

• 临床研究 •

# 急性心肌梗死并发肺部感染患者的临床特点和病原菌特征及危险因素分析

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**摘要:** **目的** 分析急性心肌梗死(AMI)并发肺部感染患者的临床特点、病原菌特征及危险因素, 为该类患者的治疗提供参考。**方法** 选择 2019 年 1 月至 2021 年 1 月海安市人民医院收治的 96 例 AMI 患者作为研究对象, 并根据患者在治疗过程中是否并发肺部感染将其分为感染组(40 例)和非感染组(56 例)。采集患者痰液标本并对感染病原菌进行鉴定, 同时观察肺部感染患者的临床特点。采用多因素 Logistic 回归分析探讨 AMI 患者并发肺部感染的危险因素。**结果** 96 例 AMI 患者中存在 40 例肺部感染, 共检出病原菌 22 株, 其中革兰阴性菌 14 株(占 63.64%), 革兰阳性 6 株(占 27.27%), 真菌 2 株(占 9.09%)。与非感染组比较, 感染组患者血红蛋白、白蛋白、总蛋白水平较低, 降钙素原、超敏 C 反应蛋白、肿瘤坏死因子- $\alpha$  水平较高(均  $P < 0.05$ )。单因素分析显示, AMI 患者并发肺部感染与年龄、卧床时间、有无慢性阻塞性肺疾病、有无侵入性操作存在显著关联(均  $P < 0.05$ )。多因素 Logistic 回归分析显示, 年龄  $\geq 60$  岁( $OR = 3.71$ , 95%CI: 1.62~8.49)、卧床时间  $\geq 2$  周( $OR = 3.42$ , 95%CI: 2.12~5.54)、慢性阻塞性肺疾病( $OR = 2.68$ , 95%CI: 2.19~3.29)、侵入性操作( $OR = 3.40$ , 95%CI: 2.69~4.30)及低蛋白血症( $OR = 1.37$ , 95%CI: 1.09~1.74)均为 AMI 患者并发肺部感染的相关因素(均  $P < 0.05$ )。**结论** AMI 患者并发肺部感染的病原菌以革兰阴性菌为主, 其次为革兰阳性菌; 年龄、卧床时间、慢性阻塞性肺疾病、侵入性操作及低蛋白血症均为 AMI 患者并发肺部感染的独立危险因素。

**关键词:** 急性心肌梗死; 肺部感染; 病原菌特征; 高危因素

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## Clinical characteristics, pathogen characteristics and high risk factors of pulmonary infection in patients with acute myocardial infarction

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**Abstract:** **Objective** To explore the clinical characteristics, pathogen characteristics and high risk factors of pulmonary infection in patients with acute myocardial infarction(AMI), providing a reference for the treatment. **Methods** A total of 96 patients with AMI treated in our hospital from January 2019 to January 2021 were selected as the subjects. According to whether the patients were complicated with pulmonary infection during treatment, they were divided into infection group (40 cases) or non infection group (56 cases). The sputum samples of patients were collected, the pathogens of infection were identified and analyzed, and the clinical characteristics of patients with pulmonary infection were observed. The related factors of pulmonary infection were analyzed using multivariate logistic regression. **Results** There were 40 cases of pulmonary infection in the 96 patients with AMI. A total of 22 strains of pathogenic bacteria were detected, including 14 strains of Gram-negative bacteria (63.64%), 6 strains of Gram-positive bacteria (27.27%) and 2 strains of fungi (9.09%). Compared with the non-infection group, the levels of hemoglobin, albumin and total protein in the infection group were significantly lower, and the levels of procalcitonin, high-sensitivity C-reactive protein, tumor necrosis factor alpha were higher(all  $P < 0.05$ ). Univariate analysis showed that pulmonary infection in patients with AMI was significantly related to age, bed time, chronic obstructive pulmonary disease and invasive procedure (all  $P < 0.05$ ). By multivariate logistic regres-

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sion analysis, age  $\geq 60$  years ( $OR = 3.71$ , 95%CI: 1.62 - 8.49), bed time  $\geq 2$  weeks ( $OR = 3.42$ , 95%CI: 2.12 - 5.54), chronic obstructive pulmonary disease ( $OR = 2.68$ , 95%CI: 2.19 - 3.29), invasive operation ( $OR = 3.40$ , 95%CI: 2.69 - 4.30) and hypoproteinemia ( $OR = 1.37$ , 95%CI: 1.09 - 1.74) were independent risk factors for pulmonary infection in patients with AMI (all  $P < 0.05$ ). **Conclusion** The pathogens of pulmonary infection in patients with AMI were mainly Gram-negative bacteria, followed by Gram-positive bacteria. Age, bed time, chronic obstructive pulmonary disease, invasive operation and hypoproteinemia were independent risk factors for pulmonary infection in patients with AMI.

**Keywords:** Acute myocardial infarction; Pulmonary infection; Pathogen characteristics; High risk factors

急性心肌梗死(AMI)是我国常见的并具有较高发病率、病死率的心血管疾病,一旦发病容易导致患者出现休克、心律失常及心力衰竭,已严重危害人们的生命健康<sup>[1-2]</sup>。肺部感染是 AMI 治疗过程中常见的并发症,一旦出现不仅会加重疾病进展,同时增加 AMI 治疗难度,对患者的预后及生命安全均有着严重影响<sup>[3-4]</sup>。相关文献显示,AMI 患者肺部感染发生率约 12.9%<sup>[5]</sup>。目前虽通过应用抗生素可有效达到抗感染的效果,但长时间应用容易产生耐药性,进而影响治疗效果。因此,早期预防和诊断肺部感染并给予合适的治疗对改善 AMI 患者预后具有重要作用。本研究拟分析 AMI 患者并发肺部感染的临床特点、病原菌特征及高危因素,为治疗与预防提供指导。

## 1 对象与方法

**1.1 一般资料** 选取海安市人民医院 2019 年 1 月至 2021 年 1 月收治的 96 例 AMI 患者作为本研究对象,其中男性 56 例,女性 40 例;年龄 40~78 岁,平均年龄( $52.36 \pm 3.25$ )岁。根据患者在治疗过程中是否并发肺部感染分为感染组(40 例)和非感染组(56 例)。纳入标准:(1)均已符合《急性心肌梗死诊断和治疗指南》<sup>[6]</sup>中关于 AMI 的诊断标准;(2)患者及家属签署知情同意书;(3)参照《医院感染诊断标准(试行)》<sup>[7]</sup>中关于肺部感染的标准。排除标准:(1)合并免疫系统疾病、肝肾脏疾病、血液系统疾病及恶性肿瘤者;(2)合并其他炎症性疾病;(3)近 3 个月内使用过抗菌药物者;(4)存在精神病史者;(5)不愿参与本次研究或中途放弃治疗以及死亡者;(6)临床资料不完整者。本次研究已获得海安市人民医院医学伦理委员会批准。

### 1.2 方法

**1.2.1 病原菌培养与鉴定** 感染组患者清晨用清水漱口 3 次后,用力咳出呼吸道深部痰液或采用一次性无菌吸痰器吸取出痰液至无菌广口瓶内,痰标本不少于 1 mL,随后将标本送至检验科进行检查。将痰液标本置于肉汤琼脂平板上,并放置于 37 °C 恒温培养箱中进行培养,时间 18~24 h,若培养结果提示病原菌生长可直接诊断肺部感染,并采用全自动

细菌鉴定仪(法国生物梅里埃公司生产, VITEK2-COMPACTGN13 型)检测菌株的种类,其操作和判断结果均按照美国临床实验室标准化协会(CLSI)标准<sup>[8]</sup>进行。

**1.2.2 临床基本资料及血清相关指标检测** 入院后抽取本研究患者静脉血 5 mL,常规离心后取上清液,采用博科 BK-1200 型全自动电生化分析仪(山东博科生物产业有限公司生产)检测血清血红蛋白、白蛋白、总蛋白、血钠、血钾、肌酐、甲状旁腺激素水平;采用酶联免疫吸附法检测降钙素原(PCT)、超敏 C 反应蛋白(hs-CRP)及肿瘤坏死因子  $\alpha$ (TNF- $\alpha$ )水平(试剂盒均购自武汉赛培生物科技有限公司),并进行比较分析。收集患者性别、年龄、卧床时间、吸烟史、慢性阻塞性肺疾病史、高血压史、侵入性操作等临床资料。

**1.3 统计学方法** 采用 IBM 公司 SPSS 24.0 软件进行数据分析。符合正态分布的计量资料采用均数 $\pm$ 标准差( $\bar{x} \pm s$ )表示,计量资料组间比较采用两独立样本  $t$  检验。计数资料以百分比(%)表示,组间比较采用四格表  $\chi^2$  检验。采用多因素 Logistic 回归分析探讨 AMI 患者并发肺部感染的相关因素。双侧检验水准  $\alpha = 0.05$ 。

## 2 结果

**2.1 AMI 患者并发肺部感染的病原菌分布** 40 例肺部感染患者共检出病原菌 22 株,其中革兰阴性菌 14 株,占 63.64%;革兰阳性 6 株,占 27.27%;真菌 2 株,占 9.09%。见表 1。

**2.2 两组患者血清指标水平比较** 两组患者血钠、血钾、肌酐、甲状旁腺激素水平比较差异无统计学意义(均  $P > 0.05$ )。与非感染组比较,感染组患者血红蛋白、白蛋白、总蛋白水平更低, PCT、hs-CRP、TNF- $\alpha$  水平更高(均  $P < 0.05$ )。见表 2。

**2.3 AMI 患者并发肺部感染的单因素分析** 单因素分析显示,AMI 患者并发肺部感染与性别、吸烟史、高血压史无显著关系(均  $P > 0.05$ ),但与年龄、卧床时间、有无慢性阻塞性肺疾病、有无侵入性操作有显著关系(均  $P < 0.05$ )。见表 3。

表 1 40 例 AMI 并发肺部感染患者痰液病原菌分布

| 病原菌     | 株数 | 构成比(%) |
|---------|----|--------|
| 革兰阴性菌   | 14 | 63.64  |
| 肺炎克雷伯菌  | 6  | 27.27  |
| 铜绿假单胞菌  | 4  | 18.18  |
| 大肠埃希菌   | 2  | 9.09   |
| 鲍曼不动杆菌  | 1  | 4.55   |
| 阴沟肠杆菌   | 1  | 4.55   |
| 革兰阳性菌   | 6  | 27.27  |
| 金黄色葡萄球菌 | 3  | 13.64  |
| 表皮葡萄球菌  | 2  | 9.09   |
| 粪肠球菌    | 1  | 4.55   |
| 真菌      | 2  | 9.09   |
| 白色假丝酵母  | 1  | 4.55   |
| 曲霉菌属    | 1  | 4.55   |

表 2 两组患者血清指标水平比较

| 指标                 | 感染组<br>(n=40) | 未感染组<br>(n=56) | t 值    | P 值    |
|--------------------|---------------|----------------|--------|--------|
| PCT(ng/mL)         | 1.53±0.14     | 0.68±0.12      | 31.097 | <0.001 |
| hs-CRP(mg/L)       | 41.36±6.43    | 18.26±3.18     | 23.231 | <0.001 |
| TNF-α(μg/L)        | 6.93±0.89     | 3.32±0.42      | 26.535 | <0.001 |
| 血红蛋白(g/L)          | 67.63±10.02   | 94.24±11.42    | 13.421 | <0.001 |
| 白蛋白(g/L)           | 25.52±5.30    | 36.32±5.63     | 8.522  | <0.001 |
| 总蛋白(g/L)           | 50.35±8.44    | 65.77±7.35     | 10.443 | <0.001 |
| 血钾(mmol/L)         | 3.96±0.63     | 4.01±0.66      | 0.542  | 0.165  |
| 血钠(mmol/L)         | 135.63±6.32   | 135.12±6.20    | 0.324  | 0.422  |
| 肌酐(μmol/L)         | 96.63±15.63   | 96.22±15.50    | 0.152  | 0.765  |
| 甲状旁腺激素<br>(mmol/L) | 1.33±0.44     | 1.32±0.42      | 0.252  | 0.673  |

2.4 AMI 患者并发肺部感染的多因素 Logistic 回归分析

表 4 AMI 患者并发肺部感染危险因素的 Logistic 回归分析

| 自变量      | β     | SE    | Waldχ <sup>2</sup> 值 | P 值    | OR(95%CI)       |
|----------|-------|-------|----------------------|--------|-----------------|
| 年龄≥60 岁  | 1.312 | 0.422 | 16.424               | <0.001 | 3.71(1.62~8.49) |
| 卧床时间≥2 周 | 1.231 | 0.245 | 12.632               | <0.001 | 3.42(2.12~5.54) |
| 慢性阻塞性肺疾病 | 0.987 | 0.104 | 14.523               | <0.001 | 2.68(2.19~3.29) |
| 侵入性操作    | 1.224 | 0.314 | 18.540               | <0.001 | 3.40(2.69~4.30) |
| 低蛋白血症    | 0.321 | 0.120 | 13.635               | <0.001 | 1.37(1.09~1.74) |

3 讨 论

3.1 AMI 并发肺部感染患者的预后 AMI 是一种威胁人类健康的急性缺血性心脏病,近年来随着我国人口饮食结构和生活方式的改变,其发病率、病死率也在逐年攀升<sup>[9]</sup>。该病病情危重,发展迅速,且致残率、致死率均较高,而一经确诊需要立即住院给予相关治疗。近年来我国 AMI 的药物和介入治疗

表 3 AMI 患者并发肺部感染的单因素分析

| 因素       | 总例数<br>(n=96) | 感染组<br>(n=40) | 未感染组<br>(n=56) | χ <sup>2</sup> 值 | P 值    |
|----------|---------------|---------------|----------------|------------------|--------|
| 年龄(岁)    |               |               |                | 16.648           | <0.001 |
| ≥60      | 46            | 28            | 18             |                  |        |
| <60      | 50            | 12            | 38             |                  |        |
| 性别       |               |               |                | 0.456            | 0.341  |
| 男        | 56            | 26            | 30             |                  |        |
| 女        | 40            | 16            | 23             |                  |        |
| 卧床时间(周)  |               |               |                | 13.422           | <0.001 |
| ≥2       | 52            | 30            | 22             |                  |        |
| <2       | 44            | 10            | 34             |                  |        |
| 吸烟史      |               |               |                | 0.765            | 0.109  |
| 有        | 42            | 20            | 22             |                  |        |
| 无        | 54            | 20            | 24             |                  |        |
| 慢性阻塞性肺疾病 |               |               |                | 10.321           | <0.001 |
| 有        | 47            | 26            | 21             |                  |        |
| 无        | 52            | 14            | 35             |                  |        |
| 侵入性操作    |               |               |                | 18.425           | <0.001 |
| 有        | 48            | 28            | 20             |                  |        |
| 无        | 51            | 13            | 36             |                  |        |
| 高血压史     |               |               |                | 0.152            | 0.889  |
| 有        | 43            | 19            | 24             |                  |        |
| 无        | 53            | 21            | 32             |                  |        |

以 AMI 患者是否并发肺部感染为因变量(是 = 1, 否 = 0),以年龄、卧床时间、有无慢性阻塞性肺疾病、有无侵入性操作、低蛋白血症为自变量,回归分析显示,年龄≥60 岁、卧床时间≥2 周、慢性阻塞性肺疾病、侵入性操作及低蛋白血症均为影响 AMI 患者并发肺部感染的危险因素(均 P<0.05)。见表 4。

手段不断进步,但仍有部分患者在治疗过程中发生肺部感染,进而加重患者病情恶化程度,甚至死亡,严重影响患者的功能恢复和预后<sup>[10]</sup>。有研究表明,早发现早治疗是降低肺部感染患者病死率的有效手段<sup>[11]</sup>。近年来随着致病菌谱改变和抗生素滥用,临床对药物使用的准确性也提出了更高标准<sup>[12]</sup>。因此,重视肺部感染相关因素并在早期预防 AMI 合并肺部感染

的发生以及合理用药是目前临床研究的主要课题。

**3.2 AMI 并发肺部感染的病原菌特征** 肺部感染是指肺实质感染及下呼吸道的感染,其病原体主要为细菌、真菌、支原体和病毒<sup>[13-14]</sup>。本研究结果显示,40 例 AMI 并发肺部感染患者中共检出病原菌 22 株,其中革兰阴性菌 14 株(占 63.64%),革兰阳性菌 6 株(占 27.27%),真菌 2 株(占 9.09%),说明 AMI 并发肺部感染患者病原菌分布较广,但主要以革兰阴性菌为主。可能与抗生素广泛应用而导致的菌群失调有关。有研究报道显示,AMI 患者合并医院感染病原菌以革兰阴性菌为主,占分离菌株总数的 55.20%<sup>[15]</sup>。同时本研究结果显示,与非感染组比较,感染组患者血红蛋白、白蛋白、总蛋白水平更低,PCT、hs-CRP、TNF- $\alpha$  水平更高,说明该类患者血红蛋白、白蛋白、总蛋白水平均降低,同时提示肺部感染可导致 AMI 患者血清炎症因子水平升高,与叶寅寅等<sup>[16]</sup>研究结果相似。

**3.3 AMI 患者并发肺部感染的危险因素** 本研究单因素分析结果显示,AMI 患者并发肺部感染与年龄增大、卧床时间延长、慢性阻塞性肺疾病、侵入性操作存在显著相关性。同时多因素 Logistic 回归分析结果显示,年龄 $\geq 60$ 岁、卧床时间 $\geq 2$ 周、慢性阻塞性肺疾病、侵入性操作、低蛋白血症均为影响 AMI 患者并发肺部感染的危险因素。AMI 患者年龄越大越容易并发肺部感染,可能是由于老年人呼吸器官退化并且对病原微生物的清除能力下降、自然防御机能减弱,因此导致肺部感染的概率升高。卧床时间越长越容易导致 AMI 患者并发肺部感染,可能是由于长时间卧床降低了患者运动、呼吸、循环水平,进而导致身体免疫功能降低,因此在治疗过程中容易被病原菌入侵,引发肺部感染。慢性阻塞性肺疾病容易导致 AMI 患者并发肺部感染,可能是由于慢性阻塞性肺疾病患者气道内存在慢性炎症,因此更容易引发感染。侵入性操作能够增加患者肺部接触并感染病原菌的风险。低蛋白血症患者机体中淋巴细胞数目减少,免疫功能降低,导致机会性感染风险增加<sup>[17-20]</sup>。

综上所述,AMI 患者并发肺部感染的病原菌以革兰阴性菌为主,其次为革兰阳性菌;年龄、卧床时间、慢性阻塞性肺疾病、侵入性操作及低蛋白血症均为 AMI 患者并发肺部感染的独立危险因素。因此,临床可根据病原菌检出情况合理应用抗生素治疗,同时通过重点关注以上因素预防肺部感染发生。但本研究也存在一定的局限性,本研究为单中心研究,样本量相对较小,下一步将扩大研究单位与样

本量,同时对 AMI 发生肺部感染患者进行前瞻性研究。

## 参考文献

- [1] Zhong Q, Gao Y, Zheng X, et al. Geographic variation in process and outcomes of care for patients with acute myocardial infarction in China from 2001 to 2015[J]. JAMA Netw Open, 2020, 3(10): e2021182.
- [2] Teixeira T, Hafyane T, Jerosch-Herold M, et al. Myocardial partition coefficient of gadolinium: a pilot study in patients with acute myocarditis, chronic myocardial infarction, and in healthy volunteers[J]. Can J Cardiol, 2019, 35(1): 51-60.
- [3] Chakir M, ME Jamili, BoudharZ, et al. Simultaneous acute myocardial infarction, bilateral pulmonary embolism, and acute ischaemic cerebral stroke, a delayed complication in a patient with COVID-19 infection: case report[J]. Eur Heart J Case Rep, 2021, 5(6): ytab218.
- [4] Huaman MA, Kryscio RJ, Fichtenbaum CJ, et al. Tuberculosis and risk of acute myocardial infarction: a propensity score-matched analysis[J]. Epidemiol Infect, 2017, 145(7): 1363-1367.
- [5] 陈晓群,邵燕.急性心肌梗死患者住院期间发生肺部感染的危险因素分析[J].浙江临床医学,2018,20(3): 507-508.  
CHEN Xiao-qun, SHAO Yan. Analysis of risk factors for pulmonary infection during hospitalization in patients with acute myocardial infarction[J]. Zhejiang Clin Med, 2018, 20(3): 507-508. (in Chinese)
- [6] 华医学会心血管病学分会,中华心血管病杂志编辑委员会,《中国循环杂志》编辑委员会,等.急性心肌梗死诊断和治疗指南[J].中华心血管病杂志,2001,29(12): 710-725.
- [7] 中华人民共和国卫生部.医院感染诊断标准(试行)[J].中华医学杂志,2001,81(5): 314-320.
- [8] 王辉,史红.引进 CLSI 微生物检验标准促进实验室标准化进程[J].中华检验医学杂志,2010,33(6): 485-487.  
WANG Hui, SHI Hong. Introduction of CLSI microbiology standard will improve the standardization of Chinese laboratories[J]. Chin J Lab Med, 2010, 33(6): 485-487. (in Chinese)
- [9] Lin X, Green JC, Xian H, et al. Holiday and weekend effects on mortality for acute myocardial infarction in Shanxi, China: a cross-sectional study[J]. Int J Public Health, 2020, 65(6): 847-857.
- [10] 段玉彩,魏亚君,郭玲,等.急性心肌梗死合并肺部感染患者多耐药菌分布特征及心肌酶谱指标与炎症因子的关系分析[J].现代生物医学进展,2019,19(18): 141-145.  
DUAN Yu-cai, WEI Ya-jun, GUO Ling, et al. Distribution characteristics of multidrug-resistant bacteria in patients with acute myocardial infarction complicated with pulmonary infection and the relationship between myocardial enzymes and inflammatory factors[J]. Progr Mod Biomed, 2019, 19(18): 141-145. (in Chinese)
- [11] Case BC, Yerasi C, Forrestal BJ, et al. Comparison of characteristics and outcomes of patients with acute myocardial infarction with versus without coronavirus-19[J]. Am J Cardiol, 2021, 144: 8-12.
- [12] Richter MF, Drown BS, Riley AP, et al. Predictive compound accumulation rules yield a broad-spectrum antibiotic[J]. Nature, 2017, 545(7654): 299-304.
- [13] 李宝亮,苏华,李梦嘉,等.急性 ST 段抬高性心肌梗死并发肺部感染住院患者血 D-D 与 Fib 和 CRP 分析[J].中华医院感染学杂志,2020,30(4): 51-55.  
LI Bao-liang, SU Hua, LI Meng-jia, et al. Analysis of blood D-D, Fib and CRP in hospitalized patients with acute ST-segment elevation myocardial infarction complicated with pulmonary infection[J]. Chin J Nosocomiol, 2020, 30(4): 51-55. (in Chinese)

(下转第 1231 页)

- Physiol, 2019, 317(4): G484-G492.
- [15] Yamada N, Iwamoto C, Kano H, et al. Evaluation of purine utilization by *Lactobacillus gasseri* strains with potential to decrease the absorption of food-derived purines in the human intestine[J]. Nucleosides Nucleotides Nucleic Acids, 2016, 35(10/12): 670-676.
- [16] Vieira AT, Macia L, Galvão I, et al. A role for gut microbiota and the metabolite-sensing receptor GPR43 in a murine model of gout[J]. Arthritis Rheumatol, 2015, 67(6): 1646-1656.
- [17] Lin XY, Shao TJ, Wen XH, et al. Combined effects of MSU crystals injection and high fat-diet feeding on the establishment of a gout model in C57BL/6 mice[J]. Adv Rheumatol, 2020, 60(1): 52.
- [18] Xu XX, Li CH, Zhou P, et al. Uric acid transporters hiding in the intestine[J]. Pharm Biol, 2016, 54(12): 3151-3155.
- [19] Serrano JL, Figueiredo J, Almeida P, et al. From xanthine oxidase inhibition to *in vivo* hypouricemic effect: an integrated overview of *in vitro* and *in vivo* studies with focus on natural molecules and analogues[J]. Evid Based Complement Alternat Med, 2020, 2020: 9531725.
- [20] Lukkunaprasit T, Rattanasiri S, Turongkaravee S, et al. The association between genetic polymorphisms in ABCG2 and SLC2A9 and urate: an updated systematic review and meta-analysis[J]. BMC Med Genet, 2020, 21(1): 210.
- [21] Oshima S, Shiiya S, Nakamura Y. Combined supplementation with glycine and tryptophan reduces purine-induced serum uric acid elevation by accelerating urinary uric acid excretion: a randomized, single-blind, placebo-controlled, crossover study[J]. Nutrients, 2019, 11(11): 2562.
- [22] Starobova H, Nadar EI, Vetter I. The NLRP3 inflammasome: role and therapeutic potential in pain treatment[J]. Front Physiol, 2020, 11: 1016.
- [23] Joosten LA, Abdollahi-Roodsaz S, Dinarello CA, et al. Toll-like receptors and chronic inflammation in rheumatic diseases: new developments[J]. Nat Rev Rheumatol, 2016, 12(6): 344-357.
- [24] Guo Y, Li H, Liu Z, et al. Impaired intestinal barrier function in a mouse model of hyperuricemia[J]. Mol Med Rep, 2019, 20(4): 3292-3300.
- [25] Guo Y, Yu Y, Li H, et al. Inulin supplementation ameliorates hyperuricemia and modulates gut microbiota in uox-knockout mice[J]. Eur J Nutr, 2021, 60(4): 2217-2230.
- [26] Lv Q, Xu D, Zhang X, et al. Association of hyperuricemia with immune disorders and intestinal barrier dysfunction[J]. Front Physiol, 2020, 11: 524236.
- [27] Haslberger A, Terkeltaub R. Editorial: can GPR43 sensing of short-chain fatty acids unchain inflammasome-driven arthritis?[J]. Arthritis Rheumatol, 2015, 67(6): 1419-1423.
- [28] Cleophas MC, Crişan TO, Lemmers H, et al. Suppression of monosodium urate crystal-induced cytokine production by butyrate is mediated by the inhibition of class I histone deacetylases[J]. Ann Rheum Dis, 2016, 75(3): 593-600.
- [29] Batista MA, Nicoli JR, Martins Fdos S, et al. Pretreatment with citrulline improves gut barrier after intestinal obstruction in mice[J]. JPEN J Parenter Enteral Nutr, 2012, 36(1): 69-76.
- [30] Raspé C, Czeslick E, Weimann A, et al. Glutamine and alanine-induced differential expression of intracellular IL-6, IL-8, and TNF- $\alpha$  in LPS-stimulated monocytes in human whole-blood[J]. Cytokine, 2013, 62(1): 52-57.
- [31] Yang JH, Bhargava P, McCloskey D, et al. Antibiotic-induced changes to the host metabolic environment inhibit drug efficacy and alter immune function[J]. Cell Host Microbe, 2017, 22(6): 757-765.
- [32] Lowe JR, Briggs AM, Whittle S, et al. A systematic review of the effects of probiotic administration in inflammatory arthritis[J]. Complement Ther Clin Pract, 2020, 40: 101207.
- [33] 王力, 方志荣, 沈雅庭, 等. 酪酸梭菌对高尿酸血症大鼠血尿酸及炎症因子水平的影响[J]. 南方医科大学学报, 2017, 37(5): 678-682. WANG Li, FANG Zhi-rong, SHEN Ya-ting, et al. Effects of *Clostridium butyricum* on serum uric acid and inflammatory mediators in rats with hyperuricemia[J]. J South Med Univ, 2017, 37(5): 678-682. (in Chinese)
- [34] Shi Y, Li J, Yang P, et al. Colchicine increases intestinal permeability, suppresses inflammatory responses, and alters gut microbiota in mice[J]. Toxicol Lett, 2020, 334: 66-77.
- [35] Kunishima C, Inoue I, Oikawa T, et al. Activating effect of benzbramarone, a uricosuric drug, on peroxisome proliferator-activated receptors[J]. PPAR Res, 2007, 2007: 36092.

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(上接第 1212 页)

- [14] Chao Y, Hu W, Geng X. The neuroprotective strategic analysis for patients with acute myocardial infarction combined with hypoxic ischemic encephalopathy in ICU[J]. Hellenic J Cardiol, 2017, 58(6): 427-431.
- [15] 段红茹, 柳静文. 急性心肌梗死患者合并医院感染病原菌检测及预后研究[J]. 陕西医学杂志, 2018, 47(5): 74-76.
- [16] 叶寅寅, 赵洪静, 张金玉, 等. 早期慢性肾衰竭患者并发肺部感染的临床特点, 病原菌检出情况及相关危险因素分析[J]. 中国病原生物学杂志, 2020, 15(10): 1207-1209. YE Yin-yin, ZHAO Hong-jing, ZHANG Jin-yu, et al. Clinical characteristics of a pulmonary infection in patients with early chronic renal failure, detection of pathogens, and analysis of related risk factors[J]. Chin J Pathog Biol, 2020, 15(10): 1207-1209. (in Chinese)
- [17] 王树泉, 何鑫, 韩秀明. 缺血性脑卒中患者并发肺部感染的病原菌分布, 危险因素及血清因子水平分析[J]. 中国病原生物学杂志, 2020, 15(2): 96-98. WANG Shu-quan, HE Xin, HAN Xiu-ming. Analysis of pathogens, risk factors, and serum factor levels in patients with ischemic stroke and a pulmonary infection[J]. Chin J Pathog Biol, 2020, 15(2): 96-98. (in Chinese)
- [18] 袁明皓, 张文玉, 邹宁, 等. 急性脑梗死患者并发肺部感染的危险因素分析[J]. 第三军医大学学报, 2019, 41(2): 153-157. YUAN Ming-hao, ZHANG Wen-yu, ZOU Ning, et al. Risk factors for pulmonary infection in patients with acute cerebral infarction[J]. J Army Med Univ, 2019, 41(2): 153-157. (in Chinese)
- [19] Geng YJ, Wei ZY, Qian HY, et al. Pathophysiological characteristics and therapeutic approaches for pulmonary injury and cardiovascular complications of coronavirus disease 2019[J]. Cardiovasc Pathol, 2020, 47: 107228.
- [20] Sieri S, Agnoli C, Grioni S, et al. Glycemic index, glycemic load, and risk of coronary heart disease: a pan-European cohort study[J]. Am J Clin Nutr, 2020, 112(3): 631-643.

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