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• 临床研究 •

# 急性化脓性骨髓炎患者病原菌分布及 早期 MRI 诊断价值分析\*

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**【摘要】** 目的 分析急性化脓性骨髓炎患者病原菌分布特点及早期 MRI 诊断价值。方法 回顾性分析本院脊柱骨科接诊的 92 例急性化脓性骨髓炎患者及 60 例同期体检健康者的临床资料。采集患者窦道分泌物进行细菌培养及病原菌鉴定。培养分离的金黄色葡萄球菌检测后分为 MRSA 与 MSSA 两组,对比两组菌株的耐药性。采集急性化脓性骨髓炎患者及健康对照组的静脉血,检测血清 CRP、ESR 水平。对急性化脓性骨髓炎患者早期进行 X 线、CT、MRI 检查,对比三种检查方式的诊断准确率、软组织病变率、骨髓异常率,分析 MRI 在急性化脓性骨髓炎早期的诊断价值。结果 92 例急性化脓性骨髓炎患者共培养出 104 株病原菌,81 例患者为单一病原菌感染。65 株为革兰阳性菌,以金黄色葡萄球菌为主。39 株为革兰阴性菌,以铜绿假单胞菌为主。43 株金黄色葡萄球菌中共检出 14 株 MRSA,检出率为 32.56%。MRSA 对青霉素、红霉素、阿奇霉素、克林霉素的耐药率均高于 MSSA,其中对阿奇霉素的耐药率差异有统计学意义( $P < 0.05$ )。两组菌株对环丙沙星、左氧氟沙星、莫西沙星、庆大霉素、四环素、复方新诺明的耐药率均低于 40%,其中对环丙沙星、莫西沙星的耐药率差异有统计学意义( $P < 0.05$ ),未发现对万古霉素、利奈唑胺的耐药株。急性化脓性骨髓炎患者血清 CRP、ESR 水平均显著高于健康对照组( $t = 28.107, 40.574; P < 0.05$ )。X 线共检出 47 例,45 例患者于患病 12 d 内可观察到局部软组织肿胀,17 例患者于发病两周后可观察到局限性骨质疏松,诊断准确率为 51.09%(47/92),软组织病变检出率为 48.91%(45/92),骨髓异常检出率为 18.48%(17/92)。CT 共检出 58 例,55 例患者于患病 7 d 内可观察到局部软组织肿胀,29 例患者于发病 7~10 d 内可观察到局限性骨质疏松、异常,患病 10 d 后可见明显骨皮质损失及骨膜反应表现,诊断准确率为 63.04%(58/92),软组织病变检出率为 59.78%(55/92),骨髓异常检出率为 31.52%(29/92)。MRI 共检出 90 例,85 例患者于 2 d 内即可观察到软组织界限模糊,83 例患者于 3 d 内即可观察到骨髓异常信号,诊断准确率为 97.83%(90/92),软组织病变检出率为 92.39%(85/92),骨髓异常检出率为 90.22%(83/92)。X 线、CT、MRI 的诊断准确率、软组织病变检出率、骨髓异常检出率差异有统计学意义( $P < 0.05$ )。结论 急性化脓性骨髓炎患者病原菌主要为金黄色葡萄球菌,MRSA 对抗菌药物的耐药率普遍高于 MSSA。患者血清 CRP、ESR 水平显著升高,临床可作为辅助诊断指标。MRI 对比 X 线、CT 优势明显,对急性化脓性骨髓炎患者病早期诊断具有重要价值。

**【关键词】** 急性化脓性骨髓炎;病原菌;耐甲氧西林金黄色葡萄球菌;磁共振成像

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## Distribution of pathogenic bacteria in patients with acute suppurative Osteomyelitis and the value of early MRI diagnosis

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**【Abstract】** **Objective** To analyze the distribution of pathogenic bacteria in patients with acute suppurative Osteomyelitis and the value of early MRI diagnosis. **Methods** The clinical data of 92 cases of acute suppurative osteomyelitis and 60 cases of healthy people in the same period who were admitted to the Department of Spine and Orthopaedics in our hospital were analyzed retrospectively. The patient sinus secretions were collected for bacterial culture and pathogen identification. The *Staphylococcus aureus* isolated in this study were divided into MRSA and MSSA groups after detection, and the drug resistance of the two groups was compared. The venous blood of patients with acute suppurative Osteomyelitis and healthy control group was collected to detect the serum CRP and ESR levels. X-ray, CT and MRI were performed in

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the early stage of acute suppurative Osteomyelitis. The diagnostic accuracy, soft tissue lesion rate and bone marrow abnormality rate of the three examination methods were compared, and the diagnostic value of MRI in the early stage of acute suppurative Osteomyelitis was analyzed. **Results** A total of 104 strains of pathogenic bacteria were cultured from 92 patients with acute suppurative Osteomyelitis, and 81 patients were infected by a single pathogen. 65 strains were Gram positive bacteria, mainly *Staphylococcus aureus*. 39 strains were Gram negative bacteria, mainly *Pseudomonas aeruginosa*. A total of 14 MRSA strains were detected from 43 *S. aureus* strains, with a detection rate of 32.56%. The drug resistance rate of MRSA to penicillin, Erythromycin, Azithromycin and Clindamycin was higher than that of MSSA, and the drug resistance rate to Azithromycin was significantly different between the two groups ( $P < 0.05$ ). The drug resistance rates of the two groups of strains to Ciprofloxacin, Levofloxacin, Moxifloxacin, Gentamicin, tetracycline, and Trimethoprim/sulfamethoxazole were all lower than 40%, of which the drug resistance rates to Ciprofloxacin and Moxifloxacin were statistically different ( $P < 0.05$ ), there were no strains resistant to Vancomycin and Linezolid. The serum CRP and ESR levels of patients with acute suppurative Osteomyelitis were significantly higher than those of healthy controls ( $t = 28.107, 40.574; P < 0.05$ ). A total of 47 cases were detected by X-ray examination. Local soft tissue swelling was observed in 45 patients within 12 days of onset, and localized osteoporosis was observed in 17 patients two weeks after onset. The diagnostic accuracy was 51.09% (47/92), the detection rate of soft tissue lesions was 48.91% (45/92), and the detection rate of bone marrow abnormalities was 18.48% (17/92). A total of 58 cases were detected by CT. Local soft tissue swelling was observed in 55 patients within 7 days of onset, while localized osteoporosis and abnormalities were observed in 29 patients within 7-10 days of onset. After 10 days of onset, significant cortical loss and periosteal reactions were observed. The diagnostic accuracy was 63.04% (58/92), the detection rate of soft tissue lesions was 59.78% (55/92), and the detection rate of bone marrow abnormalities was 31.52% (29/92). A total of 90 cases were detected by MRI, of which 85 patients could observe blurred soft tissue boundaries within 2 days, and 83 patients could observe abnormal bone marrow signals within 3 days. The diagnostic accuracy was 97.83% (90/92), the detection rate of soft tissue lesions was 92.39% (85/92), and the detection rate of bone marrow abnormalities was 90.22% (83/92). The diagnostic accuracy, detection rate of soft tissue lesions, and detection rate of bone marrow abnormalities of X-ray, CT, and MRI showed statistically significant differences ( $P < 0.05$ ). **Conclusion** The pathogenic bacteria of acute suppurative Osteomyelitis patients were mainly *S. aureus*, and the drug resistance rate of MRSA was generally higher than that of MSSA. The serum CRP and ESR levels of patients were significantly elevated, which can be used as auxiliary diagnostic indicators in clinical practice. MRI has obvious advantages over X-ray and CT, which is of great value in early diagnosis of acute suppurative Osteomyelitis.

**【Key words】** acute suppurative osteomyelitis; pathogenic bacteria; methicillin-resistant *Staphylococcus aureus*; magnetic resonance imaging

急性化脓性骨髓炎(acute suppurative osteomyelitis, ASO)主要是由细菌侵入骨髓而引起的一种感染性疾病,发病部位多位于肱骨、股骨、胫骨等,是骨科常见疾病之一<sup>[1]</sup>。相关研究显示,急性化脓性骨髓炎主要由革兰阳性菌经血源性、创伤性途径引发感染,金黄色葡萄球菌是主要致病菌<sup>[2]</sup>。耐甲氧西林金黄色葡萄球菌(methicillin-resistant *Staphylococcus aureus*, MRSA)于1961年首次被发现,已成为全球范围内主要的致病菌,2019年CHINET中国细菌耐药监测的结果显示金黄色葡萄球菌中MRSA检出率为31.4%,耐药率及多重耐药率较高,给临床诊疗工作带来重大挑战<sup>[3]</sup>。如果患者耽误治疗则可转化为慢性骨髓炎,给患者带来严重的身心损害,如果可以在早期得到正确的诊断与及时治疗,可以降低病情恶化的几率,寻找早期诊断指标,对改善患者预后具有积极临床意义<sup>[4]</sup>。影像学检查作为急性化脓性骨髓炎早期诊断的常用手段,针对疑似病例应行X线检查、CT或磁共振

成像(Magnetic Resonance Imaging, MRI)检查。MRI对软组织、骨髓病变有较好的显示效果,当患者骨髓腔发生炎性浸润后,炎性细胞含水量丰富, T1WI和T2WI序列上会出现异常信号变化, STIR序列则通过短T1抑制脂肪组织信号,可对髓腔内水肿进行清晰的显示,可获得更为丰富细致的影像学资料,临床诊断准确率优于X线检查、CT<sup>[5]</sup>。

本次研究回顾性分析92例急性化脓性骨髓炎患者的临床资料,探讨本地区急性化脓性骨髓炎患者病原菌分布特点及早期MRI诊断价值,结果报告现报道如下。

## 材料与方法

### 1 研究对象

回顾性分析本院脊柱骨科接诊的92例急性化脓性骨髓炎患者的临床资料。其中,男性患者50例,女性42例,年龄20~62岁。患病部位:胫腓骨32例,股

骨 27 例,踝骨 18 例,膝关节 14 例,骨盆 1 例。纳入标准:①结合患者临床症状、骨髓穿刺结果及细菌培养结果确诊为急性化脓性骨髓炎;②接受 X 线、CT、MRI 检查,影像学资料完整。排除标准:①非急性化脓性骨髓炎;②合并血液系统及其他部位感染者;③合并恶性肿瘤、肝肾、心脑血管疾病者;④合并精神方面疾病者。随机选取 60 例同期体检健康者为健康对照组。

本次研究已通过本院伦理协会审核,所有患者均已签署知情通知书。

## 2 病原菌鉴定

采集患者窦道分泌物进行细菌培养及病原菌鉴定。于严格无菌条件下,采用 3% 碘伏对患者窦道周围皮肤进行清洁消毒,使用一次性棉拭子插入窦道深部旋转 2~3 圈采集深部分泌物,将棉拭子置入无菌试管内,立即送检。将分泌物标本接种于血琼脂培养基上,培养 24~48h,挑取饱满菌落,采用全自动微生物分析仪(法国梅里埃)进行病原菌鉴定。

## 3 MRSA 与 MSSA 耐药性对比

将本次研究中培养分离的金黄色葡萄球菌纯菌落加入生理盐水制备成混悬液,采用 K-B 纸片扩散法进行药敏试验,30  $\mu$ g 头孢西丁纸片抑菌环直径 $\leq$ 21 mm 则可初步判定为 MRSA 菌株,采用 PCR 对初筛后的 MRSA 菌株扩增 *mecA* 基因,检出特异性亮带者,即为 MRSA。采用 K-B 纸片扩散法和最低抑菌浓度进行药敏试验,对比 MRSA 与 MSSA 的耐药性,药敏试验结果依据 CLSI 2020 版进行判读。

## 4 血清 CRP、ESR 水平检测

健康对照组患者于体检时,急性化脓性骨髓炎患者于入院第二天未进行治疗前,空腹状态下,采集静脉血 3~5 mL,静置 15 min 后,3 000 r/min(离心半径 8.7 cm)离心 10 min,留存上清液。采用酶联免疫吸附法检测血清 CRP 水平,采用魏氏法检测血清 ESR 水平。

## 5 X 线、CT、MRI 检查

由两名以上经验丰富影像学医师对 X 线、CT、MRI 三种不同方法扫描获取的影像学资料进行阅片、分析、判断扫描结果,观察局部软组织肿胀、脓肿、骨质增生硬化、骨膜反应、骨膜破坏、骨髓异常信号等,对比三种检查方法的诊断准确率、软组织病变率、骨髓异常率。当两者判定意见存在较大分歧时,引入第三人进行辅助判断。

X 线检查:嘱患者采仰卧位,采用 Philips digital diagnost TH 数字化 X 线摄影系统(德国西门子),对患者患病部位及邻近组织进行检查,全自动自动曝光,进行常规正位片或正、侧位拍片,填写相关检测项目及参数。

CT 扫描:嘱患者采仰卧位,采用 Lightspeed 128 层螺旋 CT 扫描仪(美国通用公司)进行检查,管电压 120 kv,管电流 200 mAs,层厚及层间距设置为 2.5~5 mm 之间,螺距 1,矩阵 512 $\times$ 512,进行常规平扫后,将数据传入工作站,进行扫描图像重建。

MRI 扫描:嘱患者采仰卧位,除去所有金属类物品、手机、磁卡等,采用 1.5T 超导型磁共振成像系统(德国西门子)及体线圈、Synspin 脊柱线圈及膝关节专用线圈对患者进行横轴位、矢状位、冠状位扫描,采集图像。扫描序列及参数:自动回波 SET1WI,重复时间=450~680 ms,回波时间=11 ms,层厚 3~5 mm,视野 230 mm $\times$ 230 mm,矩阵 230 $\times$ 256;快速自旋回波 FSET2WI,重复时间=2400 ms,回波时间=114 ms,层厚 3~5 mm,视野 280 mm $\times$ 280 mm,矩阵 256 $\times$ 320;短时反转恢复序列 STIR,重复时间=4000~4500 ms,回波时间=70 ms,反转时间=130~150 ms,层厚 3~5 mm,视野 230 mm $\times$ 230 mm,矩阵 230 $\times$ 256;多梯度回波序列 T2WI,重复时间=905 ms,回波时间=26 ms,层厚 3~5 mm,视野 180 mm $\times$ 180 mm,矩阵 256 $\times$ 256。

## 6 统计分析

采用 SPSS 26.0 对本次研究数据进行统计分析,组间比较采用 *t* 或  $\chi^2$  进行检验, $P < 0.05$  为组间差异有统计学意义。

# 结 果

## 1 病原菌分布特点

92 例急性化脓性骨髓炎患者共培养出 104 株病原菌,其中 81 例患者为单一病原菌感染,10 例患者为两种病原菌混合感染,1 例患者为三种病原菌混合感染。104 株病原菌中,62.50% 为革兰阳性菌(65/104),37.50% 为革兰阴性菌(39/104)。革兰阳性菌中,66.15% 为金黄色葡萄球菌(43/65),16.92% 为表皮葡萄球菌(11/65),7.69% 为凝固酶阴性葡萄球菌(5/65),6.15% 为产气荚膜杆菌(4/65),3.08% 为粪肠球菌(2/65)。革兰阴性菌中,43.59% 为铜绿假单胞菌(17/39),23.08% 为肺炎克雷伯菌(9/39),12.82% 为阴沟肠杆菌(5/39),10.26% 为鲍曼不动杆菌(4/39),7.69% 为大肠埃希菌(3/39),2.56% 为产气肠杆菌(1/39)。

## 2 MRSA 与 MSSA 对抗菌药物的药敏试验结果比较

43 株金黄色葡萄球菌中共检出 14 株 MRSA,29 株 MSSA,MRSA 检出率为 32.56%(14/43)。MRSA 与 MSSA 对青霉素、红霉素、阿奇霉素、克林霉素的耐药率均高于 50%,其中对阿奇霉素的耐药率差异有统计学意义( $P < 0.05$ )。对环丙沙星、左氧氟沙星、莫西

沙星、庆大霉素、四环素、复方新诺明的耐药率均低于40%，其中对环丙沙星、莫西沙星的耐药率差异有统计学意义( $P < 0.05$ )。两组菌株均未发现对万古霉素、利奈唑胺的耐药株。见表1。

表1 MRSA与MSSA对抗菌药物的药敏试验结果比较  
Table 1 Comparison of antimicrobial susceptibility test results between MRSA and MSSA

抗菌药物 Antibiotics	MRSA(n=14)		MSSA(n=29)		$\chi^2$	P
	耐药株数 No.	耐药率(%) Drug resistance rate	耐药株数 No.	耐药率(%) Drug resistance rate		
青霉素	14	100.00	28	96.55	0.494	0.482
红霉素	13	92.86	20	68.97	3.020	0.082
阿奇霉素	13	92.86	17	58.62	5.247	0.022
克林霉素	12	85.71	22	75.86	0.554	0.457
环丙沙星	5	35.71	3	10.34	4.013	0.045
左氧氟沙星	4	28.57	3	10.34	2.301	0.129
莫西沙星	4	28.57	1	3.45	5.799	0.016
万古霉素	0	0.00	0	0.00	*	*
庆大霉素	4	28.57	7	24.14	0.097	0.755
四环素	5	35.71	4	13.79	2.742	0.098
复方新诺明	4	28.57	3	10.34	2.301	0.129
利奈唑胺	0	0	0	0	*	*

注：“\*”表示未进行统计学分析。

### 3 急性化脓性骨髓炎患者血清CRP、ESR水平比较

急性化脓性骨髓炎患者血清CRP水平为(36.89 ± 9.56)mg/L,健康对照组血清CRP水平为(7.54 ± 2.40)mg/L,差异有统计学意义( $t = 28.107, P < 0.05$ )。急性化脓性骨髓炎患者血清ESR水平为(52.84 ± 10.95)mm/h,健康对照组血清ESR水平为(5.90 ± 1.43)mm/h,差异有统计学意义( $t = 40.574, P < 0.05$ )。

### 4 MRI在急性化脓性骨髓炎早期诊断中的应用价值分析

X线共检出47例,检查结果显示:45例患者于患病12d内可观察到局部软组织肿胀,肌肉骨髓间距增大,皮下脂肪层明显增厚,17例患者于发病两周后可观察到局限性骨质疏松、异常,未观察到患者出现骨皮质损伤。CT共检出58例,检查结果显示:55例患者于患病7d内可观察到局部软组织肿胀,29例患者于发病7~10d内可观察到局限性骨质疏松、异常,患病10d后可见明显骨皮质损伤及骨膜反应表现。MRI共检出90例,检查结果显示:85例患者于2d内即可观察到软组织界限模糊,T2W1序列上呈现信号略升高,83例患者于3d内即可观察到骨髓异常信号,T1W1信号微缩减,T2W1信号略提升,随患者病程延长,表现越明显。X线、CT、MRI的诊断准确率、软组织病变检出率、骨髓异常检出率,对比差异具有统计学意义( $P < 0.05$ )。见表2。

表2 MRI在急性化脓性骨髓炎早期诊断中的应用价值分析  
Table 2 The value of MRI in the early diagnosis of acute suppurative Osteomyelitis

方法 Method	软组织病变检出率 Detection rate of soft tissue lesions		骨髓异常检出率 Detection rate of bone marrow abnormalities		诊断准确率 Diagnostic accuracy	
	病例数 No.	检出率 Rate(%)	病例数 No.	检出率 Rate(%)	病例数 No.	检出率 Rate(%)
X线	45	48.91	17	18.48	47	51.09
CT	55	59.78	29	31.52	58	63.04
MRI	85	92.39	83	90.22	90	97.83
$\chi^2$	42.625		107.937		52.317	
P	0.000		0.000		0.000	

## 讨论

急性化脓性骨髓炎主要由化脓性细菌通过血源性、外伤性、骨骼附近软组织感染扩散三种途径侵入骨髓,临床表现为化脓性渗出和坏死,起病急骤且病情进展快,可引起骨质增生、破坏甚至坏死,严重可引发脓毒败血症,后期可出现肢体短缩、延长、成角等后遗症[6]。化脓性骨髓炎可涉及骨髓、骨皮质、骨膜和周围的软组织,常继发于骨科创伤后,是骨科医生常见棘手问题之一,金黄色葡萄球菌、溶血性链球菌、铜绿假单胞菌等是骨髓炎最常见的几种致病菌[7-8]。本研究共培养出104株病原菌,62.50%为革兰阳性菌,主要为金黄色葡萄球菌,37.50%为革兰阴性菌,主要为铜绿假单胞菌。陈志军等[9]研究显示,金黄色葡萄球菌和铜绿假单胞菌依然是化脓性骨髓炎的主要致病菌,与本次研究结果一致。

金黄色葡萄球菌是临床主要致病菌之一,机体感染后常积聚成团,在细小动脉内形成栓塞,阻塞血管的末端,导致局部组织坏死,为细菌的生长、繁殖提供有利条件[10]。本次研究培养分离出43株金黄色葡萄球菌,共检出14株MRSA,检出率为32.56%。两组菌株对青霉素、红霉素、阿奇霉素、克林霉素的耐药率较高,对环丙沙星、左氧氟沙星、莫西沙星、庆大霉素、四环素、复方新诺明的耐药率较低,其中对阿奇霉素、环丙沙星、莫西沙星的耐药率差异显著,未发现对万古霉素、利奈唑胺的耐药株。MRSA受*mecA*基因介导,可产生独特的青霉素结合蛋白(PBPP2a),对β内酰胺类和头孢类抗菌药物耐药,对氨基糖苷类、大环内酯类、氟喹诺酮类、四环素类及利福平的耐药率高于MSSA,成为临床治疗较为棘手的问题[11]。

化脓性骨髓炎属于炎性反应疾病之一,机体可释放大量炎症介质、细胞因子,可导致机体免疫紊乱、炎症反应失控,患者血清指标会出现一定变化,通过检测能够灵敏反映患者病情变化的血清指标水平,对患者早期诊断及后期疗效判断具有重要意义[12]。本次研究中,急性化脓性骨髓炎患者血清CRP、ESR水平显

著高于健康对照组,与何冬等<sup>[13]</sup>研究结果一致。

本次研究中,X线检查诊断准确率为51.09%,软组织病变检出率为48.91%,骨髓异常检出率为18.48%,CT诊断准确率为63.04%,软组织病变检出率为59.78%,骨髓异常检出率为31.52%。MRI诊断准确率为97.83%,软组织病变检出率为92.39%,骨髓异常检出率为90.22%。三种检查方式的诊断准确率、软组织病变检出率、骨髓异常检出率差异明显。与刘峰<sup>[14]</sup>研究结果基本一致。MRI检查具有较高分辨率,可通过多参数、多方位成像,对患者病变情况进行全面观察,主要包括STIR及常规SE序列,对横断位、冠状位及矢状位进行扫描,可有效显示骨髓及软组织病变,有利于疾病早期诊断,临床应用价值高于其他检查方式<sup>[15]</sup>。

综上所述,急性化脓性骨髓炎患者病原菌主要为革兰阳性菌,以金黄色葡萄球菌为主,MRSA检出率为32.56%,对临床常见抗菌药物的耐药率高于MSSA菌株。血清CRP、ESR水平显著升高,MRI的诊断准确率、软组织病变率、骨髓异常率高于其他检查方式。

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