

doi: 10.13241/j.cnki.pmb.2022.10.009

• 临床研究 •

分侧肾上腺静脉取血与肾上腺 CT 对原发性醛固酮增多症诊断的价值比较研究 *

张卫东¹ 张佳伟¹ 宋志强¹ 马哲¹ 刘建国²

(1 清华大学第一附属医院泌尿外科 北京 100016; 2 清华大学第一附属医院心脏中心 北京 100016)

摘要 目的:研究原发性醛固酮增多症(PA)患者行分侧肾上腺静脉取血(AVS)、肾上腺 CT 诊断的效果。**方法:**数据遴选本院 2018 年 1 月-2021 年 11 月收治的 70 例原发性醛固酮增多症患者,所有患者均行肾上腺 CT、AVS 诊断,对最终诊断结果比较分析。**结果:**收缩压、舒张压、空腹血糖、总胆固醇在单双侧间无差异($P>0.05$),双侧肾素活性、血清醛固酮肾素比值较单侧存在差异($P<0.05$);肾上腺 CT 与 AVS 诊断的符合率情况:肾上腺 CT 显示为单侧异常、双侧异常及双侧正常患者,AVS 符合率分别为 65.00%、31.25%、50.00%;单独肾上腺 CT 诊断:灵敏度为 57.1%,特异度为 25.7%,肾上腺静脉采血诊断:灵敏度为 74.3%,特异度为 42.9%;并联联合诊断灵敏度为 100.0%,特异度为 26.3%,串联诊断灵敏度为 19.5%,特异度为 100.0%。**结论:**PA 是临床常见疾病,具有患病率高、预后差等特点,临床依靠临床表现、血液生化检查诊断 PA 疾病,但仅借助血液生化检验进行诊断治疗较困难,功能定位是治疗关键。实际工作中,可以临床通过 CT 检查及 AVS 检查功能定位诊断,但对于 PA 患者来说,仅借助肾上腺 CT 诊断结果制定治疗方案,可能导致手术侧选择错误,建议愿意接受肾上腺手术治疗者,推荐先行 AVS,正确选择治疗方案,达到改善预后作用,效果较理想、值得临床借鉴推广。

关键词:分侧肾上腺静脉取血;肾上腺 CT;原发性醛固酮增多症;诊断价值

中图分类号:R586;R445 **文献标识码:**A **文章编号:**1673-6273(2022)10-1841-05

Comparative Study on the Value of Lateral Adrenal Vein Blood Sampling and Adrenal CT in the Diagnosis of Primary Aldosteronism*

ZHANG Wei-dong¹, ZHANG Jia-wei¹, SONG Zhi-qiang¹, MA Zhe¹, LIU Jian-guo²

(1 Urinary Surgery, The First Affiliated Hospital of Tsinghua University, Beijing, 100016, China;

2 Heart Center, The First Affiliated Hospital of Tsinghua University, Beijing, 100016, China)

ABSTRACT Objective: To study the effect of partial adrenal vein blood sampling (AVS) in patients with primary aldosteronism (PA) The effect of CT diagnosis of adrenal gland. **Methods:** 70 patients with primary aldosteronism treated in our hospital from January 2018 to November 2021 were selected. All patients were diagnosed by adrenal CT and AVS. The final diagnostic results were compared and analyzed. **Results:** There was no significant difference in systolic blood pressure, diastolic blood pressure, fasting blood glucose and total cholesterol between one and two sides ($P>0.05$); There were differences in renin activity and serum renin aldosterone renin ratio between the two sides ($P<0.05$). The coincidence rate of AVS was 65.00 %, 31.25 % and 50.00 % respectively; Single adrenal CT diagnosis: sensitivity was 57.1 %, specificity was 25.7 %, adrenal venous blood collection diagnosis: sensitivity was 74.3 %, specificity was 42.9%; The sensitivity and specificity of parallel combined diagnosis were 100.0 %, 26.3%, 19.5 % and 100.0 %, respectively. **Conclusion:** PA is the clinical common disease, with high prevalence, poor prognostic features, clinical rely on clinical manifestation, blood biochemical examination in the diagnosis of PA disease, but only with the help of blood biochemical test for pathologic classification is more difficult, function orientation is the key treatment, through by surgery treatment of adrenal tumor or unilateral primary adrenal hyperplasia can heal, But bilateral adrenal hyperplasia drug treatment can be used to promote recovery, practice, clinical by CT examination and AVS check clear etiology classification is feasible, but for patients with PA, only with the aid of planned treatment in adrenal CT diagnosis, possible unnecessary adrenal surgery, should choose to give non-surgical treatment, cause upper respiratory side choose wrong. It is recommended that patients who are willing to perform adrenal surgery should have AVS first and choose the right treatment plan to improve the prognosis. The effect is ideal and worthy of praise.

Key words: Lateral adrenal vein blood sampling; Adrenal CT; Primary aldosteronism; Diagnostic value

Chinese Library Classification(CLC): R586; R445 **Document code:** A

Article ID:1673-6273(2022)10-1841-05

* 基金项目:北京首都特色临床研究项目(Z161100000516167)

作者简介:张卫东(1971-),男,本科,副主任医师,研究方向:泌尿系结石及肾上腺疾病,

电话:13901360345, E-mail: zhangweidong7111@163.com

(收稿日期:2022-01-12 接受日期:2022-01-31)

前言

原发性醛固酮增多症(Primary aldosteronism, PA)是指肾上腺皮质病变导致机体过多分泌醛固酮,造成体液容量扩张、潴钠排钾,对肾素-血管紧张素系统造成抑制^[1,2],经流行病学显示,此病是引起继发性高血压的常见诱因之一,其中在难治性高血压中的比例高达20%,在普通高血压中的比例约为10%。分析病因尚未明确,可能与肾上腺皮质病变、肾上腺皮质增生及醛固酮瘤等因素有关,患病后患者表现为高血压、低血钾、周期性麻痹、乏力及肢端麻木等症状^[3,4],若疾病持续进展,则引起恶性心律失常、心肌梗死及肾衰竭,甚至危及患者生命。研究表明,PA患者具有易伴危险因素、血压水平分级高及危险度分层高等特点,部分群体常伴有心脑血管并发症,故定位诊断,特别是功能定位诊断对疾病治疗有积极作用,利于为患者疾病治疗提供参考^[5,6]。随着现代医疗事业发展,临床利用单侧肾上腺切除治疗醛固酮腺瘤或者单侧肾上腺增生,稳定血压波动、纠正低血钾或者低血压现象^[7],但肾上腺切除术治疗双侧肾上腺增生的效果有限,给予长期服用醛固酮的竞争性抑制剂治疗控制病情。目前PA的定位诊断较常见方式为肾上腺CT、肾上腺静脉取血(Adrenal venous sampling, AVS),但CT诊断有限、仅能对肾上腺病变的结构信息直观显示,不能进行功能定位,易有误诊或漏诊,未获得患者青睐满意^[8,9],鉴于此,本文选择本院2018年1月-2021年11月收治的70例原发性醛固酮增多症患者作为研究对象,分析PA患者行AVS、肾上腺CT诊断的价值,报道如下。

1 资料与方法

1.1 一般资料

将本院2018年1月-2021年11月收治的70例原发性醛固酮增多症患者纳入研究,所有患者均行腹腔镜下单侧肾上腺切除术,其中男性39例,女性31例,年龄40-70岁,均值(52.41±5.23)岁;高血压分级:1级28例,2级24例,3级18例;合并症:冠心病18例,心房颤动17例,心力衰竭15例,外周血管疾病14例,其他6例;体质量19-26 kg/m²,均值(23.54±0.38) kg/m²。患者知情、签署知情同意书,经伦理委员会审批同意。

手术治疗适应症:①醛固酮瘤;②单侧肾上腺增生;③分泌醛固酮肾上腺皮质癌或异位肿瘤;④由于药物不良反应不能耐受长期药物治疗的特发性醛固酮增多症。

药物治疗适应症:①特发性醛固酮增多症;②I型家族性醛

固酮增多症;③不能耐受或者不愿意手术的醛固酮腺瘤;④ARR阳性且不愿意或不能接受进一步检查者^[10]。

纳入标准:①经ARR>30,并经卡托普利试验确诊为"原发性醛固酮增多症";②均行肾上腺CT、AVS检查;③呈低血钾、乏力、肢端麻木及高血钾等表现;④有完整性资料。

排除标准:①重要脏器功能异常;②伴传染性疾病、恶性肿瘤;③内分泌疾病、凝血功能障碍;④检查禁忌症;⑤精神病史或患有精神病;⑥中途转院。

1.2 研究方法

①肾上腺CT检查:涉及仪器为飞利浦双源CT,给予非心电图门控螺旋扫描完成常规扫描,从膈肌至髂动脉分叉水平为扫描范围,根据患者体重指数,酌情调整扫描参数:电压为80-120 kV,3D自动管电流,机架旋转时间0.5-0.6 s,螺距0.984,准直器宽度64×0.6 mm,重建层厚0.625 mm,选择60-100 mL碘普罗胺注射液(厂家:德国拜耳公司),控制注射流速为4.5-5.5 mL/s,经肘静脉完成注射后,在动脉期完成肾、肾上腺及肾动脉扫描,延迟30 s后完成延迟扫描。

②AVS诊断:术前停用影响醛固酮浓度结果的降压药物,尽量纠正低血钾,病房时经股静脉留置20G留置针,固定备用,术中局部麻醉留置针部位后,利用导丝-鞘管交换技术,将5F下肢血管鞘经股静脉置入其中,5F MPA1导管在体外改良后,在下腔静脉远端中借助超滑导丝(260 cm×0.035)将导管置入其中,选择5F改良MPA1导管作为右侧肾上腺静脉插管,选择5F带侧孔TIG导管作为左侧插管,患者左侧肾上腺静脉、右侧肾上腺静脉、下腔静脉远端各留取血样2份,对血皮质醇及醛固酮浓度进行检测。AVS成功定义:肾上腺血样皮质醇与下腔静脉血样皮质醇比值≥2,两侧肾上腺静脉血样皮质醇比值<1.5。

1.3 统计学方法

采用SPSS22.0软件整理分析数据,计量资料采用均数±标准差($\bar{x} \pm s$),组间比较采用独立样本t检验。计数资料采用构成比[n(%)],组间比较采用卡方检验(χ^2)检验。检验水准P=0.05。

2 结果

2.1 研究对象单侧和双侧特征

收缩压、舒张压、空腹血糖、总胆固醇在单双侧间无差异(P>0.05),双侧肾素活性、血清醛固酮肾素比值较单侧存在差异(P<0.05),详见表1。

表1 单双侧原发性醛固酮增多症临床特征

Table 1 Clinical features of unilateral and bilateral primary aldosteronism

Groups	n	SP(mmHg)	DP(mmHg)	FBG(mmol/L)	TC(mmol/L)	Renin activity (μg/L·h)	Serum renin aldosterone renin ratio
Unilateral groups	40	142.5±12.3	94.3±3.6	4.9±1.3	4.3±1.2	0.29±0.03*	61.8±3.26*
Bilateral groups	30	143.1±10.5	94.2±2.8	5.0±2.0	4.2±0.8	0.48±0.04	36.7±2.42

Note: Compared with bilateral groups, *P<0.05.

2.2 肾上腺CT与AVS诊断的符合率情况

肾上腺CT与AVS诊断的符合率情况:肾上腺CT显示为

单侧异常、双侧异常及双侧正常患者,AVS符合率分别为65.00%、31.25%、50.00%,见表2。

表 2 肾上腺 CT 与 AVS 诊断的符合率情况比较[(n),%]

Table 2 Comparison of coincidence rate between adrenal CT and AVS[(n),%]

Adrenal CT	Adrenal vein blood collection			Number of compliance cases	Number of PA cases	Coincidence rate
	Left	Right	Bilateral			
Unilateral abnormality	20	8	12	26	40	65.00 %
Unilateral abnormality	7	5	4	5	16	31.25 %
Bilateral abnormality	9	3	2	7	14	50.00 %
Total	36	16	18	38	70	54.29 %

2.3 肾上腺 CT 与 AVS 单独诊断评价

诊断均以病理检查结果为主,并且根据患者病情二者方法采样串联联合诊断方式,即为两种方法诊断均为阳性判断为阳

性。评价显示:单独肾上腺 CT 诊断:灵敏度为 57.1 %,特异度为 25.7 %,肾上腺静脉采血诊断:灵敏度为 74.3 %,特异度为 42.9 %。具体见表 3。

表 3 肾上腺 CT 与 AVS 单独诊断评价

Table 3 Separate diagnostic evaluation of adrenal CT and AVS

Adrenal CT	Adrenal vein blood collection			Total
	Left	Right	Bilateral	
Unilateral abnormality	20	8	12	40
Unilateral abnormality	7	5	4	16
Bilateral abnormality	9	3	2	14
Total	36	16	18	70

2.4 肾上腺 CT 与 AVS 并联联合诊断评价

并联联合诊断判断其中一种方法诊断即判断为阳性,串联诊断其中一种方法为阳性即判断为阳性。根据数据显示二者并

联联合诊断灵敏度为 100.0 %,特异度为 26.3 %,串联诊断灵敏度为 19.5 %,特异度为 100.0 %,详细见表 4。

表 4 肾上腺 CT 与 AVS 联合诊断评价

Table 4 Combined diagnostic evaluation of adrenal CT and AVS

Adrenal CT	Adrenal vein blood collection	Patient	Control group
Positive	Negative	25	8
Negative	Positive	37	20
Positive	Positive	15	0
Negative	Negative	0	10

3 讨论

原发性醛固酮增多症是临床常见疾病,具有较高的患病率,临床呈高血压、低血钾等症状表现^[11,12]。与原发性高血压比较,此病患者肾脏、心脏等高血压靶器官损害更严重,患病后若疾病持续进展,则危及患者生命安全,故遵守早诊断、早治疗原则有重要作用^[13,14]。研究发现,PA 被认为是引起继发性高血压的常见原因,在非选择性高血压患者中的患病率为 11 %,分析病因尚未明,可能与醛固酮产生性腺瘤、双侧特发性肾上腺增生、单侧肾上腺增生有关,患者腺瘤、增生结果决定最终的治疗方案^[15,16]。经调查研究发现,目前临床诊断肾上腺瘤的主要手段为 CT、MRI,与 AVS 检查比较,具有无创、价格低廉及技术难度简单等优势^[17,18],但既往相关医学表明,CT 诊断敏感度较低,

分析敏感度较低的原因与 CT 无法检查直径 <5 mm 的腺瘤有关,继而临床实际诊断时,建议结合肾上腺静脉取血检查准确判断疾病,避免肾上腺增生患者实行肾上腺切除治疗^[19,20]。临床诊治 PA 疾病的关键点为分型功能分侧定位,AVS 为新型诊断技术,一直被认为是功能分侧定位的“金标准”,随着医疗事业发展,临床应用 AVS 技术的成功率高达 97 %,临床尚未解释 AVS 的统一标准,插管方式、病例选择等因素,均会影响最终结果^[21,22]。因此本文分析了 PA 患者行 AVS、肾上腺 CT 诊断的价值。

本文通过对单侧和双侧特征显示血压、血糖、血脂无明显差异,但是两组患者双侧肾素活性、血清醛固酮肾素比值较单侧存在差异,表明双侧患者疾病严重程度大于单侧,并且通过以上两种方法检查定位后,肾上腺 CT 显示为单侧异常、双侧

异常及双侧正常患者,AVS符合率分别为65.00%、31.25%、50.00%。该结果与Wolley M^[23]报道具有相似性,因此肾上腺CT诊断可对肾上腺病变的结构性信息直观显示,AVS诊断可对醛固酮过度分泌的功能性信息直观显示,联合诊断可明确疾病,尽量在结果一致的前提下实行手术治疗,达到改善预后目的,具临床实践价值^[24]。但是临床上上述两种方法均可能会出现一定漏诊现象,经过评价单独肾上腺CT诊断:灵敏度为57.1%,特异度为25.7%,肾上腺静脉采血诊断:灵敏度为74.3%,特异度为42.9%;并联合诊断灵敏度为100.0%,特异度为26.3%,串联诊断灵敏度为19.5%,特异度为100.0%。该结果与Aono D^[25]报道具有相似性。进一步分析可知:从临床实际情况来看,AVS采血时要求相关操作者提供丰富的经验完成双侧肾上腺静脉准确插管,右肾上腺静脉尺寸较小、解剖学变异等因素^[26,27],均导致手术成功难度增加,据统计,各中心AVS双侧采血成功率在59%-97%,分析导致采血成功率不高的因素有:① AVS是目前我国开展的新技术,临床缺乏相关经验较丰富的介入科医师;② 实际开展AVS采血流程时,临床采用非ACTH刺激法较多,且另外分析导致左侧采血失败的原因与导管头端进入深度欠佳,右侧更易发生解剖变异情况,显著增加准确定位难度,如:误入副肝静脉等,建议实际操作时提出针对性改进办法。因此根据患者疾病严重以及诊断目的确定,是为了早期发现疾病,进行进一步治疗,还需要排除有疾病可能性,选择两种诊断联合方式,若想要早期发现病变需要尽早发现所有可能的对象就需要选择并联合检测方法,若需要进行疾病排除疾病,就选择串联联合方式,排除没有可能的患者,提高患者生活质量^[28-30]。但本研究仍有不足:如研究对象多为中老年群体、观察年限较短、所选病例数不足及设计方案简单等,通过对比肾上腺CT、AVS诊断结果虽能明确疾病情况、为后续治疗提供参考,但无法规避研究偏倚性,鉴于此后期需优化研究设计方案,通过大数据研究为疾病治疗提供参考数据,进一步开展研究,保证治疗方案的真实性、可靠性。

综上所述,PA患者行肾上腺CT、AVS诊断具有相似的敏感度,CT诊断在形态学改变方面,AVS诊断在内分泌改变方面,实际诊断时易两者结合,对于CT扫描无法明确结节性质、影像学表现正常,激素检测确定为腺瘤者,建议实行AVS诊断,使其联合诊断为后续治疗提供参考依据,效果显著。

参考文献(References)

- [1] Armanini D, Sabbadin C, Andrisani A, et al. Primary aldosteronism: Involvement of sympathetic system in the persistence of hypertension after surgery [J]. *J Clin Hypertens (Greenwich)*, 2020, 22 (9): 1616-1617
- [2] Vaidya A, Carey RM. Evolution of the Primary Aldosteronism Syndrome: Updating the Approach [J]. *J Clin Endocrinol Metab*, 2020, 105(12): 3771-3783
- [3] Brown JM, Siddiqui M, Calhoun DA, et al. The Unrecognized Prevalence of Primary Aldosteronism: A Cross-sectional Study [J]. *Ann Intern Med*, 2020, 173(1): 10-20
- [4] Young WF Jr. Diagnosis and treatment of primary aldosteronism: practical clinical perspectives[J]. *J Intern Med*, 2019, 285(2): 126-148
- [5] Pillai PR, Griffith M, Schwarcz MD, et al. Primary Aldosteronism: Cardiovascular Risk, Diagnosis, and Management [J]. *Cardiol Rev*, 2020, 28(2): 84-91
- [6] Monticone S, D'Ascenzo F, Moretti C, et al. Cardiovascular events and target organ damage in primary aldosteronism compared with essential hypertension: a systematic review and meta-analysis [J]. *Lancet Diabetes Endocrinol*, 2018, 6(1): 41-50
- [7] Mulatero P, Monticone S, Deinum J, et al. Genetics, prevalence, screening and confirmation of primary aldosteronism: a position statement and consensus of the Working Group on Endocrine Hypertension of The European Society of Hypertension [J]. *J Hypertens*, 2020, 38(10): 1919-1928
- [8] Okamoto K, Ohno Y, Sone M, et al. Should Adrenal Venous Sampling Be Performed in PA Patients Without Apparent Adrenal Tumors[J]? *Front Endocrinol (Lausanne)*, 2021, 12(1): 645395
- [9] Ay A, Pfm B, In M H, et al. Evaluation of Adrenal Vein Sampling Use and Outcomes in Patients With Primary Aldosteronism-ScienceDirect [J]. *J Sur Res*, 2020, 256(1): 673-679z
- [10] Mm D Z C, Chen T, Tian M H, et al. Exploration Of The Seated Saline Suppression Test For The Diagnosis Of Primary Aldosteronism In The Chinese Population - ScienceDirect[J]. *End Prac*, 2020, 26(8): 891-899
- [11] Xu Z, Yang J, Hu J, et al. Primary Aldosteronism in Patients in China With Recently Detected Hypertension[J]. *J Am Coll Cardiol*, 2020, 75 (16): 1913-1922
- [12] Cesari M, Seccia TM, Maiolino G, et al. Primary aldosteronism in elderly, old, and very old patients[J]. *J Hum Hypertens*, 2020, 34(12): 807-813
- [13] Kometani M, Yoneda T, Aono D, et al. Primary Aldosteronism with Parathyroid Hormone Elevation: A Single-center Retrospective Study [J]. *Int Med*, 2021, 60(7): 993-998
- [14] Rossi GP, Cesari M, Lenzini L, et al. Disease monitoring of Primary Aldosteronism [J]. *Best Pract Res Clin Endocrinol Metab*, 2020, 34 (2): 101417
- [15] Mulè G, Geraci G, Carollo C, et al. Haemodynamics of primary aldosteronism associated with adrenocortical adenoma: insights from bioimpedance cardiography measurements [J]. *J Intern Med*, 2021, 289(1): 134-136
- [16] Choudhary MK, Värri E, Matikainen N, et al. Primary aldosteronism: Higher volume load, cardiac output and arterial stiffness than in essential hypertension[J]. *J Intern Med*, 2021, 289(1): 29-41
- [17] Asmar M, Wachtel H, Yan Y, et al. Reversing the established order: Should adrenal venous sampling precede cross-sectional imaging in the evaluation of primary aldosteronism?[J]. *J Surg Oncol*, 2015, 112 (2): 144-148
- [18] Udare A, Agarwal M, Siegelman E, et al. CT and MR imaging of acute adrenal disorders[J]. *Abdom Radiol (NY)*, 2021, 46(1): 290-302
- [19] Aggarwal A, Das CJ. Contrast-enhanced ultrasound in evaluation of adrenal lesions with CT/MRI correlation[J]. *Br J Radiol*, 2021, 94 (1120): 20201170
- [20] Tang W, Yu XR, Zhou LP, et al. Adrenal schwannoma: CT, MR manifestations and pathological correlation [J]. *Clin Hemorheol Microcirc*, 2018, 68(4): 401-412
- [21] O'Toole SM, Sze WC, Chung TT, et al. Low-grade Cortisol

- Cosecretion Has Limited Impact on ACTH-stimulated AVS Parameters in Primary Aldosteronism [J]. *J Clin Endocrinol Metab*, 2020, 105(10): 519
- [22] Wada N, Baba S, Sugawara H, et al. Laterality Diagnosis of Adrenal Vein Sampling for Primary Aldosteronism Using Aldosterone Alone [J]. *J End Soc*, 2021, 5(Sup-1): A291-A291
- [23] Wolley M, Thuzar M, Stowasser M. Controversies and advances in adrenal venous sampling in the diagnostic workup of primary aldosteronism[J]. *Best Pract Res Clin Endocrinol Metab*, 2020, 34(3): 101400
- [24] Okamura K, Okuda T, Fukuda Y, et al. A Case of Primary Aldosteronism Due to A Primary Adrenal Adenoma Diagnosed by Segmental Adrenal Venous Sampling (S-AVS) Using a Modified Catheter System and Lateral Cine Angiography [J]. *Am J Case Rep*, 2019, 20(2): 139-145
- [25] Aono D, Kometani M, Karashima S, et al. Primary aldosteronism subtype discordance between computed tomography and adrenal venous sampling[J]. *Hypertens Res*, 2019, 42(12): 1942-1950
- [26] Loberg C, Antoch G, Stegbauer J, et al. Update: Selective adrenal venous sampling (AVS) - Indication, technique, and significance[J]. *Rofo*, 2021, 193(6): 658-666
- [27] Deinum J, Groenewoud H, Van der Wilt GJ, et al. Adrenal venous sampling: cosyntropin stimulation or not [J]? *Eur J Endocrinol*, 2019, 181(3): D15-D26
- [28] Wolley M, Thuzar M, Stowasser M. Controversies and advances in adrenal venous sampling in the diagnostic workup of primary aldosteronism[J]. *Best Pract Res Clin Endocrinol Metab*, 2020, 34(3): 101400
- [29] Ohno Y, Naruse M, Beuschlein F, et al. Adrenal Venous Sampling-Guided Adrenalectomy Rates in Primary Aldosteronism: Results of an International Cohort (AVSTAT)[J]. *J Clin Endocrinol Metab*, 2021, 106(3): e1400-e1407
- [30] Kocjan T, Jensterle M, Vidmar G, et al. Adrenal vein sampling for primary aldosteronism: a 15-year national referral center experience [J]. *Radiol Oncol*, 2020, 54(4): 409-418

(上接第 1828 页)

- [23] Asencio-Egea M, Gaitán-Pitera J, Huertas-Vaquero M, et al. Interhospital dissemination of KPC-3 producing-Klebsiella pneumoniae ST512. Detection by MALDI-TOF [J]. *Enferm Infecc Microbiol Clin (Engl Ed)*, 2021, 39(2): 83-86
- [24] Bassetti M, Echols R, Matsunaga Y, et al. Efficacy and safety of cefiderocol or best available therapy for the treatment of serious infections caused by carbapenem-resistant Gram-negative bacteria (CREDIBLE-CR): a randomised, open-label, multicentre, pathogen-focused, descriptive, phase 3 trial [J]. *Lancet Infect Dis*, 2021, 21(2): 226-240
- [25] Cano E J, Caflisch K M, Bollyky P L, et al. Phage Therapy for Limb-threatening Prosthetic Knee Klebsiella pneumoniae Infection: Case Report and In Vitro Characterization of Anti-biofilm Activity[J]. *Clin Infect Dis*, 2021, 73(1): e144-e151
- [26] 戴晓玥,吴亮,夏雯,等.鲍曼不动杆菌 OmpA 经 ROS/NLRP3 信号通路调控 THP-1 细胞自噬和凋亡 [J]. *江苏大学学报 (医学版)*, 2020, 30(5): 423-429
- [27] Yan YQ, Fang Y, Zheng R, et al. NLRP3 Inflammasomes in Parkinson's disease and their Regulation by Parkin [J]. *Cells*, 2020, 446(2): 323-334
- [28] Zheng M, Kanneganti TD. The regulation of the ZBP1-NLRP3 inflammasome and its implications in pyroptosis, apoptosis, and necroptosis (PANoptosis)[J]. *Int J Mol Sci*, 2020, 297(1): 26-38
- [29] Chen R, Shang H, Niu X, et al. Establishment and evaluation of an indirect ELISA for detection of antibodies to goat Klebsiella pneumoniae[J]. *BMC Vet Res*, 2021, 17(1): 107-111
- [30] Chen X, Qin S, Zhao X, et al. L-Proline protects mice challenged by Klebsiella pneumoniae bacteremia [J]. *J Microbiol Immunol Infect*, 2021, 54(2): 213-220
- [31] Di Pilato V, Errico G, Monaco M, et al. The changing epidemiology of carbapenemase-producing Klebsiella pneumoniae in Italy: toward polyclonal evolution with emergence of high-risk lineages [J]. *J Antimicrob Chemother*, 2021, 76(2): 355-361
- [32] Falcone M, Tiseo G, Nicastro M, et al. Cefiderocol as Rescue Therapy for Acinetobacter baumannii and Other Carbapenem-resistant Gram-negative Infections in Intensive Care Unit Patients[J]. *Clin Infect Dis*, 2021, 72(11): 2021-2024
- [33] Groft L M, Claeys K C, Heil E L. An evaluation of meropenem/vaborbactam for the treatment of nosocomial pneumonia [J]. *Expert Opin Pharmacother*, 2021, 22(3): 265-271
- [34] Hu Y, Anes J, Devineau S, et al. Klebsiella pneumoniae: Prevalence, Reservoirs, Antimicrobial Resistance, Pathogenicity, and Infection: A Hitherto Unrecognized Zoonotic Bacterium [J]. *Foodborne Pathog Dis*, 2021, 18(2): 63-84