·临床研究·

慢性肾脏病维持性血液透析患者高磷血症与心血管参数的相关性

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【摘 要】 目的 探讨慢性肾脏病(CKD)维持性血液透析患者高磷血症与心血管参数左心室肥厚(LVH)和主动脉钙化(AC)的相关性。**方法** 回顾性分析2018年1月至2019年3月重庆医科大学附属第一医院收治的465例CKD透析患者的临床资料。收集患者的基线资料、实验室指标、二维超声心动图检查、胸部CT平扫以及胸部X线检查等资料。将328例行二维超声心动图检查的患者按是否存在LVH，分为LVH组234例及非LVH组94例。将330例行胸部CT平扫或胸部X线检查的患者按是否存在AC，分为AC组199例及非AC组131例。将269例同时行二维超声心动图及胸部CT平扫或胸部X线检查的患者按血清磷水平，分为低血清磷组36例(血清磷水平<0.81 mmol/L)、正常血清磷组106例(0.81≤血清磷水平≤1.45 mmol/L)及高血清磷组127例(血清磷水平>1.45 mmol/L)。采用SPSS 26.0统计软件进行数据分析。根据数据类型，组间比较分别采用t检验、Mann-Whitney U检验或χ^2检验。采用多因素logistic回归模型分析血清磷水平与LVH及AC的关系。**结果** 与非LVH组比较，LVH组患者收缩压[(150.80±25.19)和(144.00±24.94) mmHg(1 mmHg=0.133 kPa)]、舒张压[(85.50±18.18)和(79.96±14.80) mmHg]、血清磷[(1.97±0.76)和(1.73±0.73) mmol/L]及糖尿病患病率[25.21%(59/234)和15.96%(15/94)]均显著升高，年龄[(49.25±13.52)和(52.78±12.34)岁]、血红蛋白[(98.51±26.10)和(107.05±26.48) g/L]、血清钙[(2.07±0.29)和(2.16±0.31) mmol/L]及白蛋白[(38.09±5.94)和(39.74±5.77) g/L]水平均显著降低，差异均有统计学意义(均P<0.05)。与非AC组相比，AC组的患者年龄[(57.82±10.32)和(45.87±11.75)岁]、血红蛋白[(102.22±24.57)和(94.55±28.16) g/L]、血清钙[(2.16±0.28)和(2.00±0.31) mmol/L]、血清磷[(1.99±0.76)和(1.81±0.74) mmol/L]、钙磷乘积[(52.70±20.02)和(44.54±18.42) mg/dl]、糖尿病患病率[28.64%(57/199)和15.27%(20/131)]及高血压患病率[28.64%(57/199)和15.27%(20/131)]均显著升高，舒张压[(81.67±15.00)和(87.31±19.35) mmHg]及降磷药物的使用率[39.70%(79/199)和55.73%(73/131)]均显著降低，差异均有统计学意义(均P<0.05)。多因素logistic回归分析表明，舒张压升高(OR=1.017，95%CI 1.001~1.033；P=0.038)、血清磷升高(OR=1.581，95%CI 1.080~2.316；P=0.019)、合并糖尿病(OR=0.540，95%CI 0.296~0.987；P=0.045)以及白蛋白下降(OR=0.934，95%CI 0.891~0.979；P=0.004)是CKD维持性血液透析患者合并LVH的独立危险因素。年龄(OR=1.091，95%CI 1.067~1.117；P<0.001)、血清磷升高(OR=0.307，95%CI 0.128~0.734；P=0.008)、钙磷乘积(OR=1.085，95%CI 1.046~1.125；P<0.001)以及合并糖尿病(OR=2.039，95%CI 1.041~3.995；P=0.038)是CKD维持性血液透析患者合并AC的独立危险因素。高血清磷组LVH患病率显著高于正常血清磷组，差异有统计学意义[80.31%(102/127)和61.32%(65/106)；P<0.05)。**结论** 高磷血症是CKD维持性血液透析患者LVH及AC的独立危险因素，对高磷血症进行控制是改善CKD患者心血管疾病的关键。

【关键词】 慢性肾脏病；透析；高磷血症；左心室肥厚；主动脉钙化

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Correlation of hyperphosphatemia and cardiovascular parameters in chronic kidney disease patients on maintenance dialysis

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【Abstract】 Objective To investigate the correlation of hyperphosphatemia with cardiovascular parameters, left ventricular hypertrophy (LVH) and aortic calcification (AC), in chronic kidney disease (CKD) patients undergoing maintenance hemodialysis. **Methods** A total of 465 CKD patients on dialysis admitted to the First Affiliated Hospital of Chongqing Medical University from January 2018 to March 2019 were enrolled in this retrospective study. Their baseline data, laboratory indicators, two-dimensional echocardiogram, chest CT plain scan, and chest X-ray films were collected. For the 328 patients who received two-dimensional

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echocardiography, they were divided into LVH group (n=234) and non-LVH group (n=94) based on the presence or absence of LVH. While, the 330 patients who underwent chest CT plain scan or chest X-ray examination were divided into AC group (n=199) and non-AC group (n=131). The 269 patients who underwent both two-dimensional echocardiography and chest CT plain scan or chest X-ray examination were divided into low, normal and high serum phosphorus groups (serum phosphorus level: <0.81, 0.81-1.45, >1.45 mmol/L; n=36, 106, 127, respectively). SPSS statistics 26.0 was used for data analysis. Depending on data type, student's t test, Mann Whitney U test, or *Chi*-square test was used for intergroup comparison. Multivariate logistic regression model was performed to analyze the relationship of serum phosphorus level with LVH and AC. **Results** The LVH group had significantly older age [(49.25±13.52) *vs* (52.78±12.34) years], higher systolic blood pressure [(150.80±25.19) *vs* (144.00±24.94) mmHg (1 mmHg=0.133 kPa)], diastolic blood pressure [(85.50±18.18) *vs* (79.96±14.80) mmHg] and serum phosphorus level [(1.97±0.76) *vs* (1.73±0.73) mmol/L], and larger proportion of diabetes [25.21% (59/234) *vs* 15.96% (15/94)], but obviously lower hemoglobin [(98.51±26.10) *vs* (107.05±26.48) g/L], serum calcium [(2.07±0.29) *vs* (2.16±0.31) mmol/L] and albumin [(38.09±5.94) *vs* (39.74±5.77) g/L] when compared with the non-LVH group (all P<0.05). Statistically older age [(57.82±10.32) *vs* (45.87±11.75) years], higher hemoglobin [(102.22±24.57) *vs* (94.55±28.16) g/L], serum calcium [(2.16±0.28) *vs* (2.00±0.31) mmol/L], serum phosphorus [(1.99± 0.76) *vs* (1.81±0.74) mmol/L], calcium phosphorus product [(52.70±20.02) *vs* (44.54±18.42) mg/dl] and proportions of diabetes [28.64% (57/199) *vs* 15.27% (20/131)] and hypertension [28.64% (57/199) *vs* 15.27% (20/131)], and lower diastolic blood pressure [(81.67±15.00) *vs* (87.31±19.35) mmHg] and usage rate of phosphorus lowering drugs [39.70% (79/199) *vs* 55.73% (73/131)] were observed in AC group than in non-AC group (all P<0.05). Multivariate logistic regression analysis showed that increased diastolic pressure (OR=1.017, 95% CI 1.001-1.033; P=0.038), increased serum phosphorus (OR=1.581, 95% CI 1.080-2.316; P=0.019), diabetes mellitus (OR=0.540, 95%CI 0.296-0.987; P=0.045) and decreased albumin (OR=0.934, 95%CI 0.891-0.979; P=0.004) were independent risk factors for LVH in maintenance hemodialysis patients. Age (OR=1.091, 95% CI 1.067-1.117; P<0.001), elevated serum phosphorus (OR=0.307, 95% CI 0.128-0.734; P=0.008), calcium phosphorus product (OR=1.085, 95%CI 1.046-1.125; P<0.001), and diabetes mellitus(OR=2.039, 95% CI 1.041-3.995; P=0.038) were independent risk factors for AC in these CKD patients on maintenance hemodialysis. The incidence of LVH was significantly higher in the high serum phosphorus group than the normal serum phosphorus group [80.31% (102/127) *vs* 61.32% (65/106); P<0.05]. **Conclusion** Hyperphosphatemia is an independent risk factor for LVH and AC in CKD patients undergoing maintenance hemodialysis. Controlling hyperphosphatemia is essential to improve cardiovascular disease in CKD patients.

【Key words】 chronic kidney disease; dialysis; hyperphosphatemia; left ventricular hypertrophy; aortic calcification

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慢性肾脏病(chronic kidney disease,CKD)已成为近年来我国愈发显著的公共卫生问题。2009至2010年期间进行的一项全国范围的横断面调查显示,我国CKD患病率为10.8%[1]。随着我国新一轮医疗卫生体制改革的推进,一项针对全国住院患者的数据库显示[2],2010至2017年CKD住院患者的比例从3.58%上升至4.95%,每年仅CKD患者的透析费用就可达153亿,给医疗保健系统带来巨大负担。有研究发现,心血管疾病是CKD患者死亡的主要病因,>50%的透析患者死于心血管疾病[3]。除了高血压、糖尿病、血脂异常及吸烟等传统因素外,炎症、蛋白尿及矿物质代谢异常等,也会增加CKD患者心血管疾病的风险,尤其是钙、磷含量的增加[3]。一项关于CKD患者心血管事件的meta分析显示,血清磷浓度升高与心血管事件风险增加显著相关[4],血清磷水平较高患者,发生左心室肥厚(left ventricular hypertrophy,LVH)及主动脉钙化(aortic calcification, AC)的可能性更大。本研究探讨CKD维持性血液透析患者高磷血症与心血管参数LVH及AC的相关性,以期为临床心血管疾病的治疗提供依据。

1 对象与方法

1.1 研究对象

回顾性分析2018年1月至2019年3月于重庆医科大学附属第一医院肾脏内科进行维持性血液透析治疗的465例CKD患者的临床资料。纳入标准:(1)年龄18~65岁;(2)维持性透析时间>6个月。排除标准:(1)有严重的共存疾病,包括慢性心力衰竭(纽约心脏病协会心功能分级3级或4级心力衰竭)、肝硬化、艾滋病及器官移植;(2)需要在6个月内使用免疫抑制剂治疗的肾病或免疫性疾病;(3)2年内有化疗史的恶性肿瘤;(4)孕妇及哺乳期妇女;(5)有介入治疗手术史;(6)急性肾损伤。

1.2 方法

1.2.1 基线资料 收集患者透析龄、人口统计学资料、生活行为方式、用药史、静息血压、身高和体质量等一般资料。记录钙、磷、血红蛋白、白蛋白、甲状旁腺激素等生化指标。

1.2.2 LVH的诊断 对患者进行二维超声心动图检查,由1名具有心脏超声学诊断经验的主治及以上职称医师进行评判分析。患者采取适宜体位(仰

卧位、左侧卧位等)露出皮肤,涂耦合剂、探头紧贴皮肤后即可进行检查。测量指标包括:室间隔舒张末厚度(inter-ventricular septum end-diastolic thickness,LVST)、左心室后壁舒张末厚度(left ventricular posterior wall end-diastolic thickness,PWTH)、左心室舒张末径(left ventricular end-diastolic diameter,LVEDd)及左心室质量(left ventricular mass,LVM)。计算 LVM 及左心室质量指数(left ventricle mass index,LVMI)。$LVM = 0.8[1.04(IVST+PWT+LVEDd)^3 - LVEDd^3] + 0.6$[5]。LVMI = LVM/体表面积。体表面积 = 0.006 1×身高(cm) + 0.012 8×质量(kg) - 0.152 9。男性 LVMI>125 g/m^2、女性 LVMI>120 g/m^2 为 LVH[6]。

1.2.3 AC 的诊断 对患者行胸部 CT 平扫或胸部 X 线检查,由 1 名具有主治及以上职称的影像学医师进行诊断分析。

1.3 统计学处理

采用 SPSS 26.0 统计软件进行数据分析。计量资料呈正态分布者以均数±标准差($\bar{x}\pm s$)表示,2 组间比较采用独立样本 t 检验;呈非正态分布者以中位数(四分位数间距)[$M(Q_1, Q_3)$]表示,2 组间比较采用 Mann-Whitney U 检验。计数资料以例数(百分率)表示,组间比较采用 χ^2 检验,对理论频数不满足 χ^2 要求的数据采用 Fisher 精确概率法检验,多组间两两比较采用 bonferroni 法对检验水准进行校正。采用多因素 logistic 回归模型评价血清磷水平对 LVH 及 AC 的影响。P<0.05 为差异有统计学意义。

2 结 果

2.1 患者的一般资料

本研究共 465 例患者均为 CKD5 期,年龄(52.56±11.39)岁,其中男性 263 例(56.56%)。所纳入患者病因较多,其中肾小球肾炎 147 例(31.61%)、糖尿病肾病 102 例(21.94%)、高血压肾病 108 例(23.23%)、多囊肾 26 例(5.59%)、梗阻性肾病 14 例(3.01%)、痛风 13 例(2.80%)、抗中性粒细胞胞浆抗体相关性血管炎 13 例(2.80%)、乙肝相关性肾炎 5 例(1.08%)、缺血性肾病 2 例(0.43%)、免疫球蛋白 A 肾病 3 例(0.65%)、移植肾失功能 2 例(0.43%)以及紫癜性肾炎 3 例(0.65%)。

2.2 LVH 组与非 LVH 组患者一般资料比较

将 328 例行二维超声心动图检查的 CKD 维持性血液透析患者按是否存在 LVH,分为 LVH 组 234 例及非 LVH 组 94 例。与非 LVH 组比较,LVH 组患者收缩压、舒张压、血清磷及糖尿病患病率均显著升高,年龄、血红蛋白、血清钙及白蛋白水平均显著降低,差异均有统计学意义(均 P<0.05;表 1)。

2.3 CKD 维持性血液透析患者 LVH 的多因素 logistic 回归分析

多因素 logistic 回归分析进一步证实,舒张压升高、血清磷升高、合并糖尿病以及白蛋白下降是 CKD 维持性血液透析患者合并 LVH 的独立危险因素。详见表 2。

2.4 AC 组与非 AC 组患者一般资料比较

将 330 例行胸部 CT 平扫或胸部 X 线检查的 CKD 维持性血液透析患者按是否存在 AC,分为 AC 组 199 例及非 AC 组 131 例。与非 AC 组相比,AC 组的患者年龄、血红蛋白、血清钙、血清磷、钙磷乘积、糖尿病及高血压患病率均显著升高,舒张压及降磷药物的使用率均显著降低,差异均有统计学意义(均 P<0.05;表 3)。

表 1 LVH 组与非 LVH 组患者一般资料比较

Table 1 Comparison of general data between LVH group and non-LVH group

Item	LVH group(n=234)	Non-LVH group(n=94)	$t/Z/\chi^2$	P value
Age(years, $\bar{x}\pm s$)	49.25±13.52	52.78±12.34	2.278	0.023
Etiology[n(%)]			6.967	0.073
DN	43(18.38)	28(29.79)		
GN	59(25.21)	15(15.96)		
HN	74(31.62)	31(32.98)		
Others	58(24.79)	20(21.28)		
SBP(mmHg, $\bar{x}\pm s$)	150.80±25.19	144.00±24.94	-2.226	0.027
DBP(mmHg, $\bar{x}\pm s$)	85.50±18.18	79.96±14.80	-2.864	0.004
Use of phosphate-lowering drugs[n(%)]	109(46.58)	46(48.94)	0.149	0.699
Hb(g/L, $\bar{x}\pm s$)	98.51±26.10	107.05±26.48	-2.669	0.008
Ca(mmol/L, $\bar{x}\pm s$)	2.07±0.29	2.16±0.31	-2.31	0.022
P(mmol/L, $\bar{x}\pm s$)	1.97±0.76	1.73±0.73	2.602	0.010
Ca-P product(mg/dl, $\bar{x}\pm s$)	50.28±19.72	46.20±20.36	1.663	0.097
Albumin(g/L, $\bar{x}\pm s$)	38.09±5.94	39.74±5.77	-2.273	0.024
PTH(pg/ml, $\bar{x}\pm s$)	280.0±349.2	294.5±358.9	-0.043	0.965
Diabetes mellitus[n(%)]	59(25.21)	15(15.96)	5.149	0.023
Hypertension [n(%)]	43(18.38)	28(29.79)	3.289	0.070

LVH: left ventricular hypertrophy; DN: diabetic nephropathy; GN: glomerulonephritis nephropathy; HN: hypertensive nephropathy; SBP: systolic blood pressure; DBP: diastolic blood pressure; Hb: hemoglobin; Ca: calcium; P: phosphorus; PTH: parathyroid hormone. 1 mmHg=0.133 kPa.

表2 CKD维持性血液透析患者LVH的多因素logistic回归分析

Table 2 Multivariate logistic regression analysis of LVH in maintenance hemodialysis patients with CKD

Factor	*B*	*Wald*	*P* value	*OR*	95%*CI*
DBP	0.017	4.31	0.038	1.017	1.001-1.033
P	0.458	5.543	0.019	1.581	1.080-2.316
Diabetes mellitus	-0.616	4.005	0.045	0.540	0.296-0.987
Alb	-0.068	8.096	0.004	0.934	0.891-0.979

CKD: chronic kidney disease; LVH: left ventricular hypertrophy; DBP: diastolic blood pressure; P: phosphorus; Alb: albumin.

2.5 CKD维持性血液透析患者AC的多因素logistic回归分析

多因素logistic回归分析证实,年龄、血清磷升高、钙磷乘积以及合并糖尿病是CKD维持性血液透析患者合并AC的独立危险因素。详见表4。

2.6 血清磷水平与心血管参数的相关性

根据改善全球肾脏病预后组织指南建议,将269例既有二维超声心动图,也有影像学检查结果的患者分为低血清磷组36例(血清磷<0.81 mmol/L)、高血清磷组127例(血清磷>1.45 mmol/L)及正常血清磷组106例(0.81≤血清磷≤1.45 mmol/L),3组间AC患病率比较,差异无统计学差异(P>0.05)。3组间LVH患病率比较,差异有统计学意义(P<0.05;表5)。高血清磷组LVH患病率显著高于正常血清磷组,差异有统计学意义(P<0.05;表5)。

3 讨 论

CKD患者常常出现高磷血症,肾脏对磷滤过下降导致磷在体内潴留是CKD患者发生高磷血症最根本的原因,而高磷血症又是诱发心血管疾病的常见因素。一项对3 300例无心力衰竭和CKD人群进行的前瞻性研究显示[7],血清磷每增加10 mg/L,心力衰竭的风险增加1.74倍。此外,一项关于动脉粥样硬化的多种族研究中,纳入4 494例未发生过任何心血管疾病的参与者,发现膳食磷酸盐摄入量每增加预计值的1/5,LVM增加1.06 g[8]。目前,关于CKD人群中磷与心血管参数LVH及AC之间关系的研究较少。Chue等[9]采用心血管磁共振成像技术对208例CKD 2~4期非糖尿病患者血清磷(平均血清磷1.1 mmol/L)与LVMI之间的相关性进行研究,发现即使大多数患者血清磷在改善全球肾脏病预后组织指南的推荐范围内,磷对透析前CKD各阶段患者的心血管结构仍有影响。本研究针对CKD维持性血液透析患者进行回顾性分析,探讨高磷血症与LVH和AC的相关性。

本研究中,与非LVH组比较,LVH组患者血清磷显著升高,同时高血清磷组患者LVH发生率显著高于正常血清磷组(P<0.05)。血清磷水平是CKD维持性血液透析患者合并LVH的独立危险因素。CKD患者血清磷和LVH之间的关联可能与以下原因有关:第一,高磷血症引起的血管钙化和动脉僵硬降低了大血管顺应性[10],从而使心脏后负荷增加,引起LVH;第二,磷对心肌细胞的毒性作用可能是心肌细胞肥大和间质细胞增殖的原因[11]。

高磷血症作为肾病矿物质和骨代谢异常的代表,与血管钙化的关系最为密切。随着血清磷升高,血管平滑肌钙化的易感性增加,会对多个信号通路产生影响。研究显示,高磷血症、高密度脂蛋白胆固醇低水平是AC的危险因素[12]。本研究显示CKD维持性血液透析患者AC的患病率为60.30%(199/330)。与非AC组比较,AC组患者血清磷显著升高,血清磷水平是CKD维持性血液透析患者合并LVH的独立危险因素。高磷血症、高钙磷乘积常伴随心血管钙化、

表3 AC组与非AC组患者一般资料比较

Table 3 Comparison of general data between AC group and non-AC group

Item	AC group(n=199)	Non-AC group(n=131)	$t/Z/\chi^2$	*P* value
Age(years, $\bar{x}\pm s$)	57.82±10.32	45.87±11.75	-8.203	<0.001
Etiology[n(%)]			24.43	<0.001
DN	57(28.64)	20(15.27)		
GN	57(28.64)	20(15.27)		
HN	52(26.13)	48(36.64)		
Others	33(16.58)	43(32.82)		
SBP(mmHg, $\bar{x}\pm s$)	149.71±22.81	151.46±26.53	0.637	0.525
DBP(mmHg, $\bar{x}\pm s$)	81.67±15.00	87.31±19.35	2.976	0.003
Use of phosphate-lowering drugs[n(%)]	79(39.70)	73(55.73)	8.167	0.004
Hb(g/L, $\bar{x}\pm s$)	102.22±24.57	94.55±28.16	-2.609	0.001
Ca(mmol/L, $\bar{x}\pm s$)	2.16±0.28	2.00±0.31	-4.595	<0.001
P(mmol/L, $\bar{x}\pm s$)	1.99±0.76	1.81±0.74	-2.111	0.036
Ca-P product(mg/dl, $\bar{x}\pm s$)	52.70±20.02	44.54±18.42	-3.696	<0.001
Albumin(g/L, $\bar{x}\pm s$)	39.42±7.32	39.95±8.73	-0.08	0.936
PTH(pg/ml, $\bar{x}\pm s$)	343.73±408.74	439.11±569.25	1.597	0.112
Diabetes mellitus[n(%)]	57(28.64)	20(15.27)	7.901	0.005
Hypertension[n(%)]	57(28.64)	20(15.27)	7.901	0.005

AC: aortic calcification; DN: diabetic nephropathy; GN: glomerulonephritis nephropathy; HN: hypertensive nephropathy; SBP: systolic blood pressure; DBP: diastolic blood pressure; Hb: hemoglobin; Ca: calcium; P: phosphorus; PTH: parathyroid hormone. 1 mmHg=0.133 kPa.

表 4 CKD 维持性血液透析患者 AC 的多因素 logistic 回归分析

Table 4 Multivariate logistic regression analysis of AC in maintenance hemodialysis patients with CKD

Factor	*B*	*Wald*	*P* value	*OR*	95%*CI*
Age	0.088	55.135	<0.001	1.091	1.067-1.117
P	-1.182	7.043	0.008	0.307	0.128-0.734
Ca-P product	0.081	19.301	<0.001	1.085	1.046-1.125
Diabetes mellitus	0.712	4.312	0.038	2.039	1.041-3.995

CKD: chronic kidney disease; AC: aortic calcification; P: phosphorus; Ca: calcium.

表 5 血清磷水平与 LVH 及 AC 的相关性分析

Table 5 Correlation of blood phosphorus level with AC and LVH

Group	*n*	LVH	AC
Normal phosphorus	106	65(61.32)	57(53.77)
Low phosphorus	36	26(72.22)	21(58.33)
High phosphorus	127	102(80.31)*	81(63.78)
P value		0.024	0.150

LVH: left ventricular hypertrophy; AC: aortic calcification. Compared with normal phosphorus group, *$P<0.05$.

左室肥大、心血管事件(如心肌梗死、充血性心力衰竭)出现。有研究称,血清磷升高可增加 AC 的发生率,磷酸钙晶体在血管中沉积引起的 AC 是 CKD 相关死亡和心血管并发症的主要原因[13]。钙化血管弹性降低,更易发生 AC,引起心脏功能障碍[14]。动物实验表明,高水平的细胞外磷酸盐可刺激血管平滑肌细胞(vascular smooth muscle cells, VSMCs)转分化为成骨样细胞,增加 VSMCs 中钙的积累,从而诱导钙化[15]。高血清磷也可诱导 VSMCs 中特定平滑肌蛋白表达的缺失,并使 VSMCs 获得软骨表型[16]。有研究指出,血液透析患者随着年龄的增加,血管在不断血流冲击和舒缩活动的刺激下,发生脂类物质堆积、平滑肌及弹力蛋白减少等结构性改变,也会造成血管壁内膜发生钙化,且随着血液透析时间的增加,患者血管内钙磷被动沉积、钙化促进因子活性增加以及钙化抑制因子活性降低,会促进血管钙化[12]。此外,本研究 AC 组患者降磷药物使用率显著低于非 AC 组。2016 年的一项研究[17]也发现了磷结合剂在中国的使用情况并不令人满意,提醒临床医师需要重视 CKD 患者矿物质代谢紊乱的治疗。

综上,CKD 维持性血液透析患者高磷血症与心血管参数 LVH 和 AC 独立相关。对 CKD 患者血清磷水平进行控制,有利于减少心血管事件的发生率及改善预后。本研究有以下局限性:首先,本研究为基于横断面数据的回顾性研究,无法做出因果推断;其次,本研究虽对血清磷浓度分层分析,但例数较少,仅初步探讨不同血清磷浓度与 LVH 及 AC 的关系;第三,研究中心血管参数的测量并没有包含整个队列。

【参考文献】

[1] Zhang L, Wang F, Wang L, *et al*. Prevalence of chronic kidney disease in China: a cross-sectional survey[J]. Lancet, 2012, 379(9818): 815-822. DOI: 10.1016/S0140-6736(12)60033-6.

[2] Yang C, Wang, H, Zhao X, *et al*. CKD in China: evolving spectrum and public health implications[J]. Am J Kidney Dis, 2020, 76(2): 258-264. DOI: 10.1053/j.ajkd.2019.05.032.

[3] Jankowski J, Floege J, Fliser D, *et al*. Cardiovascular disease in chronic kidney disease: pathophysiological insights and therapeutic options[J]. Circulation, 2021, 143(11): 1157-1172. DOI: 10.1161/CIRCULATIONAHA.120.050686.

[4] Major RW, Cheng MRI, Grant RA, *et al*. Cardiovascular disease risk factors in chronic kidney disease: a systematic review and meta-analysis[J]. PLoS One, 2018, 13(3): e0192895. DOI: 10.1371/journal.pone.0192895.

[5] Reichek N, Helak J, Plappert T, *et al*. Anatomic validation of left ventricular mass estimates from clinical two-dimensional echocardiography: initial results[J]. Circulation, 1983, 67(2): 348-52. DOI: 10.1161/01.cir.67.2.348.

[6] Lang RM, Badano LP, Mor-Avi V, *et al*. Recommendations for cardiac chamber quantification by echocardiography: an update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging[J]. J Am Soc Echocardiogr, 2015, 28(1): 1-39, e14. DOI: 10.1016/j.echo.2014.10.003.

[7] Dhingra R, Gona P, Benjamin EJ, *et al*. Relations of serum phosphorus levels to echocardiographic left ventricular mass and incidence of heart failure in the community[J]. Eur J Heart Fail, 2010, 12(8): 812818. DOI: 10.1093/eurjhf/hfq106.

[8] Selamet U, Tighiouart H, Sarnak MJ, *et al*. Relationship of dietary phosphate intake with risk of end-stage renal disease and mortality in chronic kidney disease stages 3-5: the modification of diet in renal disease study[J]. Kidney Int, 2016, 89(1): 176-184. DOI: 10.1038/ki.2015.284.

[9] Chue CD, Edwards NC, Moody WE, *et al*. Serum phosphate is associated with left ventricular mass in patients with chronic kidney disease: a cardiac magnetic resonance study[J]. Heart, 2012, 98(3): 219-224. DOI: 10.1136/heartjnl-2011-300570.

[10] Wang J, Wang F, Dong S, *et al*. Levels of serum phosphorus and cardiovascular surrogate markers[J]. J Atheroscler Thromb, 2016, 23(1): 95-104. DOI: 10.5551/jat.31153.

[11] Nakamura H, Tokumoto M, Mizobuchi M, *et al*. Novel markers of left ventricular hypertrophy in uremia[J]. Am J Nephrol, 2010, 31(4): 292-302. DOI: 10.1159/000279768.

[12] 姜聪娇, 杜小英, 金劼. 终末期肾病行血液透析患者腹主动脉钙化进展的相关因素研究[J]. 现代实用医学, 2019, 31(2): 180-182. DOI: 10.3969/j.issn.1671-0800.2019.02.018.

[13] Mizobuchi M, Towler D, Slatopolsky E. Vascular calcification: the killer of patients with chronic kidney disease[J]. J Am Soc Nephrol, 2009, 20(7): 1453-1464. DOI: 10.1681/ASN.2008070692.

[14] Reid IR, Gamble GD, Bolland MJ. Circulating calcium concentrations, vascular disease and mortality: a systematic review[J]. J Intern Med, 2016, 279(6):524-540. DOI: 10.1111/joim.12464.

[15] Yao L, Sun YT, Sun W, *et al*. High phosphorus level leads to aortic calcification *via* ßcatenin in chronic kidney disease[J]. Am J Nephrol, 2015, 41(1): 2836. DOI: 10.1159/000370250.

[16] Leopold JA. Vascular calcification: mechanisms of vascular smooth muscle cell calcification[J]. Trends Cardiovasc Med, 2015, 25(4): 267-74. DOI: 10.1016/j.tcm.2014.10.021.

[17] Zhou C, Wang F, Wang JW, *et al*. Mineral and bone disorder and its association with cardiovascular parameters in Chinese patients with chronic kidney disease[J]. Chin Med J (Engl), 2016, 129(19): 2275-2280. DOI: 10.4103/0366-6999.190678.

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