

## $^{18}\text{F}$ -FDG PET/CT在脊柱感染诊治中的应用及与MRI的比较

### Application of $^{18}\text{F}$ -FDG PET/CT in the diagnosis and treatment of spinal infection and comparison with MRI

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## ·综述·

# <sup>18</sup>F-FDG PET/CT 在脊柱感染诊治中的应用及与 MRI 的比较

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**【摘要】** 脊柱感染(SI)是一种由致病菌沿中轴骨血行播散引起的疾病。虽然 MRI 是诊断 SI 的首选影像学检查方法,但在诊断和鉴别诊断等方面亦有其局限性。<sup>18</sup>F-氟脱氧葡萄糖(FDG) PET/CT 作为一种一站式的全身检查方法,在鉴别感染原发灶和脊柱术后感染及评估治疗疗效等方面较具优势。笔者重点从 SI 的诊断、鉴别诊断和疗效评估三个方面综述<sup>18</sup>F-FDG PET/CT 在 SI 诊治中的应用及其与 MRI 的比较。

**【关键词】** 骨疾病, 感染性; 正电子发射断层显像术; 体层摄影术, X 线计算机; 氟脱氧葡萄糖 F18; 磁共振成像

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## Application of <sup>18</sup>F-FDG PET/CT in the diagnosis and treatment of spinal infection and comparison with MRI

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**【Abstract】** Spinal infection (SI) is a disease caused by pathogenic bacteria spreading along the axial skeleton. Although MRI is the first imaging examination method for SI diagnosis, it has some disadvantages in diagnosis and differential diagnosis of SI. And <sup>18</sup>F-FDG PET/CT, as one-stop general check-up method, is superior to MRI in identifying specific primary lesion and postoperative infection, and evaluating treatment response. The review mainly includes the clinical application of <sup>18</sup>F-FDG PET/CT in early diagnosis, differential diagnosis and therapeutic efficacy evaluation of SI and compares it with MRI.

**【Key words】** Bone disease, infectious; Positron-emission tomography; Tomography, X-ray computed; Fluorodeoxyglucose F18; Magnetic resonance imaging

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脊柱感染(spinal infection, SI)是一种由致病菌沿中轴骨血行播散<sup>[1]</sup>引起的疾病,主要表现为椎间盘炎、椎体骨髓炎和脊椎脓肿,根据发病部位可将脊椎脓肿分为脊髓硬膜外脓肿、脊髓脓肿、腰大肌脓肿及椎旁脓肿等。SI按病理类型分为脊柱结核、化脓性脊柱炎和布鲁氏杆菌脊柱炎等。金黄色葡萄球菌是 SI 最常见的致病菌,其次是结核杆菌<sup>[2]</sup>。SI 的症状通常是非特异性的,严重者可出现脊柱畸形、神经功能损伤、瘫痪甚至病死。虽然 MRI 是诊断 SI 的首选影像学检查方法,但其可能

无法显示出所有病灶。<sup>18</sup>F-FDG PET/CT 作为一种一站式的全身检查方法,在鉴别感染原发灶和脊柱术后感染等方面较具优势<sup>[3]</sup>。此外,<sup>18</sup>F-FDG PET/CT 还可用于 SI 的疗效评估。MRI 是目前临床实践中最常用的 SI 诊断方法,但在诊断和鉴别诊断等方面亦有其局限性。我们主要就<sup>18</sup>F-FDG PET/CT 在 SI 诊治中的应用及其与 MRI 的比较进行综述。

### 1 SI 的诊断

<sup>18</sup>F-FDG PET/CT 的诊断效能不受 SI 症状出现

时间的影响,对SI的早期诊断优于MRI。Kouijzer等<sup>[4]</sup>的研究结果显示,在SI患者出现腰痛等症状两周内和两周后行MRI检查的灵敏度分别为77.8%和100%,但经专家会诊校正后,不同时间的诊断灵敏度的差异缩小了;而这项研究的结果同时也显示,出现症状两周内和两周后行<sup>18</sup>F-FDG PET/CT的灵敏度均为100%,<sup>18</sup>F-FDG PET/CT的诊断效能与症状出现时间无关。因此,推荐SI患者在早期出现症状短时间内,当MRI检查结果为阴性时,应进一步行专家会诊或<sup>18</sup>F-FDG PET/CT检查。

MRI是诊断脊髓硬膜外脓肿和脊髓脓肿的首选方法;而<sup>18</sup>F-FDG PET/CT在诊断椎旁脓肿或腰大肌脓肿方面更具优势。Kouijzer等<sup>[4]</sup>的研究结果显示,在11例SI患者中,MRI可以检测到5例脊髓硬膜外脓肿或脊髓脓肿,而<sup>18</sup>F-FDG PET/CT仅能检测到1例。Smids等<sup>[5]</sup>的研究结果显示,MRI几乎能检测到所有脊髓硬膜外脓肿和脊髓脓肿,而约50%患者的<sup>18</sup>F-FDG PET/CT结果呈阴性。另外,其研究结果还显示,在18例SI出现椎旁脓肿的患者中,<sup>18</sup>F-FDG PET/CT与MRI诊断椎旁脓肿的灵敏度分别为94%和61%;在8例SI出现腰大肌脓肿的患者中,<sup>18</sup>F-FDG PET/CT与MRI诊断腰大肌脓肿的灵敏度分别为100%和63%。

## 2 SI的鉴别诊断

脊柱退行性病变是正常骨关节反复动作造成的某一部位老化或劳损。虽然MRI是诊断SI的首选影像学检查方法<sup>[3-5]</sup>,但是相较于<sup>18</sup>F-FDG PET/CT,MRI较难区分SI与脊柱退行性病变<sup>[5]</sup>。Luoma等<sup>[6]</sup>的研究结果表明,36%的Modic I型椎间盘退行性病变患者的椎间盘T2加权信号异常增强,与椎体骨髓炎相似。Ohtori等<sup>[7]</sup>的前瞻性研究结果表明,MRI区分SI和脊柱退行性病变患者的灵敏度为50%、特异度为96%;<sup>18</sup>F-FDG PET/CT区分SI和退行性病变患者的灵敏度和特异度均为100%。Riccio等<sup>[8]</sup>随机选取了500例50岁以上的脊柱退行性关节炎患者并行<sup>18</sup>F-FDG PET/CT检查,结果发现,只有4例(0.8%)患者呈现假阳性,这证实了<sup>18</sup>F-FDG PET/CT对脊柱退行性病变具有较好的鉴别效能。但是,Aliyev等<sup>[9]</sup>认为,椎间盘和棘突对<sup>18</sup>F-FDG的摄取与年龄呈正相关,且越严重的脊柱退行性病变出现高<sup>18</sup>F-FDG摄取的可能性越大,以<sup>18</sup>F-FDG的

摄取高低区分SI与脊柱退行性病变还有待考究。

MRI难以区分SI患者脊柱术后手术区域感染和骨组织重建修复,且在手术部位植入金属限制了MRI的应用。而<sup>18</sup>F-FDG的摄取受植入金属影响最小<sup>[3-4,10]</sup>。脊柱术后<sup>18</sup>F-FDG PET/CT显像的特征性表现可能对SI具有独特的鉴别诊断价值。Bagrosky等<sup>[11]</sup>的研究结果表明,脊柱内固定术后感染患者的<sup>18</sup>F-FDG PET/CT影像表现包括多个相邻椎体的脊柱和软组织<sup>18</sup>F-FDG摄取升高,而非感染性炎症患者仅在脊柱内固定针棒装置周围存在<sup>18</sup>F-FDG摄取升高,经<sup>18</sup>F-FDG PET/CT诊断和随访证实的5例非感染性炎症患者最终免于手术。

脊柱结核发病率居全身骨关节结核发病率的首位。<sup>18</sup>F-FDG PET/CT在区分脊柱结核与化脓性脊柱炎方面缺乏显著特异性。Lee等<sup>[12]</sup>的研究结果表明,MRI对脊柱结核与化脓性脊柱炎的鉴别能力优于<sup>18</sup>F-FDG PET/CT。Dureja等<sup>[13]</sup>对33例脊柱结核患者行治疗前<sup>18</sup>F-FDG PET/CT检查,发现其浮动范围较大,SUV<sub>max</sub>最小为5.9,最大为30.3,这说明脊柱结核病灶对<sup>18</sup>F-FDG摄取的可变性较大<sup>[14]</sup>。Lee等<sup>[12]</sup>的另一项区分脊柱结核和化脓性脊柱炎的双时相显像研究结果显示,脊柱结核和化脓性脊柱炎的<sup>18</sup>F-FDG摄取在延迟图像与早期图像上都没有显著差异。因此,单纯SUV<sub>max</sub>定量分析可能不适合用于脊柱结核与化脓性脊柱炎的鉴别诊断<sup>[15]</sup>。谭蓓蓓和郭婧澜<sup>[16]</sup>的研究结果显示,椎旁“冷脓肿”、“放射性冷区”等脊柱结核的特征性表现可能有助于提高<sup>18</sup>F-FDG PET/CT对脊柱结核与化脓性脊柱炎的鉴别诊断效能。

另外,<sup>18</sup>F-FDG PET/CT在区分骨感染性疾病和恶性肿瘤方面缺乏特异性<sup>[17]</sup>,多项研究曾报道了<sup>18</sup>F-FDG PET/CT误诊SI或脊柱恶性肿瘤的案例<sup>[5,18]</sup>。虽然穿刺活检是脊柱病变的确诊方法,但在获得的病理组织较少时常无法明确诊断,尤其是SI等的良性病变。因此,有必要对诊断工具进行改进,例如将<sup>18</sup>F-FDG PET/CT与人工智能相结合等<sup>[19]</sup>。

## 3 SI的疗效评估

在SI治疗有效的早期会出现SUV<sub>max</sub>减小<sup>[13-14]</sup>,而MRI通常在SI几个月后才出现相应影像的改变,因此,<sup>18</sup>F-FDG PET/CT对早期治疗反应的评

估优于MRI<sup>[20]</sup>。Nanni等<sup>[21]</sup>通过对SI患者治疗前后病灶局部SUV<sub>max</sub>的变化率为34%来评估其治疗疗效,灵敏度与特异度均达到82%。

<sup>18</sup>F-FDG PET/CT可能有助于确定SI的治疗终止时间,而Zarrouk等<sup>[20]</sup>的一项前瞻性研究结果表明,MRI不能准确评估SI患者是否可以停止抗菌药物治疗,该研究对29例治疗结束后的SI患者进行随访,结果显示所有患者均未复发,而其中2/3的患者治疗结束时,MRI仍显示异常。在Gasbarrini等<sup>[22]</sup>的研究中,一例脊柱结核SI患者治疗结束后的MRI显示原有异常征象消失,但临床结果证实病情仍有进展。Yu等<sup>[23]</sup>提出,可根据<sup>18</sup>F-FDG在病变区域的分布特点,确定化脓性脊柱炎的治疗终止时间,即如果<sup>18</sup>F-FDG的摄取局限于椎间盘边缘,无论摄取强度如何,患者都被视为痊愈。以<sup>18</sup>F-FDG在病变区域的分布特点鉴别是否治愈的研究结果显示,在20例SI患者中,10例被认定为治愈的患者不再接受额外的抗生素治疗,且在随访期32个月内均未发生SI<sup>[8]</sup>。

相较于MRI,<sup>18</sup>F-FDG PET/CT辅助SI手术清创定位更有助于缩小手术范围<sup>[24-25]</sup>。Nakahara等<sup>[24]</sup>的术前研究结果显示,相较于<sup>18</sup>F-FDG PET/CT的异常代谢活动区域,MRI的异常信号区域更广泛;<sup>18</sup>F-FDG PET/CT诊断手术中实际存在感染灶的准确率(89.8%)高于MRI(59.2%),并且具有100%的灵敏度。但在临床实践中,外科医师不会仅参考MRI检查结果来确定手术区域,常会基于临床经验并综合患者临床资料对手术区域做相应的调整,所以<sup>18</sup>F-FDG PET/CT在辅助外科医师确定SI手术范围中的临床价值还有待进一步研究。

#### 4 小结与展望

Ito等<sup>[26]</sup>对<sup>18</sup>F-FDG PET/CT在SI诊治中产生的临床影响的回顾性研究结果显示,<sup>18</sup>F-FDG PET/CT改变了医师对52%(15/29)患者的临床决策,包括延长了10例SI患者的治疗周期,校正了3例患者的活检定位,增加了2例患者的手术治疗。但由于该研究纳入的患者数量有限,且为回顾性研究,所以,<sup>18</sup>F-FDG PET/CT对临床影响的效能还有待大样本研究结果证实。在最近的一项关于成人SI诊断的共识文件中,专家们推荐将<sup>18</sup>F-FDG PET/CT应用于以下患者:(1)疑似SI患者伴红细胞沉降率

(ESR)和(或)C反应蛋白(CRP)升高,且MRI检查难以确诊;(2)原发性和术后SI患者存在MRI检查禁忌证;(3)术后同时存在骨感染和软组织感染的SI患者。(4)行<sup>18</sup>F-FDG PET/CT诊断的SI患者可重复行<sup>18</sup>F-FDG PET/CT检查以评估抗生素的治疗反应<sup>[27]</sup>。与MRI相比,<sup>18</sup>F-FDG PET/CT在SI诊断与治疗方面都具有独特优势,尤其是对不能进行MRI检查或MRI检查不能明确诊断的患者更具应用价值。由于目前的研究多为回顾性研究,还需更多的前瞻性研究进一步证实。此外,在SI诊治的初步研究中,新型核医学显像仪器PET/MRI的临床应用效能也优于MRI<sup>[28]</sup>,但其与<sup>18</sup>F-FDG PET/CT的对比研究仍有待深入探讨。

**利益冲突** 本研究由署名作者按以下贡献声明独立开展,不涉及任何利益冲突。

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