

招飞医学选拔中黄斑中心凹毛细血管化1例并文献复习

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摘要: **背景** 黄斑中心凹毛细血管化(macular-foveal capillarization, MFC)是一种中心凹无血管区(foveal avascular zone, FAZ)异常血管化的病理现象, 可由先天性或获得性因素导致, 也可见于视力正常的健康人群。**目的** 报道招飞医学选拔中发现的视力正常青少年MFC一例并进行文献复习, 旨在为招飞医学选拔提供参考经验。**方法** 使用超广角眼底照相、相干光断层成像(optical coherence tomography, OCT)及相干光层析血管成像(optical coherence tomography angiography, OCTA)进行视网膜结构检查, 使用多焦视网膜电图(multifocal electroretinogram, mfERG)、Rabin锥对比度视力、视野等进行视功能检查。**结果** 该学员18岁, 男, 眼底检查可见黄斑中心凹反光减弱、中心凹无血管区面积减小; OCT及OCTA可见黄斑中心凹发育不良, 毛细血管穿过黄斑中心凹区域与周围视网膜毛细血管网络相连; 多焦视网膜电图可见中心峰值降低。**结论** 招飞医学选拔中, 在常规视力检查基础上, 积极采用眼底检查及OCT、OCTA等新技术、新设备辅助检查, 可有效发现潜在影响高性能飞行视功能的眼底微结构异常, 对提升选拔的科学性与精准性具有重要价值。

关键词: 招飞; 医学选拔; 黄斑中心凹毛细血管化; 中心凹无血管区; 光学相干光断层成像

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Macular-foveal capillary in medical selection of flight cadets selection: A case report and literature review

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Abstract: Background Macular-foveal capillarization (MFC), characterized by abnormal vascularization within the foveal avascular zone (FAZ), arises from congenital or acquired factors and may occur in healthy individuals with normal vision. **Objective** To report a case of MFC identified during flight cadets' medical selection in an adolescent with normal vision and review relevant literature, so as to provide reference for air force medical selection. **Methods** The candidate underwent routine fundus examination. Retinal structure was assessed using ultra-wide-angle fundus photography, optical coherence tomography (OCT) and optical coherence tomography angiography (OCTA). Visual function was evaluated with multifocal electroretinogram (mfERG), Rabin cone contrast testing and visual field testing. **Results** This 18-year-old male cadet exhibited diminished foveal reflex and reduced area of the FAZ upon fundus examination. OCT/OCTA demonstrated foveal hypoplasia, with capillaries traversing the foveal center connecting to the surrounding retinal capillary network. mfERG showed a reduced central peak response. **Conclusion** In the medical selection for flight pilot candidates, in addition to routine visual acuity examinations, the active use of fundus examinations as well as new technologies and equipment such as OCT and OCTA for auxiliary assessments can effectively identify potential microstructural abnormalities in the fundus that may affect visual performance during high-performance flight. This approach holds significant value in enhancing the scientific rigor and precision of the selection process.

Keywords: flight cadets' medical selection; macular-foveal capillary; foveal avascular zone; optical coherence tomography

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黄斑中心凹毛细血管化(macular-foveal capillarization, MFC)是一种中心凹无血管区(foveal avascular zone, FAZ)异常血管化的病理现象, 可因先天性或获得性因素导致, 可见于视力

正常的健康人群。本文报道了1例招收飞行学员医学选拔中通过多模态影像技术确诊先天性MFC, 并发现其视觉电生理异常, 旨在探讨此类先天异常改变的筛查策略, 为优化招飞医学选拔提供依据。

1 病例资料

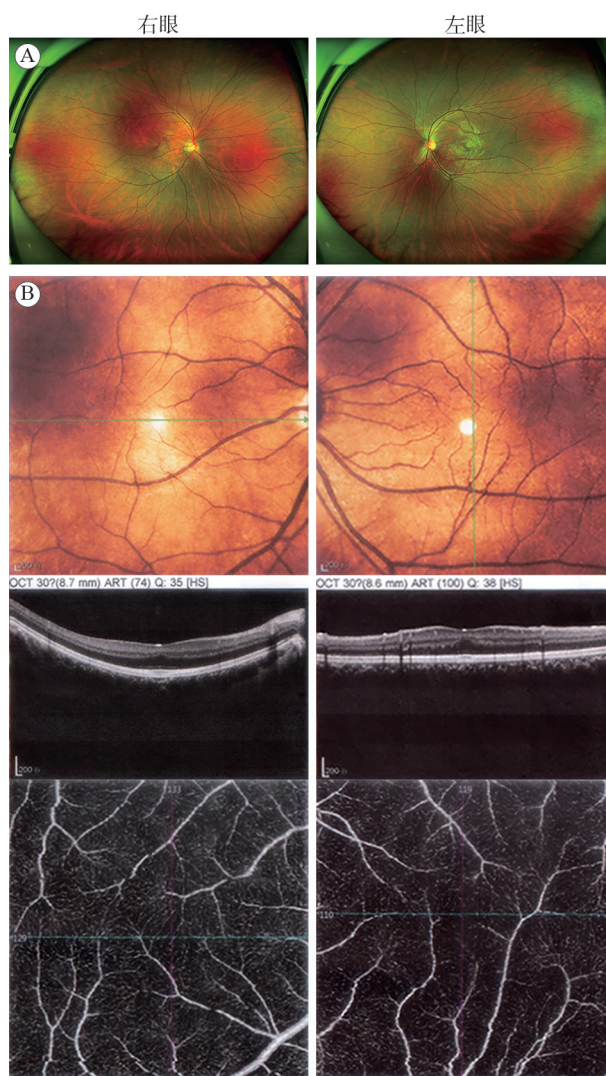
患者, 男, 18岁, 参加招收飞行学员医学选拔定选阶段学员。眼科体格检查裸眼视力(兰道特环形视力表, “C”字表)双眼1.0, 眼压双眼16 mmHg, 角膜、前房及晶体等眼前节检查未见异常, 双眼眼底可见视盘边清色正, 黄斑中心凹不明显、中心凹反光点消失、中心凹无血管区面积减小(图1A)。相干光断层成像(optical coherence tomography, OCT)及相干光层析血管成像(optical coherence tomography angiography, OCTA)检查可见黄斑中心凹形态发育不良, 凹陷变浅、内层视网膜结构移位不完全、外核层增宽、中心凹网膜厚度330 μm , 黄斑中心凹无血管区毛细血管生长(图1B)。多焦视网膜电图(multifocal electroretinogram, mfERG)可见中心峰值降低(图2A); 色觉检查(假同色图法, 俞自萍版)及Rabin锥对比度视力检查正常(图2B)。

结合该学员眼科检查及辅助检查所见, 诊断为双眼中心凹毛细血管化, 根据以往研究基于OCT影像的分级法^[1], 属于I级。尽管该学员视力正常, 但mfERG检查结果异常, 提示双眼黄斑区功能存在异常^[2], 根据招收飞行学员医学选拔体格检查标准相关要求, 予以招飞医学选拔不合格结论。

2 讨论

黄斑位于眼底视盘颞侧3.5 mm处并稍下方, 因含有叶黄素丰富而呈黄色, 水平直径为1.5~1.75 mm^[3]。黄斑内层视网膜逐渐向底部凹陷形成中心凹, 中心凹处没有视杆细胞, 但视锥细胞密度高达200 000/mm², 是人类视网膜视敏度最高的区域^[4-5]。黄斑中央缺乏视网膜毛细血管的区域称为中心凹无血管区, 当FAZ发生部分或全部血管化即称为MFC。

1973年J. Yeung等首次提出MFC的概念^[6], 目前研究倾向于将MFC分为先天性和获得性。在先天无虹膜、白化病、小眼畸形、色盲、卵黄状黄斑变等先天遗传相关性病例, 以及视网膜微毛细

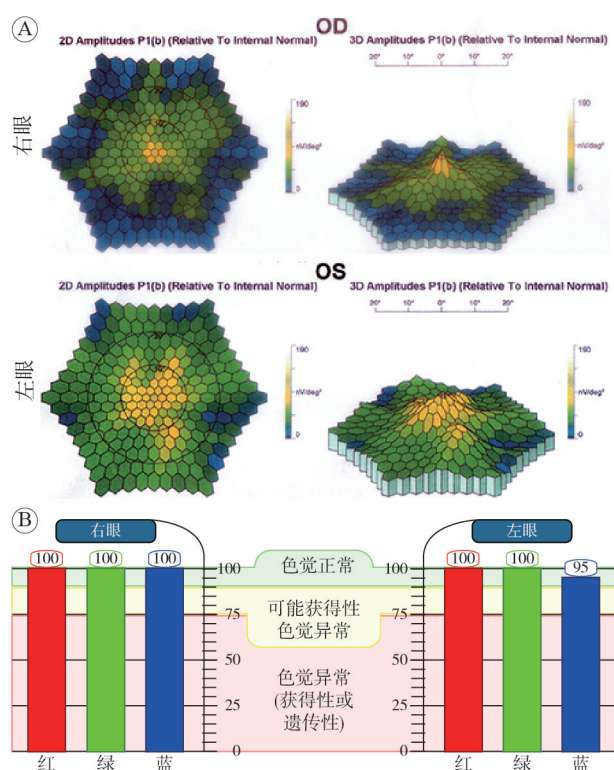


A: 眼底像, 可见中心凹反光若, 毛细血管长入; B: 相干光断层成像, 可见中心凹结构改变, 黄斑区视网膜毛细血管密集。

图1 超广角激光扫描眼底成像、光学相干光断层成像及相干光层析血管成像所见

Fig. 1 Findings of ultra-wide-angle laser scanning fundus imaging, optical coherence tomography imaging and optical coherence tomography angiography

血管循环性疾病如糖尿病性视网膜病变、视网膜静脉阻塞等视网膜血管疾病中可出现获得性MFC^[7-10], 且MFC的程度与疾病严重程度高度相关^[11-13]。值得注意的是, 在视力正常的人群中, 存在先天性MFC, 通常是在体检中无意发现。L. Frizziero研究团队^[14]对视力正常的先天性MFC患者和FAZ正常人进行了对比研究, 发现先天性MFC患者最佳矫正视力(best corrected visual acuity, BCVA)、暗光下视力(low luminance visual acuity, LLVA)、色觉和对比敏感度与FAZ正常人没有统计学差异。但先天性MFC患者中光照微视野检查黄斑中心和中央1°区域的视锥细胞光感受



A: 多焦视网膜电图, 可见双眼中心区峰值明显降低; B: 锥对比度视力检查, 可见锥对比度视力正常。

图2 多焦视网膜电图及锥对比度视力检查所见

Fig. 2 Findings of multifocal electroretinogram and cone contrast sensitivity visual acuity examination

器功能^[15]显著低于正常对照眼, 表明MFC眼在正常光照条件下的中心视力功能受损。本次招飞医学选拔中检出的先天性MFC病例检查结果与L. Frizziero研究一致。根据我们前期统计, 在招飞医学选拔中, 视力正常、无重大眼部病史等青少年人群(16~18周岁)中视网膜黄斑中心凹发育不良、黄斑部毛细血管化, 符合先天性MFC诊断标准的患者检出率约为0.25%。患者均表现为裸眼视力正常、眼底检查中心凹反光减弱甚至消失、中心凹无血管区面积减小; 黄斑OCT显示黄斑中心凹的凹陷较浅, 内层视网膜结构移位不完全, 外核层增宽, 黄斑中央视网膜厚度(CST)通常比正常眼更厚; OCTA显示毛细血管穿过黄斑中心凹区域, 与周围视网膜毛细血管网络相连。

FAZ是黄斑中心凹正常发育的必要条件^[16]。动物模型中观察到FAZ的形成先于黄斑中心凹的形成, FAZ的中心与杆状光感受器缺失区域(rod-free zone)一致。在本例MFC中, 由于FAZ的缺失, 黄斑中心凹出现了毛细血管, 导致黄斑中心凹结构发生了变化, 表现为1级黄斑发育不良(fovea hypoplasia), 即黄斑中心凹凹陷浅、外核层

增宽。此外, MFC眼在低光照条件下的黄斑中心区域记录到了杆状光感受器的反应^[14,17], 正常情况下该区域由于缺乏杆状光感受器, 通常不会有这种电生理反应。这表明在MFC眼中, 黄斑中心凹区域可能同时存在杆状和锥状光感受器。在正常发育过程中, FAZ的形成可能与杆状光感受器的缺失区同步发生, 而MFC眼中FAZ的缺失可能使得杆状光感受器能够在黄斑中心凹区域发育, 但这种联系的具体机制尚不清楚。

招飞医学选拔是保证完成空中飞行任务的首要关口^[18]。飞行员在极端条件下对于视觉功能的要求标准较高, 需要通过视力以及视觉电生理检查等多个维度对视功能进行评价。先天性MFC患者视力正常、常规眼底检查仅可见中心凹反光减弱或消失、中心凹无血管区面积减小, 容易在医学选拔中发生漏诊。而OCT和OCTA能够无创、快速、精准的显示黄斑区视网膜形态^[19]和结构^[12,20-21]的细微变化, 在疾病诊断中的作用不可替代、应用范围不断扩大^[22-24]。OCT和OCTA能够揭示MFC的典型病理改变, 对MFC的诊断和鉴别诊断尤为重要。通过本病例的mfERG检查以及文献回顾, 明确先天性MFC存在视觉功能异常, 不适合从事飞行等对视功能要求较高的特殊职业。在招飞医学选拔工作中, 应重视视觉多模态检查的应用, 尤其新的检查技术对提高招飞医学选拔的精准性具有重要意义。

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数据共享声明 本论文相关数据可依据合理理由从作者处获取, Email: frost.wty@hotmail.com。

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