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THE PREDICTIVE VALUE OF SERUM LXA4, MK AND CXCL16 FOR RENAL DAMAGE IN CHILDREN WITH ALLERGIC PURPURA

PREDIKTIVNA VREDNOST SERUMSKIH LXA4, MK I CXCL16 ZA OŠTEĆENJE BUBREGA KOD DECE SA ALERGIJSKOM PURPUROM

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Summary

Background: To explore the predictive value of the combined application of serum intermediate factor (MK), lipoxin A4 (LXA4), and CXC chemokine ligand 16 (CXCL16) for renal damage in children with Henoch-Schönlein purpura (HSP).
Methods: 117 children with HSP who were admitted to our hospital between January 2021 and December 2024 were selected for the HSP group. After treatment, they were followed up for 6 months, and the occurrence of renal damage was statistically analysed. The control group consisted of an additional 59 youngsters who voluntarily enrolled and received health examinations during the same time frame. The levels of serum MK, LXA4, and CXCL16 in the two research groups were determined using an enzyme-linked immunosorbent assay, and clinical data from children with HSP were collected. Factors contributing to renal damage in children with HSP were investigated using both univariate and multivariate logistic regression. Serum MK, LXA4, and CXCL16 levels were analysed for their predictive value for renal impairment in children with HSP using receiver operating characteristic (ROC) curves.
Results: Compared with the control group, the levels of serum MK, LXA4 and CXCL16 in the HSP group were all increased ($P<0.05$). During the 6-month follow-up, among the 117 children with HSP, 35 cases developed renal damage (renal damage group), with an incidence rate of 29.91% (35/117), and the remaining 82 cases were in the

Kratak sadržaj

Uvod: Cilj je bio da se ispita prediktivna vrednost kombinovane primene serumskih nivoa srednjeg faktora (MK), lipoksina A4 (LXA4) i CXC hemokinskog liganda 16 (CXCL16) u proceni oštećenja bubrega kod dece sa »Henoch-Schönlein« purpurom (HSP).
Metode: U studiju je uključeno 117 dece sa HSP koja su bila hospitalizovana u našoj ustanovi između januara 2021. i decembra 2024. godine. Nakon lečenja, pacijenti su praćeni 6 meseci, a pojava oštećenja bubrega je statistički analizirana. Kontrolnu grupu je činilo dodatnih 59 zdrave dece koja su dobrovoljno pristupila sistematskim pregledima u istom periodu. Nivoi serumskih MK, LXA4 i CXCL16 su određeni metodom enzimski povezanog imunosorbentnog testa (ELISA), a prikupljeni su i klinički podaci dece sa HSP. Faktori koji doprinose oštećenju bubrega su analizirani korišćenjem univarijantne i multivarijantne logističke regresije. Prediktivna vrednost serumskih MK, LXA4 i CXCL16 za bubrežno oštećenje procenjena je putem ROC krive.
Rezultati: U poređenju sa kontrolnom grupom, nivoi serumskih MK, LXA4 i CXCL16 u HSP grupi bili su značajno povećani ($P<0,05$). Tokom šestomesečnog praćenja, od 117 dece sa HSP, 35 je razvilo oštećenje bubrega (grupa sa oštećenjem bubrega), što čini učestalost od 29,91% (35/117), dok su preostalih 82 deteta činila grupu bez oštećenja bubrega. U grupi sa oštećenjem bubrega

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non-renal damage group. The proportions of children with a diagnosis time of ≥7 days, respiratory tract infections, and serum levels of MK, LXA4, and CXCL16 in the renal damage group were all higher than those in the non-renal damage group (P<0.05). However, the percentages of children with joint pain/arthritis, gastrointestinal bleeding, and EBV infection did not change statistically significantly between the two groups in terms of gender, age, or body weight (P>0.05). According to multivariate logistic regression analysis, a diagnosis time of at least seven days, respiratory tract infection, and elevated levels of serum MK, LXA4, and CXCL16 were all independent risk factors for renal damage in children with HSP (P<0.05). The results of ROC curve analysis showed that the area under the curve for the combined prediction of serum MK, LXA4, and CXCL16 levels for renal damage in children with HSP was larger than that predicted by MK, LXA4, and CXCL16 alone (P<0.05).
Conclusions: The elevated levels of serum MK, LXA4 and CXCL16 in children with HSP are closely related to renal damage. The combined prediction of serum MK, LXA4 and CXCL16 levels in children with HSP has a relatively high value.

Keywords: allergic purpura, renal damage, mid-term factor, lipoxin A4, CXC chemokine ligand 16

zabeležen je veći procenat dece sa trajanjem bolesti ≥7 dana, respiratornim infekcijama i povišenim nivoima serumskih MK, LXA4 i CXCL16 u odnosu na grupu bez oštećenja (P<0,05). Nije bilo statistički značajnih razlika između grupa u pogledu pola, uzrasta, telesne mase, prisustva bolova u zglobovima/artritisa, gastrointestinalnog krvarenja i EBV infekcije (P>0,05). Multivarijantna logistička regresiona analiza je pokazala da su trajanje bolesti ≥7 dana, respiratorna infekcija i povišeni nivoi serumskih MK, LXA4 i CXCL16 nezavisni faktori rizika za bubrežno oštećenje kod dece sa HSP (P<0,05). ROC analiza je pokazala da je površina ispod krive (AUC) za kombinovanu predikciju serumskih MK, LXA4 i CXCL16 u otkrivanju oštećenja bubrega veća nego za svaki marker pojedinačno (P<0,05).
Zaključak: Povišeni nivoi serumskih MK, LXA4 i CXCL16 kod dece sa HSP blisko su povezani sa oštećenjem bubrega. Kombinovana analiza ovih biomarkera ima relativno visoku prediktivnu vrednost za procenu rizika od bubrežnog oštećenja.

Ključne reči: alergijska purpura, oštećenje bubrega, srednji faktor, lipoksin A4, CXC hemokinski ligand 16

Introduction

Small-vessel vasculitis is the primary pathological feature of allergic purpura (HSP), a frequent systemic disease in children (1). HSP small vessel vasculitis can affect multiple parts such as the skin, joints, kidneys and digestive tract (2). Although the course of most HSP children with renal damage is self-limiting, some HSP children may still develop chronic renal insufficiency or even renal failure. It seriously affects the child's prognosis (3). Renal biopsy is the »gold standard« for assessing kidney damage, but as an invasive procedure, it has disadvantages such as difficulty in sampling and significant pain to the child. Therefore, it is necessary to look for less invasive laboratory indicators (4–6). Mid-term factor (MK) is a heparin-binding growth factor that can promote inflammatory responses by regulating immune cells (7). Lipoxin A4(LXA4) is an endogenous lipid mediator that can bind to various cell surface receptors to inhibit inflammatory responses. CXC chemokine ligand 16(CXCL16) is a chemokine that can promote inflammatory responses by activating inflammatory cell pathways (8–10).

Renal damage is a key complication determining the long-term prognosis, which can be manifested as proteinuria and hematuria, and may also progress to chronic kidney disease (11). The current prediction of renal injury risk mainly relies on clinical manifestations and routine laboratory indicators, with limited sensitivity and specificity, making early stratification and intervention difficult. Inflammatory resolution mediator LXA4, pro-inflammatory and profibrotic growth factor MK, and chemokine CXCL16 are respectively involved in inflammation resolution, endothelial and immune cell interaction, lipid and oxidative stress pathways, and are closely related to immune complex-mediated glomerular injury, interstitial fibrosis and other links (12). As a serum marker, it is expected to reflect the inflammatory balance, endothelial injury and immune recruitment status, thereby enhancing the early recognition ability of renal damage. Constructing a multi-index prediction model with LXA4, MK, and CXCL16 may improve the accuracy of risk assessment, guide the frequency of follow-up and the intensity of treatment, reduce unnecessary renal biopsies, and lower the long-term burden on the kidneys (13–15). However, this field still faces challenges such as mechanism heterogeneity, insufficient temporal dynamics of markers and standardisation of detection, confounding effects of glucocorticoids, immunomodulatory therapy, and co-infections, and limited external generalizability due to differences across central populations (16). It is urgent to clarify the threshold and incremental predictive value in prospective cohorts of children and to verify them by comparing them with existing clinical scores and urogenic indicators, to lay the evidence base for precise prevention and individualised treatment (17–19).

Our study aims to analyse changes in serum MK, LXA4, and CXCL16 levels in children with HSP and to investigate their potential to predict renal damage, with the hope of providing a foundation for the prevention and treatment of renal impairment in children with HSP.

Materials and Methods

General information

The HSP group consisted of 117 children with HSP, 66 of whom were males and 51 of whom were girls, who were admitted to our hospital in January 2021 and December 2024. The average age was 5.86±1.32 years, with a range of 1 to 14 years old. The body weight ranged from 6.72 to 62.58 kg, with an average of (16.02±2.64) kg.

Inclusion criteria: (1) HSP met the relevant diagnostic criteria in the »International Recommendations for Evidence-Based Diagnosis and Treatment of Allergic Purpura in Children«, with palpable rash accompanied by any one of the following four conditions: ① Diffuse abdominal pain, ② biopsy at any site indicated immunoglobulin A1 deposition, ③ arthritis/arachalgia, ④ kidney damage (hematuria and/or proteinuria); (2) Age ≤14 years old; (3) First onset and diagnosis and treatment.

Exclusion criteria: (1) Combined with other vascular inflammatory diseases such as Kawasaki disease and lupus vasculitis; (2) Combined with hematological diseases and immune system deficiencies; (3) Previous history of renal function impairment; (4) Combined with severe endocrine diseases and functional impairments of other vital organs; (5) Incomplete clinical data or inability to accept follow-up.

As the control group, an additional 59 children – 33 boys and 26 girls – who voluntarily visited our hospital for health examinations during that time were chosen. The age ranged from 1 to 14 years, with an average of 5.79±1.38. The average body weight was 16.13.08±2.67 kg, with a range of 8.57 to 63.44 kg. The two sets of research participants did not differ significantly in gender, age, or body weight ($P>0.05$).

Data collection

Clinical data from children with HSP were collected, including gender, age, body weight, time of diagnosis (time from symptom onset to hospital diagnosis), joint pain/arthritis, gastrointestinal bleeding, Epstein-Barr virus (EBV) infection, respiratory tract infection, etc.

Detection of serum MK, LXA4 and CXCL16 levels

All research participants had 3 mL of fasting venous blood drawn on the day following admission (the same day as testing). The samples were centrifuged for 10 minutes at 1,500 rpm, and the upper serum was collected. Serum concentrations were measured using an enzyme-linked immunosorbent assay (ELISA) kit from Wuhan Elairite Biotechnology Co., Ltd. The levels of serum MK, LXA4, and CXCL16 were detected using E-EL-H2297c, E-EL-0053c, and E-EL-H6009, respectively.

Laboratory testing methods

All children with Henoch-Schönlein purpura (HSP) included in the study had approximately 5 mL venous blood samples collected on an empty stomach in the early morning during the acute phase (within 7 days after the appearance of the rash) and the follow-up period (4 weeks and 12 weeks after the onset of the disease). Immediately after blood collection, gently invert and mix well. Let it stand at room temperature for 30 minutes to allow the blood to coagulate fully. Then, centrifuge at 3000 rpm for 10 minutes at 4 °C. Carefully aspirate the upper layer of serum, strictly avoid inhaling red blood cells or fibrin clots, and immediately aliquot into 1.5 mL sterile pyrogen-free cryotubes (no less than 200 μL per tube). The portioned serum specimens should be promptly placed in an ultra-low-temperature freezer at -80 °C for storage and testing, and repeated freezing and thawing should be avoided throughout the process. The concentrations of serum LXA4, MK, and CXCL16 were determined by Enzyme-Linked Immunosorbent Assay (ELISA) using a double-antibody sandwich method. The specific operations strictly follow the human-specific commercial ELISA kits for each index (e.g., Neogen or Cayman kits for LXA4, and R&D Systems Quantikine ELISA kits for MK). CXCL16 is conducted using the instructions of R&D Systems or Abcam kits.

Laboratory testing reagents and equipment

(1) Human Lipoxin A4 (LXA4) ELISA Kit. Manufacturer: Cayman Chemical (USA), Item No. 501070, Detection range: 7.8–1,000 pg/mL, Sensitivity: ≤ 3.9 pg/mL.

(2) Human Midkine (MK) ELISA Kit. Manufacturer: R&D Systems (USA), Item No. DMK00, Detection range: 62.5–4,000 pg/mL, Sensitivity: ≤ 10.8 pg/mL.

(3) Human CXC Chemokine Ligand 16 (CXCL16) ELISA Kit. Manufacturer: Abcam (UK), Item No. ab214030, Detection range: 15.6–1,000 pg/mL, Sensitivity: ≤ 2.0 pg/mL.

(4) Core experimental equipment

Microplate Reader, model: SpectraMax® M5 Multi-Mode Microplate Reader, manufacturer: Molecular Devices (USA);

Plate Washer, model: ELx405™ Select Deep Well Washer, Manufacturer: BioTek Instruments (USA);

Low-temperature high-speed Centrifuge (Refrigerated Centrifuge), model: centrifuge 5425R,

manufacturer: Eppendorf (Germany), rotor model: F-45-30-11 (fixed angle rotor, compatible with 15 mL/50 mL conical tubes);

Precision Pipettes (Pipettes), model: Research® plus series, manufacturer: Eppendorf (Germany).

Diagnosis and classification of renal damage

After admission, children with HSP received treatment in accordance with the »International Recommendations for Evidence-Based Diagnosis and Treatment of Allergic Purpura in Children«, including dietary control, anti-infection measures, rash treatment, joint symptom treatment, gastrointestinal symptom treatment, and glucocorticoid treatment. After the treatment, the patients were followed up for 6 months through outpatient reexamination, and the occurrence of renal damage was statistically analysed.

Diagnostic criteria for renal damage:

Hematuria*:* Gross hematuria or microscopic hematuria twice within one week

(red blood cells ≥3 / high-power field of view);

(2) Proteinuria: ① Within a week, microalbumin levels are up three times; ② >150 mg of urine protein in 24 hours or >0.2 mg/mg of urine protein/creatinine; ③ Urine protein is positive three times within one week in routine urine tests. Renal damage is diagnosed if either hematuria and/or proteinuria is met. According to whether renal damage occurred.

Statistical analysis methods

Statistical analyses were performed using SPSS version 25.0. Categorical data were expressed as counts and percentages, and group comparisons were conducted using the χ^2 test. Continuous variables with a normal distribution were expressed as mean ± standard deviation ($\bar{x}\pm s$) and compared using the *t*-test. For non-normally distributed continuous variables, data were expressed as median (P25, P75) and compared using the rank-sum test. Logistic regression was used to identify factors associated with renal damage in children with HSP. The predictive value of serum MK, LXA4, and CXCL16 levels for renal injury in children with HSP was assessed using receiver operating characteristic (ROC) curve analysis. A *P*-value of less than 0.05 was considered statistically significant.

Results

Comparison of serum MK, LXA4 and CXCL16 levels between the HSP group and the control group

The levels of serum MK, LXA4, and CXCL16 in the HSP group were all higher than those in the control group (P<0.05), see *Table I*.

A total of 117 children with HSP and 59 healthy children who underwent physical examinations during the same period were included in this study. The results showed that compared with the control group, the levels of serum intermediate factor (MK), lipoxin A4 (LXA4), and CXC chemokine 16 (CXCL16) in the HSP group were significantly increased (all P<0.05). This difference suggests that children with HSP have more active inflammatory and immune responses: elevated MK may reflect enhanced vascular endothelial injury, proliferation, and remodelling; elevated CXCL16 points to increased chemotaxis and recruitment of inflammatory cells, suggesting involvement of the endothelial and immune axes. The increase in LXA4, which mediates inflammation resolution, may represent a compensatory upregulation of the body's response to inflammatory activation.

Univariate analysis of renal damage in children with HSP

During the 6-month follow-up, among the 117 children with HSP, 35 cases developed renal damage (renal damage group), with an incidence rate of 29.91% (35/117), and the remaining 82 cases were in the non-renal damage group. The proportion of children with a diagnosis time of ≥7 days, the proportion of children with respiratory tract infections, and the levels of serum MK, LXA4, and CXCL16 in the renal damage group were all higher than those in the non-renal damage group (P<0.05). Gender, age, body weight, and the percentages of children with gastrointestinal bleeding, joint pain/arthritis, and EBV infection did not differ significantly between the two groups (P>0.05), see *Table II*.

Table I Comparison of serum MK, LXA4, and CXCL16 levels between the HSP group and the control group ($\bar{x}\pm s$), ng/mL).

Group	n	MK (ng/mL)	LXA4 (ng/mL)	CXCL16 (ng/mL)
HSP group	117	0.34±0.09	0.66±0.19	2.67±0.86
Control group	59	0.22±0.03	0.47±0.11	1.55±0.47
t		9.954	7.098	9.318
P		<0.001	<0.001	<0.001

Table II Univariate analysis of renal damage in HSP patients [n (%) or z ± s or M (P25, P75)].

Item	Kidney damage group (n=35)	No renal impairment group (n=82)	x^2/t/Z	P
Gender			0.092	0.762
Male	19 (54.29)	47 (57.32)		
Female	16 (45.71)	35 (42.68)		
Age (years)	6.09±1.12	5.77±1.39	1.194	0.235
Body weight (kg)	16.43±2.60	15.84±2.66	1.110	0.269
Diagnosis time			4.763	0.029
≥7 d	9 (25.71)	7 (8.54)		
<7d	26 (74.29)	75 (91.46)		
Joint pain/arthritis			0.164	0.686
Yes	12 (34.29)	25 (30.49)		
No	23 (65.71)	57 (69.51)		
Gastrointestinal bleeding			0.624	0.430
Yes	11 (31.43)	20 (24.39)		
No	24 (68.57)	62 (75.61)		
EBV infection			3.731	0.053
Yes	20 (57.14)	31 (37.80)		
No	15 (42.86)	51 (62.20)		
Respiratory tract infection			5.774	0.016
Yes	23 (65.71)	34 (41.46)		
No	12 (34.29)	48 (58.54)		
MK (ng/mL)	0.42±0.11	0.30±0.09	5.693	0.001
LXA4 (ng/mL)	0.90 (0.63,1.03)	0.61 (0.48,0.73)	4.799	<0.001
CXCL16 (ng/mL)	3.34±0.92	2.38±0.76	5.842	<0.001

Multivariate logistic regression analysis of renal damage in children with HSP

The independent variables: respiratory tract infection (with = 1, without = 0), diagnosis time (≥7d=1, <7d=0), MK (continuous variable, original value input), LXA4 (continuous variable, original value input), and CXCL16 (continuous variable, original value input) were used in multivariate logistic regression analysis. The dependent variable was whether renal damage occurred (yes = 1, no = 0). The findings demonstrated that higher serum MK, LXA4, and CXCL16 levels, respiratory tract infections, and diagnostic times ≥7 days were independent risk factors for kidney impairment in children with HSP (P<0.05; see *Table III*).

The predictive value of serum MK, LXA4 and CXCL16 levels for renal damage in children with HSP

The area under the curve (AUC) of the combined prediction of serum MK, LXA4, and CXCL16 levels for renal damage in children with HSP was higher than that predicted by MK, LXA4, and CXCL16 alone, according to the results of ROC curve analysis (Z=3.289, 3.298, 3.095, P<0.05) (see *Table IV* and *Figure 1*).

Among the 117 children with HSP who were followed up for 6 months, 35 cases developed renal damage. Compared with those without renal damage, the levels of serum MK, LXA4 and CXCL16 in

Table III Multivariate logistic regression analysis of renal damage in children with HSP.

Item	β	SE	Waldx2	P	OR	95%CI
Diagnosis time ≥7 days	0.037	0.017	4.885	0.027	1.138	1.004 1.273
Respiratory tract infection	0.802	0.283	8.065	0.005	2.231	1.282 3.881
MK level increases	1.079	0.362	8.879	0.003	4.171	1.139 5.276
Elevated level of LXA4	0.526	0.162	10.592	0.001	1.692	1.233 2.323
Elevated levels of CXCL16	0.529	0.162	10.695	0.001	1.696	1.236 2.328

Table IV The predictive value of serum MK, LXA4, and CXCL16 levels for renal damage in children with HSP.

Indicator	AUC	95%CI	Optimal truncation value	Sensitivity (%)	Specificity (%)	Yoden Index
MK	0.786	0.701 0.857	0.31 ng/mL	88.57	53.66	0.422
LXA4	0.781	0.695 0.852	0.89 ng/mL	51.43	98.78	0.502
CXCL16	0.783	0.697 0.854	2.99 ng/mL	68.57	75.61	0.442
MK+LXA4+CXCL16	0.926	0.863 0.967	-	80.00	96.34	0.763

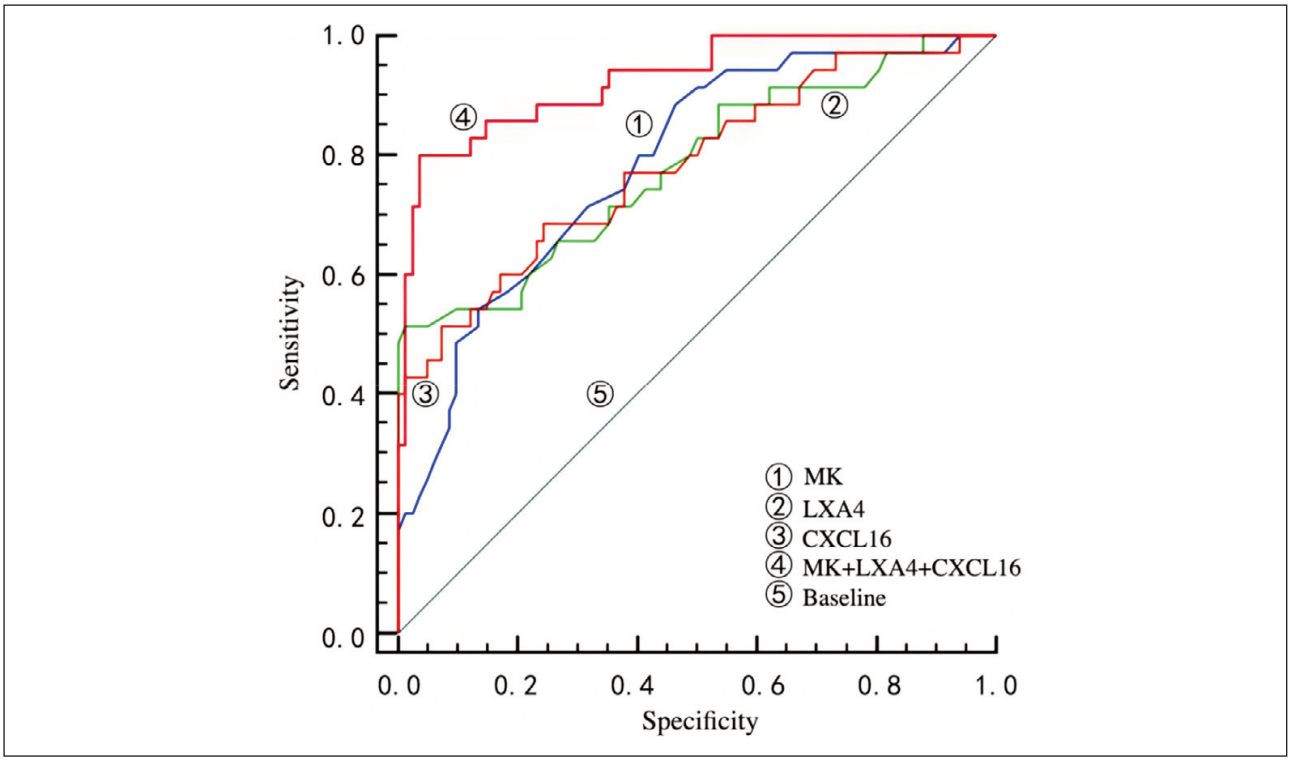

Figure 1 ROC curve analysis of serum MK, LXA4 and CXCL16 levels on renal damage in children with HSP.

the renal damage group were significantly increased (all $P<0.05$). Multivariate Logistic regression showed that a diagnosis time of ≥7 days, combined respiratory tract infection, and elevated MK, LXA4, and CXCL16 were all independent risk factors for renal damage in HSP (all $P<0.05$). ROC curve analysis further confirmed that the area under the curve for the combined use of the three indicators to predict renal damage in HSP was significantly larger than that of any single indicator ($P<0.05$), suggesting that the combined detection has stronger overall discriminative ability and higher predictive efficiency than the single detection, which can provide a basis for the early clinical identification of high-risk children and the optimisation of monitoring and intervention strategies. It has good application value.

Discussion

HSP is a systemic small-vessel vasculitis, mainly caused by factors such as genetics, immune disorders, and infections, leading to the deposition of immunoglobulin A1 on the walls of small blood vessels and resulting in autoinflammatory responses and tissue damage (20). Inflammation of the kidneys can cause kidney damage. In this study, the incidence of renal damage in 117 children with HSP was 29.91%, consistent with the 15.0–40.0% range reported in domestic studies. This indicates that the incidence of renal damage in children with HSP is relatively high. Timely prediction of renal damage is of great significance for improving the prognosis of children (21–23).

The inflammatory response is one of the important mechanisms underlying the occurrence and progression of renal damage in HSP (24). The autoinflammatory response triggered by immunoglobulin A1 deposition can further damage renal cells and impair renal function. MK is a chemokine that can promote local inflammatory cell infiltration by directly acting on or inducing the proliferation of B lymphocytes, the activation of T lymphocytes, and the recruitment of white blood cells (25). MK is mainly expressed in the proximal renal tubular epithelial cells in the kidneys. When inflammation and hypoxia occur, the MK promoter can be activated, leading to increased MK expression. Studies (26–28) have reported that knockout of MK expression in mice can reduce the infiltration of inflammatory cells such as white blood cells, improve renal function in mice with renal ischemia-reperfusion, and, at the same time, MK can cause renal damage and fibrosis by causing Th1/Th2 imbalance (29). The analysis of the reason is that vascular inflammation in children with HSP activates the MK promoter, leading to elevated MK levels (30). Elevated serum MK levels can promote T lymphocyte activation, leading to glomerular inflammation and damage.

LXA4 is an important member of the lipoxin family. It can bind to the LXA4 receptor on the cell surface to activate itself and has a wide range of effects, including dilating blood vessels, antagonising inflammatory responses, and promoting the resolution of inflammation. Studies (31–33) have shown that LXA4 can inhibit apoptosis of renal tubular cells and reduce acute kidney damage. Another study shows that upregulating LXA4 can inhibit kidney inflammation and damage by suppressing inflammatory signalling pathways. The serum LXA4 level is elevated, which is inconsistent with the anti-inflammatory mechanism of LXA4. It is considered to be related to the endogenous protective effect of LXA4 upregulation. LXA4 levels are elevated in kidney injury models. The analysis of the reason is that, in children with HSP, the higher the serum LXA4 level, the more severe the inflammatory response, which indirectly reflects the aggravation of glomerular inflammation and damage (34).

Abnormal distribution and expression of chemokines can disrupt human cellular immune function and activate and promote inflammatory responses. CXCL16 is a novel chemokine. When inflammation is present, it can directly stimulate chemokine signalling, leading to increased CXCL16 expression and interaction with inflammatory cells and chemokine cells, thereby promoting the development of inflammatory responses. Relevant studies have shown that inhibiting CXCL16 can block activation of the downstream nuclear transcription factor B signalling pathway and suppress the inflammatory response and apoptosis of renal cells. Another study shows that inhibiting CXCL16 expression can block the extracellular signal-regulated protein kinase 1/2 signalling pathway, thereby suppressing the proliferation, migration, and apoptosis of renal podocytes (35). The analysis of the reason is that vascular inflammation activation in children with HSP leads to the massive release of CXCL16. An increase in serum CXCL16 levels can promote the activation of multiple signalling pathways. Aggravating the inflammatory response in renal cells increases the risk of kidney damage (36).

Respiratory tract infections can further compromise the immune systems of children with HSP, leading to a significant accumulation of immune complexes in the kidneys and increasing the risk of kidney damage. Finally, through the analysis of the ROC curve drawn in this study, it was found that when the levels of serum MK, LXA4, and CXCL16 were 0.31, 0.89, and 2.99 ng/mL respectively, The AUCs for predicting renal damage in children with HSP were 0.786, 0.781, and 0.783 respectively, suggesting that serum MK, LXA4, and CXCL16 may serve as auxiliary predictive indicators for renal damage in children with HSP. Moreover, the AUC of the combined prediction of the three indicators for renal damage in children with HSP increased to 0.926, indicat-

ing that the combined detection of serum MK, LXA4, and CXCL16 levels can enhance the predictive value for renal damage in these children.

Conclusion

The elevated levels of MK, LXA4, and CXCL16 in the serum of children with HSP are independent risk factors for renal damage. They may serve as auxiliary predictive indicators for renal damage in children with HSP. Moreover, the combined predictive value of the three is higher. However, the age range of this study is slightly narrow. The relationship between MK, LXA4, CXCL16, and adult HSP remains under-researched.

Conflict of interest statement

All the authors declare that they have no conflict of interest in this work.

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