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· 专题研究 ·

继发性甲状旁腺功能亢进患者术后严重低钙血症风险评估模型的构建与验证

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摘要

背景与目的: 甲状旁腺切除术 (PTX) 是治疗难治性或进展性继发性甲状旁腺功能亢进 (SHPT) 的有效方法, 严重低钙血症 (SH) 是术后常见且严重的并发症, 术前有效预测 SH 对 SHPT 患者的术后管理及针对性干预治疗具有重要的临床价值, 但目前尚无 SH 风险预测评分系统。因此, 本研究探讨 SHPT 患者行 PTX 后发生 SH 的危险因素并构建术前风险预测评分模型, 以期为临床提供参考。

方法: 回顾性分析 2010 年 11 月—2022 年 3 月在中国人民解放军联勤保障部队第九六〇医院行甲状旁腺全切加自体移植术 (tPTX+AT) 的 513 例 SHPT 患者临床资料, 将患者按入院时间分为建模组 (404 例), 验证组 (109 例)。根据术后 3 d 内最低的血钙水平将患者分为 SH 组和非 SH 组, 进行单因素和多因素分析, 以确定术后 SH 的独立危险因素, 利用 Logistic 回归构建 SH 风险预测评分模型, 分别在建模组和验证组中应用受试者工作特征曲线 (ROC) 对模型进行内部验证和外部验证。

结果: 全组 513 例患者中 237 例 (46.20%) 发生术后 SH。在建模组中, 单因素分析显示, 皮肤瘙痒、身高缩短、年龄以及术前血红蛋白、碱性磷酸酶 (ALP)、白蛋白、血钙、全段甲状旁腺激素 (iPTH)、骨钙素、术前 I 型胶原 C 端肽分解片段 (β -CT_x) 与术后 SH 明显有关 (均 $P < 0.05$); 多因素分析显示, 术前 ALP > 363.5 U/L、iPTH > 2 239 pg/mL、 β -CT_x > 3.305 μ g/L 和身高缩短是术后 SH 的独立危险因素, 术前血钙 > 2.50 mmol/L 是术后 SH 的保护因素 (均 $P < 0.05$)。将 ALP > 363.5 U/L、iPTH > 2 239 pg/mL、 β -CT_x > 3.305 μ g/L 作为预测因子构建 SH 风险预测评分模型, 阳性时分别赋值 7、4、6 分, 阴性时均为 0 分。结果显示, 10~13 分时 SH 发生率为 58.82%、17 分时 SH 发生率为 82.93%。该模型在建模组和验证组 ROC 曲线下的面积 (AUC) 分别为 0.811 (95% CI=0.768~0.853)、0.826 (95% CI=0.745~0.906), 均有统计学意义 (均 $P < 0.05$)。

结论: 构建的 SHPT 患者行 PTX 后发生 SH 的风险预测评分模型预测效能较好, 可用于术前识别高风险患者, 为临床指导 SHPT 患者的术后管理和治疗提供重要参考。

关键词

甲状旁腺功能亢进症, 继发性; 甲状旁腺切除术; 低钙血症; 危险因素

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Establishment and validation of postoperative risk scoring model for severe hypocalcemia in patients with secondary hyperparathyroidism after surgery

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Abstract

Background and Aims: Parathyroidectomy (PTX) is an effective method for the treatment of refractory or progressive secondary hyperparathyroidism (SHPT). Severe hypocalcemia (SH) is a common and serious postoperative complication. Preoperative prediction of SH has crucial clinical value for postoperative management and targeted intervention of SHPT patients, but the risk prediction scoring model has not been established. Therefore, this study was designed to investigate SH risk factors in patients with SHPT after PTX and construct a preoperative risk prediction score model for clinical application.

Methods: The clinical data of 513 patients with SHPT who underwent total PTX plus autotransplantation in the 960th Hospital of PLA from November 2010 to March 2022 were retrospectively analyzed. According to admission time, they were allocated to model group (404 cases) and validation group (109 cases). The patients were classified into SH and non-SH groups according to the lowest serum calcium level within 3 d after surgery. Univariate and multivariate analyses were conducted to determine the independent risk factors for postoperative SH. Logistic regression was used to establish a predictive scoring model. The receiver operating characteristic curve (ROC) was applied to verify the model internally and externally in the model and validation groups, respectively.

Results: In the whole group of 513 patients, SH occurred in 237 cases (46.20%). In the model group, univariate analysis showed that pruritus, height shortening, age, preoperative hemoglobin, alkaline phosphatase (ALP), albumin, serum calcium, intact parathyroid hormone (iPTH), osteocalcin, β -Crosslaps (β -CT_x) were significantly associated with postoperative SH (all $P < 0.05$). Multivariate analysis showed that preoperative ALP > 363.5 U/L, iPTH $> 2\ 239$ pg/mL, β -CT_x > 3.305 μ g/L, and height shortening were independent risk factors for postoperative SH and preoperative serum calcium > 2.50 mmol/L were protective factor against postoperative SH (all $P < 0.05$). The ALP > 363.5 U/L, iPTH $> 2\ 239$ pg/mL, and β -CT_x > 3.305 μ g/L were used to establish the SH risk prediction scoring model, with the positive corresponding points of 7, 4, and 6, respectively, and the negative value of 0. The results showed that the incidence of SH was 58.82% at 10-13 points and 82.93% at 17 points. The area under ROC curves for the model group and the validation group was 0.811 (95% CI=0.768–0.853) and 0.826 (95% CI=0.745–0.906), respectively, both of which were statistically significant (both $P < 0.05$).

Conclusion: The risk prediction scoring model effectively predicts the incidence of SH after PTX in SHPT patients, which can be used to identify high-risk patients before operation and provide an essential reference for clinical guidance of postoperative management and treatment of SHPT patients.

Key words

Hyperparathyroidism, Secondary; Parathyroidectomy; Hypocalcemia; Risk Factors

CLC number: R653.2

近年来,慢性肾脏病(chronic kidney disease, CKD)的患病率在全球范围内日益攀升,已成为威胁公共健康的全球性问题。继发性甲状旁腺功能亢进(secondary hyperparathyroidism, SHPT)是CKD患者常见的并发症,可导致骨骼、皮肤及心脑血管等多系统疾病,严重影响患者的生活质量及长期生存^[1-3]。甲状旁腺切除术(parathyroidectomy, PTX)适用于内科治疗无效的顽固性或进展性SHPT患者,临床疗效显著^[4-8]。严重低钙血症(severe hypocalcemia, SH)是PTX术后常见且严重的并发症,发病率为31.7%~76.3%,严重者可导致癫痫、充血性心力衰竭甚至猝死^[9-10]。术前有效预测SH对SHPT患者的术后管理及针对性干预治疗具有重要的临床价值,相关研究^[9-13]表明,术前碱性磷酸酶(alkaline phosphatase, ALP)、血红蛋白、血钙及全段甲状旁腺激素(intact parathyroid hormone, iPTH)是术后SH的独立危险因素。然而,这些研究样本量小,且尚未构建起术前风险预测评分模型。本研究回顾性分析SHPT患者手术前后的临床资料,旨在探讨SHPT患者PTX术后发生SH的独立危险因素,并构建一种综合多种危险因素、高效、简洁的术前风险预测评分模型,以期为术后SH高危人群的个体化治疗提供重要参考。

1 资料与方法

1.1 一般资料

1.1.1 研究对象 选取2010年11月—2021年5月在中国人民解放军联勤保障部队第九六〇医院接受甲状旁腺全切加自体移植术(total parathyroidectomy with autotransplantation, tPTX+AT)的SHPT患者404例为建模组,选取2021年6月—2022年3月接受tPTX+AT的SHPT患者109例为验证组。收集患者性别、年龄、体质量、透析龄、是否服用西那卡塞、伴随症状(皮肤瘙痒、骨骼畸形、身高缩短、骨痛)、甲状旁腺切除术数目以及术前25羟维生素D、骨钙素、I型胶原氨基端前肽(propeptide of type I procollagen, PINP)、I型胶原C端肽分解片段(β -Crosslaps, β -CT_x)、血红蛋白、白蛋白、ALP、iPTH、血磷、血钙结果。术后3 d内最低的血钙水平 <1.875 mmol/L (7.5 mg/L)定义为SH,将患者分为SH组和非SH组以比较两组

间数据差异^[9, 14-15]。参考《慢性肾脏病继发甲状旁腺功能亢进外科临床实践中国专家共识(2021版)》^[1],手术指征为:(1)持续性iPTH >800 ng/mL ($15\sim65$ ng/L);(2)超声提示至少1个甲状旁腺直径 >1 cm或^{99m}Tc同位素甲氧基异丁基异腈显示高密度影;(3)无水酒精注射、甲状旁腺热消融以及内科治疗无效;(4)伴身高缩短、严重骨痛、骨骼畸形等症状严重影响生活质量。禁忌证为:(1)合并严重心、肺等功能障碍不能耐受手术;(2)严重凝血功能异常;(3)各类感染急性期。

1.1.2 纳入标准与排除标准 纳入标准:(1)初次接受PTX的SHPT患者;(2)术后20 min iPTH下降 $>$ 术前的80%;(3)病历资料完整。排除标准:(1)术后持续性甲状旁腺功能亢进;(2)二次手术;(3)病历资料不完整。本研究已经中国人民解放军联勤保障部队第九六〇医院科研伦理委员会审批通过[批件号:(2019)科研伦理审第(03)号]。

1.2 研究方法

1.2.1 手术方法 所有患者手术方式均为tPTX+AT。术前1 d行无肝素血液透析1次,术中切除的病变组织送快速冷冻病理,术后10、20 min分别抽取下肢静脉血送检甲状旁腺激素。若快速病理学证实切除组织均为甲状旁腺组织良性增生且术后20 min测得iPTH较术前至少下降80%则认定手术成功,否则需根据iPTH水平及术者经验进一步探查。具体手术流程详见本中心前期发表文献^[16]。

1.2.2 术后补钙方案 所有患者术后立即给予:10%葡萄糖酸钙注射液60~80 mL,10 mL/h泵入;口服碳酸钙600 mg/次,2次/d;骨化三醇胶囊0.5 μ g/次,2次/d。术后1周内监测血钙、血磷、iPTH 1次/d,必要时可2~3次/d。若患者无手足麻木、抽搐等低钙血症症状,术后当天不再补钙;若出现低钙血症症状且急查血钙提示SH,则按上述速度持续泵入钙剂,待无明显临床症状且血钙持续 >1.8 mmol/L,酌情过度至口服补钙,待血钙水平稳定在正常范围,口服钙则每次减少原剂量的1/3~1/2直至停药。术后24 h内采用浓度为1.75 mmol/L的高钙透析液行无肝素血液透析。

1.3 统计学处理

应用SPSS 26.0统计学软件进行数据分析。所有数据中服从正态分布的变量用平均值 \pm 标准差($\bar{x} \pm s$)表示,两组间比较采用独立样本 t 检验;不服从正态分布的变量用中位数(四分位间距)

[$M(IQR)$]表示,两组间比较采用独立样本非参数检验;分类变量两组间比较采用 χ^2 检验。将单因素分析中有统计学意义的变量纳入多因素分析,多因素分析采用二元 Logistic 回归分析,利用 Youden 指数计算危险因素临界值。构建模型采用二元 Logistic 回归分析,依据 β 值对危险因素赋分。各风险层 SH 发生率的比较采用秩和检验。利用受试者工作特征(ROC)曲线下的面积(AUC)判别模型准确度。 $P<0.05$ 为差异有统计学意义。

2 结果

2.1 一般情况

全组 513 例患者中 237 例(46.20%)发生术后 SH。建模组 404 例患者中,男 244 例,女 160 例;平均年龄(46.07±11.09)岁;其中 195 例(48.27%)发

生术后 SH。验证组 109 例患者中,男 65 例,女 44 例;平均年龄(48.79±10.92)岁;其中 42 例(38.53%)发生术后 SH。

2.2 SHPT 患者术后 SH 危险因素分析

单因素分析建模组中两组患者一般情况、临床症状、实验室指标,结果显示,皮肤瘙痒、身高缩短、年龄以及术前血红蛋白、ALP、白蛋白、血钙、iPTH、骨钙素、 β -CT_x 两组间比较具有统计学意义(均 $P<0.05$)(表 1)。将单因素分析结果有统计学意义的变量纳入多因素分析,结果显示,术前 ALP、iPTH、 β -CT_x 和身高缩短是术后 SH 的独立危险因素,术前血钙是术后 SH 的保护因素(均 $P<0.05$)(表 2)。利用 Youden 指数计算 ALP、iPTH、 β -CT_x 和血钙的临界值,分别为 363.5 U/L、2 239 pg/mL、3.305 μ g/L、2.50 mmol/L。

表 1 SHPT 患者 PTX 术后 SH 危险因素单因素分析

Table 1 Univariate analysis of risk factors for SH in patients with SHPT after PTX

因素	SH 组(n=195)	非 SH 组(n=209)	P
性别[n(%)]			
男	125(64.1)	119(56.94)	0.141
女	70(35.9)	90(43.06)	
服用西那卡塞[n(%)]	58(29.74)	65(31.10)	0.767
严重皮肤瘙痒[n(%)]	6(3.08)	22(10.53)	0.003
骨骼畸形[n(%)]	10(5.13)	6(2.87)	0.245
身高缩短[n(%)]	73(37.44)	47(22.49)	0.001
骨痛[n(%)]	157(80.51)	154(73.68)	0.103
术前血红蛋白(g/L, $\bar{x} \pm s$)	107.86±18.92	113.58±19.14	0.003
年龄[岁, $M(IQR)$]	46.0(36.0~53.0)	48.0(39.0~55.0)	0.006
体质量[kg, $M(IQR)$]	60(52~68)	60(54~70)	0.292
术前 ALP [U/L, $M(IQR)$]	652(377~1 057)	215(121~374)	0.000
术前白蛋白[g/L, $M(IQR)$]	38.1(35.4~41.6)	41.2(38.05~44.05)	0.000
术前血磷[mmol/L, $M(IQR)$]	2.21(1.91~2.55)	2.13(1.85~2.425)	0.098
术前血钙[mmol/L, $M(IQR)$]	2.43(2.29~2.55)	2.52(2.4~2.65)	0.000
术前 iPTH [pg/mL, $M(IQR)$]	2 463(1 803~3 058)	1 404(1 038~2 078.5)	0.000
术前 25 羟维生素 D [ng/mL, $M(IQR)$]	15.74(9.39~23.93)	15.46(10.21~25.265)	0.739
术前骨钙素[μ g/L, $M(IQR)$]	211.3(169~281.6)	263(216.55~300)	0.000
术前 PINP [ng/mL, $M(IQR)$]	1 200(1 056~1 200)	1 200(1 102.5~1 200)	0.999
术前 β -CT _x [μ g/L, $M(IQR)$]	6(5.02~6)	6(4.19~6)	0.011
透析龄[年, $M(IQR)$]	7(5~8)	7(5~10)	0.212
甲状旁腺切除数目[枚, $M(IQR)$]	4(4~4)	4(4~4)	0.520

表2 SHPT患者PTX术后SH危险因素多因素分析

Table 2 Multivariate analysis of risk factors for SH in SHPT patients after PTX

危险因素	β	Wald	OR	P
身高缩短	0.587	3.908	1.798	0.048
术前ALP (U/L)	0.001	12.086	1.001	0.001
术前血钙 (mmol/L)	-3.470	25.076	0.031	0.000
术前iPTH (pg/mL)	0.001	16.164	1.001	0.000
术前 β -CT _x (μ g/L)	0.562	12.588	1.754	0.000

2.3 风险预测评分模型的构建

依据临界值将各危险因素数据二分类后纳入二元 Logistic 回归分析筛选预测因子 (表3)。将ALP>363.5 U/L、iPTH>2 239 pg/mL、 β -CT_x>3.305 μ g/L作为预测因子构建SH风险预测评分模型,以 $\beta \times 4^{[17]}$ (四舍五入取整)的值作为预测因子阳性时的分值,阴性时均为0分,根据构建的风险预测评分模型对所有患者进行评分,比较各分值对应的SH发生率,进行风险分层。最终评估,得分0分为极低风险组,SH发生率为6.06%;4~7分为低风险组,SH发生率为21.23%;10~13分为中风险组,SH发生率为58.82%;17分为高风险组,SH发生率为82.93% (表4)。各风险层SH发生率差异具有统计学意义(均 $P<0.05$)。

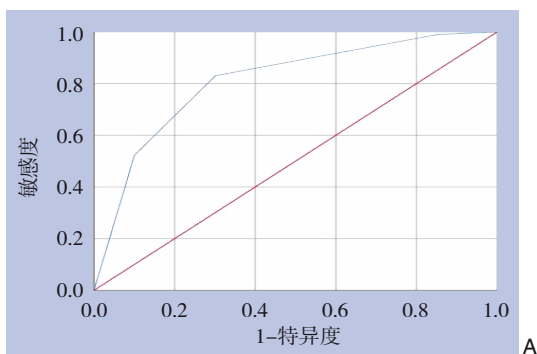


表3 SHPT患者PTX术后SH风险预测因子二元 Logistic 回归分析

Table 3 Binary Logistic regression analysis of SH risk predictors after PTX in SHPT Patients

预测因子	β	Wald	OR	P
术前ALP>363.5(U/L)	1.740	42.591	5.696	0.000
术前iPTH>2239(pg/mL)	1.083	15.018	2.952	0.000
术前 β -CT _x >3.305(μ g/L)	1.383	7.377	3.987	0.007

表4 SH风险评分分层

Table 4 Risk scoring stratification for SH

风险等级	分值	患者例数 (n)	SH例数 (n)	发生率 (%)
极低风险组	0	33	2	6.06
低风险组	4~7	146	31	21.23
中风险组	10~13	102	60	58.82
高风险组	17	123	102	82.93

2.4 风险预测评分模型的验证

以实际SH结果作为状态变量,以风险评分值作为检验变量绘制ROC曲线,结果显示,建模组中模型的ROC的AUC为0.811(95%CI=0.768~0.853)($P<0.05$);验证组中模型的ROC的AUC为0.826(95%CI=0.745~0.906)(均 $P<0.05$)(图1)。

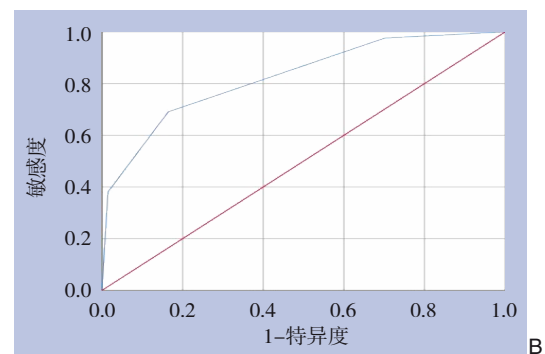


图1 ROC曲线评价SH风险预测评分模型的预测价值

A: 建模组(内部验证); B: 验证组(外部验证)

Figure 1 Predictive value of ROC curve for evaluating the SH risk prediction scoring model

A: Model group (internal validation); B: Validation group (external validation)

3 讨论

3.1 SH危险因素

SH已是公认的SHPT患者PTX术后的严重并发症,随着认识的不断加深,其危险因素的研究越来越被重视^[18-20]。本研究结果显示,术后SH的发生率为46.7%,与既往研究^[9-10]报道的31.7%~76.3%相

符合。相关研究^[9,21-23]已证实,术后SH的发生受多种因素的影响,本研究多因素分析结果显示,术前ALP>363.5 U/L、iPTH>2 239 pg/mL、 β -CT_x>3.305 μ g/L和身高缩短是术后SH的独立危险因素,术前血钙>2.50 mmol/L是术后SH的保护因素。

多项研究^[21, 23-24]证实术前ALP和术后SH相关,本研究单因素和多因素分析显示,术前ALP是术

后SH的独立影响因素,随着ALP水平的增高SH发生的风险也会随之增加。但不同研究者计算出的临界值存在差异,本研究结果ALP的临界值363.5 U/L,而其他研究^[11,21,23]结果ALP的临界值分别有307、420、277 U/L,这种差异可能与不同研究中心样本量、纳入标准以及围手术期管理不同有关,因此,未来还需综合多中心、大样本的临床研究,以提高其准确性和实用性。

iPTH的分泌主要受血钙浓度的调节,但在CKD患者中,甲状旁腺对钙的敏感度明显降低,导致机体需持续性刺激甲状旁腺分泌iPTH以维持正常的血钙浓度,最终发展为SHPT^[25]。iPTH也是反应SHPT患者骨吸收的重要指标,有研究显示,iPTH可促进骨吸收^[20,26],其机制为iPTH活化成骨细胞后可激活破骨细胞从而促进骨吸收(成骨-破骨细胞耦联)^[27]。然而,术后iPTH水平的骤然下降,导致成骨-破骨细胞耦联活化被破坏,骨吸收减弱,大量血钙被吸收入骨^[28],这间接解释了术前低iPTH和低钙与术后SH发生的关系。本研究及既往相关研究^[10,21-22]证实,术前iPTH和血钙水平是术后发生SH的独立危险因素,术前iPTH水平与术后SH的发生呈正相关,术前血钙水平与术后SH的发生呈负相关。并且本研究通过计算得出血钙 >2.50 mmol/L是术后发生SH的保护因素,这或许可以为术前预防性补钙和术后干预提供新的思路 and 参考。

此外,本研究结果显示, β -CT_x和身高缩短是术后SH的独立危险因素,这也是关于术后SH危险因素研究的新发现和新突破。既往鲜有研究报道 β -CT_x和身高缩短与术后SH相关,其作用机制尚不十分明确。据有关退缩人综合征的临床研究^[29]报道,透析龄、ALP、PTH、成纤维细胞生长因子-23是SHPT患者身高缩短的危险因素,由此推测,伴身高缩短的SHPT患者往往长期处于钙磷调节及骨代谢紊乱、iPTH和ALP水平较高且病情较重,因此术后发生SH的概率更高。据报道^[12,15,30],年龄、术前血红蛋白和白蛋白也被认为是术后SH的独立危险,但在本研究中未得到证实,还需更多的前瞻性研究来明确这些变量在术后SH发展中的作用。

3.2 SH风险评分模型的构建

目前,对于SHPT患者PTX术后SH的预测多是基于单个危险因素,但单个危险因素的预测能

力是有限的。因此,笔者筛选出术前ALP >363.5 U/L、iPTH $>2\ 239$ pg/mL、 β -CT_x >3.305 μ g/L三项危险因素作为预测因子构建SH风险预测评分模型,以 $\beta \times 4^{[17]}$ (四舍五入取整)的值作为预测因子阳性时的分值,得出其阳性时分别赋值7、4、6分,阴性时均为0分,再通过简单的分值相加得出总分,10~13分为中风险组,SH发生率为58.82%;17分为高风险组,SH发生率为82.93%。该风险评分模型可简单、方便、有效地预测术后SH的发生率,使预防性干预更具有针对性,使术后处理更具有时效性,这是本研究的创新点。应用ROC曲线评价该模型的准确度,一般认为,AUC >0.7 ,即可认为模型诊断效果较好,AUC越大,诊断的准确性越高。本研究SH风险预测评分模型在建模组和验证组ROC的AUC分别为0.811(95% CI=0.768~0.853)、0.826(95% CI=0.745~0.906),说明该模型可以较好地预测术后SH的发生率。但本研究依然存在不足,首先,未对高危患者的针对性干预及治疗提供具体方案,只是构建出风险预测评分模型为临床提供参考,补充钙的个体化预防策略还需凭借临床医生的经验及更多前瞻性研究评估;其次,本研究为单中心临床研究,未进行多中心临床研究与验证,为提高其准确性和实用性,还需多中心、大样本的外部验证。

综上所述,本研究认为术前ALP >363.5 U/L、iPTH $>2\ 239$ pg/mL、 β -CT_x >3.305 μ g/L和身高缩短是术后发生SH的独立危险因素;术前血钙 >2.50 mmol/L是术后发生SH的保护因素;建立的风险预测评分模型简单、方便、有效,可为早识别、早预防、早治疗SHPT患者PTX术后SH提供帮助。

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参考文献

- [1] 中国医师协会外科医师分会甲状腺外科医师委员会,中国研究型医院学会甲状腺疾病专业委员会.慢性肾脏病继发性甲状旁腺功能亢进外科临床实践中国专家共识(2021版)[J].中国实用外科杂志,2021,41(8):841-848. doi: 10.19538/j. cjps. issn1005-2208.2021.08.01. Chinese Thyroid Association, Specialized Committee of Thyroid Disease of Chinese Research Hospital Association. Chinese expert consensus on surgical practice of hyperthyroidism in patients with chronic kidney disease(2021 edition) [J]. Chinese Journal of

- Practical Surgery, 2021, 41(8): 841-848. doi: 10.19538/j. cjps. issn1005-2208.2021.08.01.
- [2] Mizobuchi M, Ogata H, Koiwa F. Secondary hyperparathyroidism: pathogenesis and latest treatment[J]. Ther Apher Dial, 2019, 23(4): 309-318. doi: 10.1111/1744-9987.12772.
- [3] Xu Y, Evans M, Soro M, et al. Secondary hyperparathyroidism and adverse health outcomes in adults with chronic kidney disease[J]. Clin Kidney J, 2021, 14(10):2213-2220. doi: 10.1093/ckj/sfab006.
- [4] 周鹏, 贺青卿, 庄大勇, 等. 甲状旁腺全切加微量甲状旁腺自体移植术在肾性甲状旁腺功能亢进中的临床应用[J]. 中华内分泌外科杂志, 2018, 12(1): 34-38. doi: 10.3760/cma. j. issn. 1674-6090.2018.01.009.
- Zhou P, He QQ, Zhuang DY, et al. Application of total parathyroidectomy with autotransplantation in secondary hyperparathyroidism[J]. Chinese Journal of Endocrine Surgery, 2018, 12(1):34-38. doi:10.3760/cma.j.issn.1674-6090.2018.01.009.
- [5] 余慧, 张森, 郝丽, 等. 甲状旁腺切除术用于难治性肾性继发性甲状旁腺功能亢进的安全性及近远期疗效[J]. 中国普通外科杂志, 2020, 29(5):581-588. doi:10.7659/j.issn.1005-6947.2020.05.009.
- Yu H, Zhang S, Hao L, et al. Safety and short-and long-term efficacy of parathyroidectomy for refractory renal secondary hyperparathyroidism[J]. Chinese Journal of General Surgery, 2020, 29(5):581-588. doi:10.7659/j.issn.1005-6947.2020.05.009.
- [6] 杨昱, 沈世凯, 张健. 甲状旁腺全切除自体前臂移植术治疗肾功能不全继发性甲状旁腺功能亢进[J]. 中国普通外科杂志, 2016, 25(5):643-647. doi:10.3978/j.issn.1005-6947.2016.05.003.
- Yang Y, Shen SK, Zhang J. Efficacy of total parathyroidectomy with forearm autograft for hyperparathyroidism secondary to chronic renal failure[J]. Chinese Journal of General Surgery, 2016, 25(5): 643-647. doi:10.3978/j.issn.1005-6947.2016.05.003.
- [7] Zhang Y, Lu Y, Feng S, et al. Evaluation of laboratory parameters and symptoms after parathyroidectomy in dialysis patients with secondary hyperparathyroidism[J]. Ren Fail, 2019, 41(1):921-929. doi: 10.1080/0886022X.2019.1666724.
- [8] Lim CTS, Kalaiselvam T, Kitan N, et al. Clinical course after parathyroidectomy in adults with end-stage renal disease on maintenance dialysis[J]. Clin Kidney J, 2018, 11(2):265-269. doi: 10.1093/ckj/sfx086.
- [9] Liu J, Huang QH, Yang M, et al. Risk factors predicting severe hypocalcemia after total parathyroidectomy without autotransplantation in patients with secondary hyperparathyroidism[J]. J Int Med Res, 2020, 48(1): 300060519897505. doi: 10.1177/0300060519897505.
- [10] Wang MJ, Chen BJ, Zou XH, et al. A nomogram to predict hungry bone syndrome after parathyroidectomy in patients with secondary hyperparathyroidism[J]. J Surg Res, 2020, 255:33-41. doi: 10.1016/j.jss.2020.05.036.
- [11] 李昱洁, 余跃天, 殷荣, 等. 继发性甲状旁腺功能亢进患者术后严重低钙血症的危险因素[J]. 临床与病理杂志, 2019, 39(7):1513-1520. doi:10.3978/j.issn.2095-6959.2019.07.022.
- Li YJ, Yu YT, Yin R, et al. Risk factors for post parathyroidectomy hypocalcemia in patients with secondary hyperparathyroidism[J]. Journal of Clinical and Pathological Research, 2019, 39(7): 1513-1520. doi:10.3978/j.issn.2095-6959.2019.07.022.
- [12] 成铭, 黄碧红, 陶冶, 等. 维持性血液透析继发性甲状旁腺功能亢进患者甲状旁腺切除术后低钙血症的危险因素分析[J]. 中华肾脏病杂志, 2022, 38(5): 397-405. doi: 10.3760/cma. j. cn441217-20210803-00057.
- Cheng M, Huang BH, Tao Y, et al. Risk factors for hypocalcemia after parathyroidectomy in maintenance hemodialysis patients with secondary hyperparathyroidism[J]. Chinese Journal of Nephrology, 2022, 38(5): 397-405. doi: 10.3760/cma. j. cn441217-20210803-00057.
- [13] 杨光, 王宁宁, 查小明, 等. 维持性血液透析患者甲状旁腺切除术后发生骨饥饿综合征的影响因素[J]. 中华肾脏病杂志, 2019, 35(8):568-574. doi: 10.3760/cma.j.issn.1001-7097.2019.08.002.
- Yang G, Wang NN, Zha XM, et al. Influencing factors of hungry bone syndrome in maintenance hemodialysis patients after parathyroidectomy[J]. Chinese Journal of Nephrology, 2019, 35(8): 568-574. doi: 10.3760/cma.j.issn.1001-7097.2019.08.002.
- [14] Sun XL, Zhang XQ, Lu Y, et al. Risk factors for severe hypocalcemia after parathyroidectomy in dialysis patients with secondary hyperparathyroidism[J]. Sci Rep, 2018, 8(1): 7743. doi: 10.1038/s41598-018-26142-9.
- [15] 张洪彬, 赵寒辉, 王素霞, 等. 303例甲状旁腺切除术围术期观察及术后严重低钙血症危险因素分析[J]. 山东大学学报: 医学版, 2020, 58(9):14-20. doi:10.6040/j.issn.1671-7554.0.2020.090.
- Zhang HB, Zhao HH, Wang SX, et al. Perioperative observation and postoperative risk factors of severe hypocalcemia after parathyroidectomy: a report of 303 cases[J]. Journal of Shandong University: Health Science, 2020, 58(9): 14-20. doi: 10.6040/j.issn.1671-7554.0.2020.090.
- [16] 周鹏, 贺青卿, 庄大勇, 等. 持续性和复发性肾性甲状旁腺功能亢进的外科治疗[J]. 中华普通外科杂志, 2019, 34(9):766-770. doi: 10.3760/cma.j.issn.1007-631X.2019.09.006.
- Zhou P, He QQ, Zhuang DY, et al. Surgical management for persistent and recurrent renal hyperparathyroidism[J]. Zhong Hua Pu Tong Wai Ke Za Zhi, 2019, 34(9):766-770. doi:10.3760/cma.j.issn.1007-631X.2019.09.006.
- [17] 王力红, 魏楠, 赵霞, 等. 老年患者中央导管相关血流感染风险预测评分模型构建与验证[J]. 中国感染控制杂志, 2019, 18(3):225-231. doi:10.12138/j.issn.1671-9638.20194226.

- Wang LH, Wei N, Zhao X, et al. Establishment and validation of risk prediction scoring model of central line-associated bloodstream infection in elderly patients[J]. Chinese Journal of Infection Control, 2019, 18(3):225-231. doi:10.12138/j.issn.1671-9638.20194226.
- [18] Cabo J, Gallagher KC, Baregamian N. Challenges and controversies in the surgical management of uremic hyperparathyroidism: A systematic review[J]. Am J Surg, 2018, 216(4):713-722. doi:10.1016/j.amjsurg.2018.07.030.
- [19] Apetrii M, Goldsmith D, Nistor I, et al. Impact of surgical parathyroidectomy on chronic kidney disease-mineral and bone disorder (CKD-MBD) – A systematic review and meta-analysis[J]. PLoS One, 2017, 12(11): e0187025. doi: 10.1371/journal.pone.0187025.
- [20] Ho LY, Wong PN, Sin HK, et al. Risk factors and clinical course of hungry bone syndrome after total parathyroidectomy in dialysis patients with secondary hyperparathyroidism[J]. BMC Nephrol, 2017, 18(1):12. doi: 10.1186/s12882-016-0421-5.
- [21] Kritmetapak K, Kongpetch S, Chotmongkol W, et al. Incidence of and risk factors for post-parathyroidectomy hungry bone syndrome in patients with secondary hyperparathyroidism[J]. Ren Fail, 2020, 42(1):1118-1126. doi: 10.1080/0886022X.2020.1841655.
- [22] Wen P, Xu LL, Zhao SS, et al. Risk factors for severe hypocalcemia in patients with secondary hyperparathyroidism after total parathyroidectomy[J]. Int J Endocrinol, 2021, 2021:6613659. doi: 10.1155/2021/6613659.
- [23] Zou Y, Zhang NR, Tang Y, et al. Predictive markers for severe hypocalcemia in dialysis patients with secondary hyperparathyroidism after near-total parathyroidectomy[J]. Ann Palliat Med, 2021, 10(10): 10712-10719. doi: 10.21037/apm-21-2509.
- [24] Fonseca-Correa JI, Nava-Santana C, Tamez-Pedroza L, et al. Clinical factors associated with early and persistent hypocalcaemia after parathyroidectomy in patients on dialysis with severe hyperparathyroidism[J]. Nephrology (Carlton), 2021, 26(5): 408-419. doi: 10.1111/nep.13854.
- [25] van der Plas WY, Noltes ME, van Ginhoven TM, et al. Secondary and tertiary hyperparathyroidism: a narrative review[J]. Scand J Surg, 2020, 109(4):271-278. doi: 10.1177/1457496919866015.
- [26] Ge YF, Yang G, Wang NN, et al. Bone metabolism markers and hungry bone syndrome after parathyroidectomy in dialysis patients with secondary hyperparathyroidism[J]. Int Urol Nephrol, 2019, 51(8):1443-1449. doi: 10.1007/s11255-019-02217-y.
- [27] Goldfarb M, Gondek SS, Lim SM, et al. Postoperative hungry bone syndrome in patients with secondary hyperparathyroidism of renal origin[J]. World J Surg, 2012, 36(6): 1314-1319. doi: 10.1007/s00268-012-1560-x.
- [28] 杨光,王宁宁,葛益飞,等.尿毒症继发甲状旁腺功能亢进症患者甲状旁腺切除术后骨转换标志物的短期变化[J].中华肾脏病杂志, 2017, 33(10): 750-756. doi: 10.3760/cma.j.issn.1001-7097.2017.10.005.
- Yang G, Wang NN, Ge YF, et al. Postoperative variations of bone turnover markers in uremic patients with secondary hyperparathyroidism after parathyroidectomy[J]. Chinese Journal of Nephrology, 2017, 33(10): 750-756. doi: 10.3760/cma.j.issn.1001-7097.2017.10.005.
- [29] 张建荣,耿燕秋,孙长丽.慢性肾衰竭继发性甲状旁腺功能亢进合并退缩人综合征的临床分析[J].中华临床医师杂志:电子版, 2013, 7(23):10563-10566. doi: 10.3877/cma.j.issn.1674-0785.2013.23.041.
- Zhang JR, Geng YQ, Sun CL. Clinical analysis of Shrinking man syndrome resulted from secondary hyperparathyroidism[J]. Chinese Journal of Clinicians: Electronic Edition, 2013, 7(23): 10563-10566. doi:10.3877/cma.j.issn.1674-0785.2013.23.041.
- [30] 章荣贵.术前白蛋白水平对继发性甲状旁腺功能亢进患者术后重度低钙血症的预测价值[J].临床与病理杂志, 2022, 42(5): 1155-1160. doi:10.3978/j.issn.2095-6959.2022.05.022.
- Zhang RG. Value of preoperative albumin level in predicting severe postoperative hypocalcemia in patients with secondary hyperparathyroidism[J]. Journal of Clinical and Pathological Research, 2022, 42(5): 1155-1160. doi: 10.3978/j.issn.2095-6959.2022.05.022.

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