characteristics of the equipment themselves, they still have certain constraints in clinical applications. In light of the deficiencies of surgical microscopes and neuroendoscopes, coupled with the progressions in digital imaging, WiFi network connectivity, screen technology and optical technology, the exoscope system has come into being as a bridge between surgical microscopes and neuroendoscopes. The exoscope possesses superior image quality and surgical visual field, better ergonomic posture, teaching efficacy as well as more efficient surgical team engagement, and its application efficacy is similar to that of surgical microscopes. At present, the literature mainly reports the disparities between exoscopes and surgical microscopes in technical equipment aspects such as depth of field, visual field, focal length and operation, lacking a summary and analysis of the specific application and surgical outcomes of exoscopes in neurosurgery. Hence, we summarize the application exoscopes in neurosurgery in recent years, analyze their advantages and limitations in clinical practice, and offer references for clinical utilization.

【Key words】Neurosurgical procedures; Exoscopes; Clinical application

手术显微镜和神经内镜的应用显著提升了神经外科手术的疗效。然而,由于设备本身固有的一些特点,使它们在临床应用方面仍然有一定的局限。因此,一种新型的体外高清视频显微镜技术系统——外视镜,应运而生。目前,国内对外视镜在神经外科手术应用中的文献综述较少,主要报道了外视镜在景深、视野、焦距及操作等技术设备层面与手术显微镜的差别,缺乏外视镜在神经外科手术具体应用和手术效果的总结分析。因此,我们总结近年来外视镜在神经外科手术中的应用报道,分析其在临

床实践中的优势和局限性,为临床提供参考。

## 1 外视镜的历史与发展

1.1 手术显微镜和神经内镜的应用现状概述 手术显微镜具有良好的深部照明、高分辨率手术视野以及立体化成像效果,能帮助手术医师更清晰地观察到术野深部的神经血管组织结构,提升显微操作的精准性<sup>[1,2]</sup>。然而,手术显微镜景深较浅且视野较窄,特别是在高倍放大时,术者需要对目标区域进行反复地对焦和角度调节,对手术节奏影响很大;另一方面,术者需要通过显微镜目镜进行观察操作,要求术者必须长期以固定的姿势进行操作,易产生疲劳感。过去几十年,微创手术迅速发展,神经内镜系统由于其高质量的图像、更好的临床结果和更高的病人满意度,已被全面应用于神经外科<sup>[3]</sup>。但是,由于神经内镜入路通道狭长,通道附近常有重要的神经血管结构,加之颅腔不能扩张或缩小等颅脑手术的特点,

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导致神经内镜主要应用于经鼻经口入路的颅底手术以及脑室手术等。

1.2 外视镜的出现和发展 鉴于手术显微镜和神经内镜的不足之处,加之数字成像、WiFi 网络连接、屏幕技术和光学技术的进步,作为手术显微镜和神经内镜的桥梁,外视镜系统应运而生<sup>[4,5]</sup>。类似于神经内镜,外视镜系统通常由远视镜、光源、高清摄像头、显示屏和支架等部分构成,其中一个直径约 10 mm、长度约 140 mm 的远视镜是外视镜区别于神经内镜的主要结构,其镜头与镜体长轴成 0° 或 90°,焦距范围 250~750 mm,视野深度 35~100 mm 的硬性、长杆状<sup>[6]</sup>。而长焦距、深景深是外视镜系统较神经内镜的关键优势所在。

软件和硬件技术进步促进了外视镜的发展,特别是 3D 外视镜的出现,以及目前最新的 3D 4K 超高清外视镜,外视镜系统每年都在不断更新。软件方面,外视镜系统可以通过整合术前磁共振弥散张量成像、术中导航等信息来可视化手术区域,从而帮助医生进行精准、安全地手术<sup>[5]</sup>。硬件方面,外视镜可以集成用于血管造影的 5-氨基乙酰丙酸和吲哚菁滤光片、气动臂、可调操作手柄、多屏幕输出以及更长的聚焦距离和更大的放大倍率,从而达到更好的图像效果和操作体验<sup>[7,8]</sup>。

2 外视镜和手术显微镜的比较

外视镜系统通过将神经内镜的外形特征与手术显微镜的图像质量相结合,取长补短,弥补了手术显微镜和神经内镜的短板<sup>[9,10]</sup>。外视镜具有深景深及宽视野的特点(手术视野直径为 50~150 mm,景深为 35~100 mm),为高倍镜下深部手术操作提供了极为便利的条件;另一方面,外视镜的焦距可达 250~750 mm,提供了较长的工作距离,方便了手术操作<sup>[7]</sup>。关于外视镜的可视化,Ricciardi 等<sup>[8]</sup>通过比较外视镜和手术显微镜后发现,外视镜在图像质量、光学功率和放大倍率的效果与显微镜相当。外视镜还可以快速地从微观视角切换到宏观视角,而当手术通道为“上窄下宽”或有其他组织结构遮挡时,显微镜镜下视野通常会受限<sup>[11,12]</sup>。外视镜系统优势在于可以以一种更符合人体工程学的姿势进行手术,减少了通过显微镜目镜观看手术视野的时间,从而降低了医生的手术疲劳感。外视镜系统在手术过程中为所有手术参与者提供相同质量的 3D 手术图像<sup>[13]</sup>。显微镜最多允许两人通过目镜进行操作,而外视镜可以实时共享同一图像,因此允许多个外科医生同时进行手

术操作,并通过与所有人员共享信息来提高手术效率<sup>[14]</sup>。同时,外视镜系统不干扰手术团队的相互交流,让所有手术人员都能参与到手术过程中<sup>[1]</sup>。

3 外视镜在神经外科手术中的应用

3.1 脑肿瘤手术 Gonen 等<sup>[15]</sup>报道 56 例胶质瘤外视镜手术,其中仅 1 例在围手术期出现并发症(术区出血),发生率仅为 1.8%。Rotermund 等<sup>[13]</sup>报道 239 例经鼻蝶入路手术治疗垂体腺瘤,基于外视镜的手术并没有发生严重的并发症;同时,在手术时间、并发症或切除范围方面,外视镜手术与显微镜手术没有显著差异。Chen 等<sup>[14]</sup>报道乙状窦后入路手术切除 81 例肿瘤,在手术时间、肿瘤切除程度、术后面神经功能、听力等方面,外视镜手术与显微镜手术类似。对比两种术式的优缺点,外视镜在视频图像质量、手术视野、操作、人体工程学以及手术团队参与等方面均相似或优于显微镜,而深度感知评为相似或低于显微镜<sup>[2,16,17]</sup>。

3.2 脑血管病手术 Hafez 等<sup>[18]</sup>应用鸡翅血管模拟颅内血管分流术,结果显示外视镜和手术显微镜都可有效地进行血管吻合,而外视镜具有实现更优三维可视化以及为教学目的与他人共享手术视野的潜力。研究认为,外视镜在图像质量、手术视野、人体工程学以及团队参与方面均优于显微镜,但是在手术时间和流程方面与显微镜相似或低于显微镜<sup>[19,20]</sup>。

3.3 脊柱手术 Ariffin 等<sup>[21]</sup>报道 69 例脊柱手术,结果显示使用外视镜的学习曲线较短;而且得益于手术期间改进的人体工程学姿势,住院医师教学效果良好;唯一的弊端在于需要重新安排手术台的设置;并发症情况与手术显微镜相当;另外,具有数字可视化功能的外视镜提供极佳的可视化效果、深度感知、清晰度和精准的目标部位处理。Siller 等<sup>[22]</sup>使用外视镜进行腰椎后路减压术 40 例、前路颈椎间盘切除+融合术 20 例,术中没有出现并发症,手术时间、术中失血量、手术疗效与显微镜手术相似;但是,外视镜手术中医生体位舒适度更优,术中流程和手术部位的可视化效果优于显微镜手术。

4 外视镜在神经外科教学中的应用

外视镜的主要优势之一是允许所有参与手术人员共享相同质量的 3D 手术图像,让所有手术人员都能更多地参与到手术过程当中,进行手术交流、传递手术信息,利于手术操作的示教和帮带,增加教学参与度,提高教学的有效性<sup>[23]</sup>。研究发现,与手术显微

镜相比,外视镜的学习曲线相对较短。在缝合的实验室培训中,当学生和住院医师同时接受外视镜和显微镜的培训时,大多数学员使用外视镜操作更加容易<sup>[23]</sup>。在颅颈畸形手术的教学,所有学生通过3D眼镜观察到三维立体的解剖结构,增强了对颅颈畸形的解剖认识,提高了学生手术操作的积极性,缩短了培养周期。

5 展望

外视镜系统虽然较显微镜及神经内镜在应用上有了较大进步,但也有其局限性。早期2D外视镜最大的缺陷就是对深部结构的放大缺乏立体视觉,影响手术操作和术者判断。新的3D外视镜改善了缺乏立体视觉这一问题,但由于长时间佩戴偏光眼镜,在极少数情况下,会导致术者出现头痛、恶心等不适,是下一步需技术改进的重点<sup>[2]</sup>。另外,在外视镜颅脑手术中,有时需要在术中切换到显微镜,原因是有些肿瘤需要使用荧光引导可视化切除,或者手术视野深度照明不足<sup>[2]</sup>。由于带有特殊滤光片的设备成本较高,目前还没有广泛使用荧光外视镜进行肿瘤切除。手术时,助手站立位置与主刀医师相反,有时会看到旋转的显示图像,使用两个或更多的3D显示器,同时将手术影像信息经软件处理,以翻转180°的形式显示于助手显示屏上,可有效解决图像旋转的问题,从而使助手能更便捷参与手术进程<sup>[2]</sup>。

总之,外视镜系统越来越多地应用于神经外科手术中,这代表着神经外科术中可视化新时代的开始。与手术显微镜相比,外视镜具有更好的图像质量和手术视野,更好的术中人体工程学姿势,更好的教学有效性以及更高效的手术团队参与,而手术疗效相似。因此,对于大多数常见的颅脑和脊柱手术,外视镜是一种安全且有效的选择。随着技术进步和发展,更多的术中可视化工具可以帮助进行手术操作,以达到更低的手术并发症和更好的预后。

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