

◁综述▷

影像学检查方法在卵巢癌可切除性评估中的研究进展

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[摘要] 卵巢癌作为女性生殖系统中的一种高度恶性肿瘤,往往在晚期才被发现,此时常伴有腹盆腔多发转移。治疗卵巢癌的首要手段是肿瘤细胞减灭手术,关键在于实现“满意减瘤术”,即术后患者体内所有的残余病灶直径 ≤ 1 cm 或无肉眼可见残余病灶。因此,术前评估卵巢癌及其腹盆腔转移灶的可切除性极为关键。在这一过程中,CT、MRI 和 PET/CT 等影像学检查方法对于卵巢癌的精确分期和转移灶评估至关重要,每种技术都提供了独特的视角和信息。目前,大量研究正在探索如何通过这些影像学手段来优化术前对卵巢癌可切除性的评估。同时,人工智能技术的快速发展为提高评估的准确性和效率带来了新的可能。尽管如此,该领域仍需进一步研究,以便更好地辅助临床医生为卵巢癌患者制定个性化的治疗方案。

[关键词] 卵巢肿瘤;体层摄影术,X 线计算机;磁共振成像;正电子发射断层显像计算机体层摄影术

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Recent advances in the use of imaging examination methods for assessing resectability in ovarian cancer

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Abstract: Ovarian cancer, a highly malignant tumor in the female reproductive system, is often discovered at an advanced stage, typically accompanied by multiple metastases in the abdominal and pelvic cavities. The primary treatment for ovarian cancer is cytoreductive surgery, with the goal of achieving “optimal debulking” meaning that residual tumor diameters in the patient’s body after surgery do not exceed 1 centimeter or are not visibly detectable. Consequently, preoperative assessment of the resectability of ovarian cancer and its abdominal and pelvic metastatic lesions is extremely critical. In this process, imaging modalities such as CT, MRI, and PET/CT play a vital role in the accurate staging and evaluation of metastatic foci, each offering distinct perspectives and information. Currently, a significant amount of research is exploring how to optimize the preoperative assessment of the resectability of ovarian cancer through these imaging methods. Moreover, the rapid development of artificial intelligence technology has introduced new possibilities for enhancing the precision and efficiency of these assessments. Nonetheless, further research is necessary in this area to better support clinicians in tailoring treatment plans for patients with ovarian cancer.

Key words: Ovarian Neoplasms; Tomography, X-ray Computed; Magnetic Resonance Imaging; Positron Emission Tomography Computed Tomography

卵巢癌是一种高度恶性的女性生殖系统肿瘤,其发病隐匿,易于转移和广泛播散,约 80% 的患者初诊时肿瘤负荷已较高,主要表现为多发腹盆腔转移。根据最新的全球癌症数据报告显示,2022 年全球卵巢癌新发病例数和死亡病例数分别居妇科肿瘤的第 3 位和第 2 位^[1],我国卵巢癌死亡率亦呈逐年增长的趋势^[2]。不同于其他实体肿瘤存在远处转移即不适合手术的特点,Ⅰ~Ⅳ期卵巢癌的主要治疗手段为肿瘤细胞减灭手术,手术的目标是尽可能彻底地切除所有病灶,达到“满意减瘤术”(指术后患者体内所有的残余病灶直径 ≤ 1 cm 或无肉眼可见残余病灶)。病灶的可切除性主要由其位置、大小及与周围组织脏器的关系等综合因素所决定。对于肿瘤负荷过高、难以达到“满意减瘤术”的晚期患者,指南^[3]推荐新辅助化

疗(Neoadjuvant chemotherapy, NACT)后再行减瘤术。因此,在术前针对腹盆腔转移灶进行可切除性评价,对初诊患者的诊疗分流至关重要。由于开腹和腹腔镜手术的侵入性和断层成像技术的不断发展,无创便捷的影像学检查在评估卵巢癌转移灶中的价值日益突显^[4-5],近年来,大量文献报道了基于影像学特征来评价卵巢癌腹盆腔转移灶可切除性的研究。本研究将综述当前影像学检查方法在卵巢癌转移灶可切除性评估中的应用进展,并探讨未来的发展方向。

1 卵巢癌转移灶“不可切除”概述

近年来,基于影像学征象评价卵巢癌腹盆腔转移灶可切除性已有很多文献报道,但受不同中心医疗水平和手术标准

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制定差异的影响,至今国际上并没有关于卵巢癌转移灶“不可切除”的统一标准定义。最新的欧洲妇科肿瘤学会(ESGO)指南认为晚期卵巢癌患者出现以下部位的转移灶是“不可切除”的^[6]:①小肠肠系膜根部弥漫性深部浸润;②小肠弥漫性癌转移累及大部分,切除会导致短肠综合征(剩余肠道<1.5 m);③胃/十二指肠、胰腺的头部/中部存在弥漫性受累/深部浸润;④累及腹腔干、肝动脉、胃左动脉;⑤中央或多段实质肝转移;⑥多发性肺实质转移瘤(最好有组织学证实);⑦不可切除的淋巴结;⑧脑转移。而 2018 年美国放射学院(ACR)的卵巢癌转移灶“不可切除”标准包括肠系膜根部、胃脾韧带、小网膜囊、肝门、肝顶、肝段间裂、膈肌和肺实质中的病变(>2 cm),腹腔干轴上方或上方的淋巴结肿大,以及骶前腹膜外病变和盆腔侧壁侵犯^[7]。

2 影像学征象评估卵巢癌转移灶可切除性

2.1 CT

CT 检查是美国国立综合癌症网络(NCCN)指南^[8]和 ACR^[7]推荐的卵巢癌术前评估转移灶位置、范围的首选影像学检查方法。CT 扫描的优势在于其广泛使用性、低成本以及快速的扫描时间等。据报道,在卵巢癌的各个阶段,CT 识别腹膜转移灶的诊断准确性介于 70%~90%之间^[9]。而考虑到转移灶在大小、形态和位置上的异质性,CT 的敏感性波动在 25%~90%之间^[9-10]。但 CT 的软组织分辨率低,在小病灶(<1 cm)的检测中存在一定的局限性,尤其是位于小肠表面或肠系膜根部的病灶。此外,腹水的存在、腹腔内脂肪组织的多少以及肠道准备的充分性也会影响病灶的检测^[11]。光谱 CT 的出现有望改变传统 CT 的局限性^[12]。Pisuchpen 等^[13]提出,使用快速千伏切换双能 CT(Rapid kilovoltage-switching dual-energy CT, rsDECT)生成的材料密度(Material density, MD)图像可能有助于更早、更准确地检测卵巢癌腹膜转移灶,然而其优势在不同经验放射科医师和患者体型中可能会有所不同。

目前已有部分研究基于 CT 特征构建模型,以评估晚期卵巢癌患者是否能够实现“满意减瘤术”。Suidan 等^[14]纳入 350 名卵巢癌患者,对 18 个 CT 特征进行五分制定性评分,发现其中 8 个 CT 特征与卵巢癌病灶的可切除性显著相关。这些特征包括小囊病变>1 cm、脾门/韧带病变、肾门上方的腹膜后淋巴结(包括膈上淋巴结)、胃-肝韧带/肝门区域病变、弥漫性小肠粘连/增厚、胆囊窝/肝节间裂病变、中重度腹水以及肠系膜上动脉根部病变,其中肠系膜上动脉根部病变与可切除性的相关性最强($OR=4.06$),通过结合临床指标,成功建立模型术前预测卵巢癌转移灶是否“不可切除”。Kumar 等^[15]进一步提出,在 CT 放射学特征的基础上结合肿瘤分子亚型、手术复杂性等因素可以对卵巢癌转移灶可切除性进行有效预测。

腹膜癌指数(Peritoneal cancer index, PCI)^[16]是当前被广泛认可的卵巢癌患者术前病灶可切除性评估系统之一,其通过对腹腔镜或影像学检查发现的腹腔腔内肿瘤的大小和大小进行评分,预测卵巢癌转移灶的可切除性,是卵巢癌患者生存的重要预后指标。Avesani 等^[17]在对 297 名卵巢癌患者进行基于 CT 的 PCI 评分后,发现其可能与无法达到“满意减瘤术”的结果相关。此外,Fagotti 等^[18]开发的基于腹腔镜的评分系统也是卵巢癌转移灶术前评估的常用工具之一,其总分定义为预测

指数值(Predictive index value, PIV),可有效预测卵巢癌转移灶的可切除性。Kim 等^[19]在此基础上构建了基于 CT 的 Fagotti 评分系统,其研究结果显示,基于 CT 的 PIV 预测模型可能有助于评估患者病灶的可切除性。

2.2 MRI

常规 MRI 能够直观显示卵巢癌的形态学特征,包括肿瘤内部结构、形状和轮廓等。其中弥散加权成像(DWI)在检测卵巢癌转移、评估肿瘤负荷和其可切除性方面发挥着重要作用。既往数据表明,DWI 在识别卵巢癌腹膜转移方面的敏感性和特异性可达到 90%和 95.5%^[20]。此外,一些研究还发现,全身 DWI 在检测卵巢癌腹膜转移、淋巴结转移及评估不可切除转移灶的能力上均不劣于 CT,在评估肠系膜根部、小肠、骨盆、乙状结肠等受累区域时,其表现可能优于 CT^[21-22]。值得注意的是,DWI 的定量参数表观弥散系数(ADC)为卵巢癌病灶可切除性评估提供了新的视角。有研究表明,卵巢癌腹膜转移灶的平均 ADC 显著低于卵巢和网膜部位病变^[23],这为临床医生在术前评估手术的可行性提供了重要的量化依据。

多项研究已经证实了 DWI 与 PCI 评分之间存在显著的相关性^[24-25]。Lee 等^[26]开发了一种基于 DWI 的 PCI 半自动量化评分方法,该方法在检测肠系膜和浆膜转移灶方面表现出色,在晚期及复发性卵巢癌患者的病灶可切除性评估中具有高度的准确性,甚至在某些情况下,其评估性能超过了传统的 PCI 评分。Li 等^[27]对结合 MRI 形态学特征(具有相对可区分边界的块状/具有大部分难以区分或浸润边界的浸润性病灶)和常规临床危险因素(CA-125 和腹水)的临床放射学模型与基于 DWI-PCI 建立的模型在预测病灶可切除性方面的能力进行了比较,结果显示两者性能相当。

此外,直肠乙状结肠的受累情况评估也是决定卵巢癌患者是否能够实现“满意减瘤术”的关键因素之一。Zhao 等^[28]研究发现,术前 MRI 通过评估直肠乙状结肠肌层的受累情况以及受累的周长比例,有助于识别需要进行直肠切除术的卵巢癌患者,从而提高实现“满意减瘤术”的可能性。

2.3 PET

作为一种先进的分子成像技术,PET 能够深刻揭示肿瘤的异质性和生物学特征,在肿瘤的术前评估中发挥着越来越重要的作用。NCCN 指南^[3]已经将 ¹⁸F-FDG PET/CT 纳入推荐,作为卵巢癌影像学学生物标志物的一部分,用于术前卵巢癌转移灶评估的补充检查。近期的一项初步研究显示,¹⁸F-FDG PET/MRI 在检测卵巢癌转移灶方面的性能可能优于 DWI,尤其是在小肠等部位^[29]。镓 68(⁶⁸Ga)标记的成纤维细胞活化蛋白抑制剂(Fibroblast activation protein inhibitor, FAPI)是一种相对较新且具有潜力的 PET 示踪剂,目前已在多种妇科恶性肿瘤的诊断中展现出了显著的效用^[30]。Chen 等^[31]研究指出,相较于 ¹⁸F-FDG PET/CT, ⁶⁸Ga-FAPI-04 PET/CT 在检测卵巢癌淋巴结及腹膜转移灶方面具有更高的敏感性。此外, Xi 等^[32]的研究也发现,与 ¹⁸F-FDG PET/CT 相比, ⁶⁸Ga-FAPI-04 PET/MRI 在检测卵巢癌转移灶方面展现出显著的优势,能够更精确地评估肿瘤负荷并预测病灶的可切除性。

3 影像组学在评估卵巢癌转移灶可切除性中的应用

影像组学,通过其高通量分析和从医学影像中提取的丰

富特征,已在疾病的诊断、治疗和预后评估中显示出巨大的应用潜力。Rizzo 等^[33]通过分析 101 例卵巢癌患者的 CT 特征建立临床影像组学模型,结果表明影像组学特征与卵巢癌转移灶可切除性有显著的相关性。Vargas 等^[34]对疑似卵巢癌转移灶进行手动分割,并提取了纹理特征,发现基于这些衍生的组织纹理异质性指标可能有效预测病灶可切除性($P \leq 0.05$)。同时,基于 MRI 特征构建的模型在预测卵巢癌转移灶可切除性中也展现出良好的性能^[35-36]。Lu 等^[37]通过提取 128 例晚期卵巢癌患者的多序列 MRI 图像(包括 T₂WI、DWI 等)的特征,成功构建了基于 MRI 的影像组学列线图,该列线图在术前预测卵巢癌转移灶可切除性方面表现出色,达到了较高的准确性(AUC=0.900)。

4 总结与展望

CT、MRI 和 PET/CT 在卵巢癌转移灶可切除性无创评估中起着至关重要的作用,越来越多的相关研究聚焦于利用不同成像工具对卵巢癌转移灶可切除性进行评估。现有研究仍面临一些挑战。首先,精准识别卵巢癌转移灶是评估卵巢癌可切除性的基础,但目前成像技术在检测微小转移灶方面的敏感性和特异性尚有不足,且转移灶的识别往往依赖于主观经验,缺乏统一的客观评估标准;其次,许多研究因样本量小、局限于单一中心,缺乏外部验证,使得预测模型难以广泛应用。因此,未来的研究需要更大规模、多中心的临床试验来优化和验证不同成像工具及其预测模型的有效性。

随着影像组学和人工智能技术的发展,医学影像学研究迎来了技术革新。这些前沿技术有望为卵巢癌患者的诊疗提供新的思路。尽管目前的研究已经开始探索影像组学特征在评估卵巢癌转移灶可切除性方面的潜力,但这一领域仍然处于早期发展阶段。随着对卵巢癌转移灶传播路径以及其与基因突变、分子亚型之间关联的深入认识,结合多组学特征将有望进一步提升对卵巢癌转移灶可切除性的评估能力。未来的研究需要整合多模态成像数据、临床病理信息和分子生物学标志物,构建出更为精确的预测模型。此外,机器学习和深度学习算法的持续发展,也为提高这些预测模型的准确性和临床实用性提供坚实的基础,有助于辅助临床为卵巢癌患者制定更个性化的治疗方案,推动精准医疗的实现。

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