Int J Clin Exp Pathol 2016;9(12):12959-12967
www.ijcep.com /ISSN:1936-2625/IJCEP0041638

Original Article

Hyperleptinaemia positively correlates with cardiometabolic syndrome in hypertensive patients

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Received October 11, 2016; Accepted October 25, 2016; Epub December 1, 2016; Published December 15, 2016

Abstract: Leptin is involved in several homeostatic functions beyond fat storage. Hyperleptinaemia has been implicated in metabolic syndrome (MetS) and cardiovascular disease (CVD). The aim of this study was to determine the relationship between serum leptin concentration and cardiometabolic risk factors in hypertensive patients. Fasting blood samples and baseline characteristics were obtained from 124 hypertensive patients. Serum leptin concentrations were determined using a commercially available enzyme immunoassay (EIA) kit. Seventy patients (56.4%) with cardiometabolic syndrome had higher serum leptin ($P < 0.001$), C-reactive protein (CRP; $P = 0.002$), insulin ($P < 0.001$), body mass index (BMI; $P < 0.001$) and homeostasis model assessment of insulin resistance (HOMA-IR; $P < 0.001$) values and higher percentages of type 2 diabetes mellitus ($P = 0.039$) and coronary artery disease ($P = 0.034$) than those in the non-cardiometabolic syndrome group. Serum leptin levels positively correlated with body weight ($P = 0.006$), waist circumference ($P < 0.001$), BMI ($P < 0.001$), total cholesterol ($P = 0.025$), logarithmically transformed triglyceride (log-triglyceride; $P = 0.008$), log-CRP ($P < 0.001$), log-insulin ($P = 0.001$) and log-HOMA-IR ($P = 0.009$) and negatively correlated with glomerular filtration rate (GFR) ($P = 0.016$) in hypertensive patients. After adjusting for factors significantly associated with serum leptin level, multivariate stepwise linear regression analysis showed that BMI ($P < 0.001$), female gender ($P < 0.001$), log-CRP ($P < 0.001$), statin use ($P = 0.001$), log-triglyceride ($P = 0.013$) and GFR ($P = 0.032$) were independent predictors of fasting serum log-leptin levels among hypertensive patients. This study showed that serum leptin levels are a strong predictor and might be a useful diagnostic surrogate of cardiometabolic syndrome in hypertensive patients.

Keywords: Leptin, metabolic syndrome, hypertension

Introduction

Metabolic syndrome (MetS), a cluster of interrelated cardiometabolic risk factors, including hyperglycaemia, visceral obesity, hypertension, elevated triglyceride (TG) and low high-density lipoprotein cholesterol (HDL-C) levels, is an independent risk factor for the onset of cardiovascular disease and type 2 diabetes [1]. The prevalence of MetS is approximately 25% in Western world adults with persistent increasing worldwide [2]. The risks of heart disease and diabetes are expected to increase by 2- to 5-fold over the next 5-10 years in patients with MetS compared with individuals without MetS [3].

Previous studies have demonstrated the relationship between MetS and adipokines such as leptin and adiponectin [4, 5]. Leptin, the most famous appetite- and energy-regulating peptide discovered in 1994, is a 16-kDa obese gene product primarily secreted by white adipose tissue [6]. The most significant role of leptin is not in meal-to-meal intake, but it is involved in a wide range of homeostatic functions beyond fat storage [4]. Hyperleptinaemia has been implicated in metabolic, inflammatory and homeostatic factors involved in obesity, hypertension and cardiovascular disease [7]. In addition, studies have revealed that leptin was involved in activating the renin-angiotensin-aldosterone system, enhancing the endothelial oxidative stress, stimulating the proliferation of vascular smooth muscle cells, inducing neointimal and medial thickening of the injured artery vascular wall and stimulating the formation of reactive oxygen species, which together result in the

Table 1. Clinical variables of the 124 hypertensive patients with or without cardiometabolic syndrome

Items	All participants (n = 124)	No cardiometabolic syndrome (n = 54)	Cardiometabolic syndrome (n = 70)	*P*-value
Age (years)	64.43 ± 9.84	65.91 ± 9.38	63.64 ± 10.14	0.205
Height (cm)	161.33 ± 8.45	161.69 ± 8.06	161.06 ± 8.78	0.679
Body weight (kg)	69.63 ± 12.49	63.94 ± 10.44	74.03 ± 12.22	< 0.001*
Waist circumference (cm)	92.45 ± 10.97	84.61 ± 7.68	98.50 ± 9.17	< 0.001*
Body mass index (kg/m^2)	26.66 ± 3.68	24.39 ± 3.07	28.41 ± 3.12	< 0.001*
Systolic blood pressure (mmHg)	134.60 ± 17.37	131.72 ± 14.64	136.83 ± 19.01	0.105
Diastolic blood pressure (mmHg)	74.00 ± 10.24	72.65 ± 9.06	75.04 ± 11.01	0.198
Total cholesterol (mg/dL)	173.60 ± 38.03	177.02 ± 35.46	170.97 ± 39.96	0.382
Triglyceride (mg/dL)	125.00 (92.25-173.50)	105.50 (78.50-130.00)	152.00 (107.75-213.75)	< 0.001*
HDL-C (mg/dL)	45.35 ± 13.13	51.41 ± 13.81	40.69 ± 10.50	< 0.001*
LDL-C (mg/dL)	102.78 ± 29.70	105.19 ± 28.52	100.93 ± 30.65	0.431
Fasting glucose (mg/dL)	110.00 (96.25-143.75)	103.00 (93.00-124.25)	121.00 (101.75-169.25)	0.002*
Blood urea nitrogen (mg/dL)	16.00 (13.00-20.00)	15.00 (13.00-18.25)	17.00 (13.75-20.25)	0.135
Creatinine (mg/dL)	1.12 ± 0.34	1.06 ± 0.31	1.17 ± 0.36	0.070
Glomerular filtration rate (mL/min)	68.93 ± 19.98	74.70 ± 21.15	65.96 ± 20.31	0.021*
C-reactive protein (mg/dL)	0.21 (0.15-0.29)	0.18 (0.13-0.23)	0.25 (0.16-0.37)	0.002*
Insulin (μU/mL)	11.95 (8.01-20.84)	9.40 (5.92-13.06)	16.40 (10.52-25.55)	< 0.001*
HOMA-IR	3.54 (2.29-6.66)	2.45 (1.57-3.73)	4.79 (3.24-8.46)	< 0.001*
Leptin (ng/mL)	10.24 (3.40-30.51)	4.46 (1.87-15.92)	15.25 (5.46-46.33)	< 0.001*
Male (%)	82 (66.1)	38 (70.4)	44 (62.9)	0.381
Diabetes (%)	59 (47.6)	20 (37.0)	39 (55.7)	0.039*
Coronary artery disease (%)	57 (46.0)	19 (35.2)	38 (54.3)	0.034*

Values for continuous variables are given as mean ± standard deviation and analysed by Student's *t*-test; variables not normally distributed are given as medians and interquartile range and analysed by Mann-Whitney U test; values are presented as number (%) and analysed using the chi-square test. Abbreviations: HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; HOMA-IR, homeostasis model assessment of insulin resistance. *$P < 0.05$ was considered statistically significant after the Student's *t*-test or Mann-Whitney U test.

imbalance between vasodilatation and vasoconstriction with the consequent development of cardiovascular disorders [8]. Leptin may also regulate insulin resistance [9], and insulin resistance with compensatory hyperinsulinaemia plays a central role in MetS [10]. However, whether the relationship between serum leptin level and MetS is primarily mediated by obesity or hyperleptinaemia in MetS patients independently of visceral obesity is still uncertain [11]. In addition, the relationship between serum leptin level and cardiometabolic syndrome in hypertensive patients has been rarely reported. Therefore, the aim of this study was to determine the relationship between serum leptin concentration and cardiometabolic risk factors in hypertensive patients.

Materials and methods

Patients

A total of 124 hypertensive patients were enrolled in this cross-sectional study conducted between January and December 2012 in a medical centre in Hualien, Taiwan. Standard mercury sphygmomanometers with appropriate cuff sizes were used to measure blood pressure (BP) of all participants on the right arm after making them rest for at least 10 minutes by trained staff in the morning. Systolic BP (SBP) and diastolic BP (DBP) were measured three times at 5-min intervals and were averaged for analysis. Hypertension among the patients enrolled in this study was defined as SBP ≥ 140 mmHg and/or DBP ≥ 90 mmHg or having received any anti-hypertensive medication in the past 2 weeks. Patients who were diagnosed with coronary artery disease (CAD) were defined as having > 50% stenosis in any segment by coronary angiography. This study was approved by the Protection of Human Subjects Institutional Review Board of Tzu-Chi University and Hospital. All patients provided their informed consent before participating in this study. Patients were excluded if they had an acute infection, acute myocardial infarction

Table 2. Clinical characteristics and fasting serum leptin levels of the 124 hypertensive patients

Characteristic		Number (%)	Leptin (ng/mL)	*P*-value
Gender	Male	82 (66.1)	17.76 ± 23.66	0.001*
	Female	42 (33.9)	29.22 ± 28.32	
Diabetes	No	65 (52.4)	22.22 ± 26.59	0.982
	Yes	59 (47.6)	21.00 ± 25.12	
Coronary artery disease	No	67 (54.0)	22.00 ± 25.28	0.962
	Yes	57 (46.0)	22.16 ± 26.61	
ACE inhibitor	No	80 (64.5)	20.70 ± 25.42	0.640
	Yes	44 (35.5)	23.36 ± 26.69	
ARB	No	57 (45.9)	20.88 ± 24.98	0.750
	Yes	67 (54.1)	22.29 ± 26.65	
β-blocker	No	52 (41.9)	18.75 ± 22.80	0.203
	Yes	72 (58.1)	23.73 ± 27.74	
CCB	No	67 (54.1)	20.45 ± 26.34	0.106
	Yes	57 (45.9)	23.04 ± 25.32	
Thiazide	No	107 (86.3)	20.21 ± 25.06	0.098
	Yes	17 (13.7)	30.66 ± 29.28	
Statin	No	54 (43.5)	28.83 ± 28.87	0.003*
	Yes	70 (56.5)	16.09 ± 21.79	
Fibrate	No	119 (96.0)	21.24 ± 25.43	0.534
	Yes	5 (4.0)	31.13 ± 35.68	

Data are expressed as mean ± standard deviation. *$P < 0.05$ was considered statistically significant after Mann-Whitney U test. Abbreviations: ARB, angiotensin receptor blocker; ACE, angiotensin-converting enzyme; CCB, calcium channel blocker.

and pulmonary oedema at the time of blood sampling, or if they refused to provide informed consent for the study.

Anthropometric analysis

Body weight of the patients was measured with light clothing and without shoes to the nearest 0.5 kg, and body height was measured to the nearest 0.5 cm. Waist circumference was measured using a tape around the waist from the point between the lowest ribs to the hip bones with the hands on the hips. Body mass index (BMI) was calculated using the Quetelet's formula as weight in kilograms divided by the height in square metres [12-14].

Biochemical investigations

After 8-12 h of overnight fasting, blood samples (approximately 5 mL) collected from all patients were immediately centrifuged at 3000 *g* for 10 min. Serum levels of blood urea nitrogen (BUN), creatinine (Cre), fasting glucose, total cholesterol (TCH), TG, HDL-C, low-density lipoprotein cholesterol (LDL-C) and C-reactive protein (CRP) were determined using an autoanalyser (COBAS Integra 800, Roche Diagnostics, Basel, Switzerland) [12-14]. Serum leptin concentrations were measured using a commercially available enzyme immunoassay (EIA) kit (SPI-BIO, Montigny le Bretonneux, France) [15, 16]. The estimated glomerular filtration rate (GFR) was calculated using the Modification of Diet in Renal Disease (MDRD) equation.

Cardiometabolic syndrome and its components

The International Diabetes Federation definition was used in this study for the evaluation of MetS prevalence [17]. Subjects were considered as having MetS if they had central (abdominal) obesity with a waist circumference ≥ 90 cm (men) or ≥ 80 cm (women) (Chinese criteria) and matched two or more of the following criteria: fasting serum glucose of ≥ 110 mg/dL, TG of ≥ 150 mg/dL, HDL-C level < 40 mg/dL in men or < 50 mg/dL in women or BP of ≥ 130/85 mmHg. Use of anti-hypertensive medication was considered as indicative of high BP in this analysis. Type 2 diabetes was determined according to the World Health Organization criteria [18]. Participants were classified as diabetic if the fasting plasma glucose was ≥ 126 mg/dL or if the 2-h glucose during an oral glucose tolerance test was ≥ 200 mg/dL or if he/she was using diabetes medication (oral or insulin). Serum insulin levels were measured using the microparticle enzyme immunosorbent assay (MEIA) method by an autoanalyser (Abbott Laboratories, Abbott Park, IL, USA). Insulin resistance was evaluated using a homeostasis model assessment of insulin resistance (HOMA-IR) as follows: HOMA-IR = fasting plasma glucose (mg/dL) × fasting serum insulin (μU/mL)/405 [12, 14].

Statistical analysis

Data were coded, entered and analysed using the Statistical Package for Social Sciences (SPSS) for Windows (version 19.0; SPSS Inc.,

Table 3. Correlation of fasting serum logarithmically transformed leptin levels and clinical variables by univariable linear regression analyses among the 124 hypertensive patients

Items	Beta	*P* value
Age (years)	-0.061	0.499
Height (cm)	-0.123	0.174
Body weight (kg)	0.244	0.006*
Waist circumference (cm)	0.349	< 0.001*
Body mass index (kg/m^2)	0.400	< 0.001*
Systolic blood pressure (mmHg)	-0.067	0.459
Diastolic blood pressure (mmHg)	0.125	0.165
Total cholesterol (mg/dL)	0.201	0.025*
Log-triglyceride (mg/dL)	0.237	0.008*
HDL-C (mg/dL)	-0.002	0.984
LDL-C (mg/dL)	0.115	0.205
Log-glucose (mg/dL)	-0.054	0.551
Log-BUN (mg/dL)	0.091	0.313
Creatinine (mg/dL)	0.056	0.538
Glomerular filtration rate (mL/min)	-0.215	0.016*
Log-CRP (mg/dL)	0.343	< 0.001*
Log-insulin (μU/mL)	0.287	0.001*
Log-HOMA-IR	0.234	0.009*

Data of triglyceride, glucose, BUN, insulin and HOMA-IR levels showed skewed distribution and therefore were log-transformed before analysis. *P < 0.05 was considered statistically significant after univariable linear analyses. Abbreviations: HDL-cholesterol, high-density lipoprotein cholesterol; LDL-cholesterol, low-density lipoprotein cholesterol; BUN, blood urea nitrogen; CRP, C-reactive protein; HOMA-IR, homeostasis model assessment of insulin resistance.

Chicago, IL, USA). The distribution pattern of the variables was checked. Normally distributed variables are expressed as mean ± standard deviation (SD), and comparisons between patients were performed using the Student's independent t-test (two-tailed). Data not normally distributed are expressed as medians and interquartile ranges, and comparisons between patients were performed using the Mann-Whitney U test (TG, fasting glucose, BUN, CRP, insulin, HOMA-IR and leptin). Data expressing the number of patients were analysed by the χ^2 test. Because TG, fasting glucose, BUN, CRP, insulin, HOMA-IR and leptin were not normally distributed, they underwent base 10 logarithmic transformations to achieve normality. Clinical variables that correlated with serum leptin levels in hypertensive patients were evaluated using univariate linear regression analysis. Variables that were significantly associated with leptin levels in hypertensive patients were tested for independency in the multivariate forward stepwise regression analysis. A P value < 0.05 was considered as statistically significant.

Results

Demographic, clinical and biochemical characteristics of the 124 hypertensive patients are presented in **Tables 1** and **2**. A total of 59 patients (47.6%) had diabetes mellitus and 57 patients (46.0%) had a medical history of CAD. Seventy patients (56.4%) had cardiometabolic syndrome, and this group of patients had higher serum leptin (P < 0.001), CRP (P = 0.002), insulin (P < 0.001), BMI (P < 0.001) and HOMA-IR (P < 0.001) values and higher percentages of type 2 diabetes mellitus (P = 0.039) and CAD (P = 0.034) than those in the non-cardiometabolic syndrome group.

The drugs used included angiotensin-converting enzyme inhibitors (ACEi; n = 44; 35.5%), angiotensin receptor blockers (ARB; n = 67; 54.1%), β-blockers (n = 72; 58.1%), calcium channel blockers (CCB; n = 57; 45.9%), thiazides (n = 17; 13.7%), statins (n = 70; 56.5%) and fibrates (n = 5; 4.0%). Fasting serum leptin levels did not differ statistically by diabetes, CAD and use of ACEi, ARB, β-blockers, CCB, thiazides or fibrates, but there was a statistically significant difference in sex and use of statins among hypertensive patients.

Results of the univariable linear analysis of leptin levels in hypertensive patients are presented in **Table 3**. Body weight (β = 0244, P = 0.006), waist circumference (β = 0.349, P < 0.001), BMI (β = 0.400, P < 0.001), TCH (β = 0201, P = 0.025), logarithmically transformed TG (log-TG; β = 0237, P = 0.008), log-CRP (β = 0.343, P < 0.001), log-insulin (β = 0287, P = 0.001) and log-HOMA-IR (β = 0234, P = 0.009) positively correlated while glomerular filtration rate (GFR) (β = -0215, P = 0.016) negatively correlated with leptin levels in our hypertensive patients.

Multivariate forward stepwise linear regression analysis of the factors (gender, statin use, body weight, waist circumference, BMI, TCH, log-TG,

Table 4. Multivariable stepwise linear regression analysis of gender, statin use, body weight, waist circumference, body mass index, total cholesterol, log-triglyceride, glomerular filtration rate, log-CRP, log-insulin and log-HOMA-IR: correlation to fasting serum log-leptin levels among the 124 hypertensive patients

Items	Beta	R square	R square change	*P* value
Body mass index (kg/m^2)	0.341	0.154	0.154	< 0.001*
Female	0.325	0.244	0.090	< 0.001*
Log-CRP (mg/dL)	0.220	0.328	0.084	< 0.001*
Statin use	-0.262	0.388	0.060	0.001*
Log-triglyceride (mg/dL)	0.173	0.420	0.032	0.013*
Glomerular filtration rate (mL/min)	-0.153	0.442	0.022	0.032*

*$P < 0.05$ was considered statistically significant after multivariable stepwise linear regression analyses. Abbreviations: CRP, C-reactive protein.

GFR, log-CRP, log-insulin and log-HOMA-IR) significantly associated with fasting serum leptin levels revealed that BMI (P < 0.001), female gender (P < 0.001), log-CRP (P < 0.001), statin use (P = 0.001), log-TG (P = 0.013) and GFR (P = 0.032) were independent predictors of fasting serum log-leptin levels among hypertensive patients (**Table 4**).

Discussion

The results of our study revealed that fasting leptin levels were higher in patients with hypertensive cardiometabolic syndrome. Besides, serum fasting leptin concentration showed a positive correlation with BMI, female gender, log-CRP and log-TG and a negative correlation with statin use and GFR among hypertensive patients.

Adiposity-related health risks including MetS, type 2 diabetes mellitus and cardiovascular diseases are worldwide health problems. Several studies have stated that hyperleptinaemia is a risk factor for developing obesity, hypertension and other cardiovascular disease [7], indicating that there is a crosstalk between leptin and cardiometabolic syndrome [3]. Recently, Montagnana et al. have demonstrated a positive correlation between leptin and the number of metabolic abnormalities of MetS according to the definition of adult treatment panel III criteria [19]. Insulin resistance with compensatory hyperinsulinaemia plays a central role in cardiometabolic syndrome [10]. Insulin metabolism is interrelated with leptin secretion and action [20]. Previous studies have reported that insulin enhances leptin secretion by stimulating leptin gene expression [21] and hyperinsulinaemia and insulin resistance lead to hyperleptinaemia via increased adiposity [22]. Besides, leptin also acts as a positive modulator of insulin. Gupta et al. observed that leptin levels positively correlated with BMI, waist circumference, BP, fasting plasma glucose, TG, TCH, fasting plasma insulin and HOMA-IR values but inversely correlated with HDL-C in North Indian adult women, indicating an association between circulating leptin levels and insulin resistance, lipid profile and other metabolic risk factors [23]. Zuo et al. reported a significant association between serum leptin concentrations and HOMA-IR in Chinese men and women, regardless of adiposity levels [24]. Moreover, studies have also stated that in Chinese overweight/obese population, circulating leptin concentrations among insulin-resistant individuals were almost double compared to those in non-insulin-resistant subjects at the same level of adiposity [24] and BMI-adjusted serum leptin concentrations were higher in diabetic and non-diabetic Iranian female populations with insulin resistance syndrome [25]. Our study also revealed that higher leptin levels, elevated insulin and HOMA-IR values, higher fasting glucose and TG and lower HDL-C levels and increased waist circumference and BMI values exhibited statistical significance between patients with hypertensive cardiometabolic syndrome and those with non-cardiometabolic syndrome. Besides, fasting serum leptin levels showed a positive correlation with higher insulin levels, elevated HOMA-IR values, higher TG levels and increased waist circumference and BMI values among hypertensive patients by univariable linear regression analyses, suggesting that circulating leptin concentration is an important predictor of insulin resistance and other metabolic risks.

Circulating leptin concentration was proportional to body mass with body fat percentage, and obese patients had increased circulating leptin concentrations than those in non-obese individuals [26, 27]. A recent study also pointed

that BMI, a proxy indicator of general obesity, showed a satisfactory correlation with leptin in men [24]. Our data also revealed a similar finding of a significant positive correlation of hyperleptinaemia with higher BMI values, suggesting that leptin resistance has an important pathogenic role in the development of obesity. Leptin resistance could promote obesity via decreased energy expenditure and a failure to decrease food intake [28]. Besides, leptin exhibited actions of lowering glucose and insulin throughout the body in vivo and leptin resistance could induce insulin resistance via interfering with insulin signalling in obese individuals [28]. Another study revealed that impaired leptin signalling could diminish the activation of AMP-activated protein kinase (AMPK) in myocytes. This condition resulted in decrease of fatty acid oxidation, which led to an increase in intra-myocellular lipids and thus to insulin resistance [29].

Several studies have revealed that females have higher serum leptin levels compared with males, similar to our study. Although the true mechanisms of this sex-related dissimilarity are still uncertain, studies have documented that leptin administration had a substantially different response in male and female animals and in human subjects [30, 31]. Some authors stated that females have higher percentage of body adiposity with increased leptin production, and an animal study also stated that sex hormones can affect brain sensitivity to leptin and insulin, which influence body fat distribution in rats models [30]. However, increasing evidence support that the gender difference seen in leptin levels could not be simply explained by sexual differences of total adiposity between males and females, but rather it is the result of differential expression of genes by sex as well as the effects of sets of sex-specific genes [32]. Previous studies have also revealed an inverse relationship between serum leptin and testosterone levels [33, 34]. Elbers et al. observed that males with suppressed testosterone levels could substantially increase their serum leptin levels, indicating that testosterone is likely to mediate such genotype-by-sex effects, with females having higher baseline leptin levels than males [33].

In addition to regulation of various physiological processes such as insulin responsiveness and glucose metabolism, leptin is also involved in lipid metabolism and inflammatory response [35]. Previous studies have demonstrated that leptin is strongly associated with lipid metabolism by directly inhibiting the essential enzyme (acetyl-CoA carboxylase) synthesis in the conversion of carbohydrates to long-chain fatty acids in adipose cells and by an indirect effect on lipid synthesis and degradation through reducing the lipogenic effects of insulin [36]. Dubey et al. [37] and Montagnana et al. [19] also showed that leptin resistance is an important pathogenesis of dyslipidaemia.

Leptin is associated with a pro-inflammatory, atherogenic milieu and several reports have also stated the positive correlation between serum leptin levels and hs-CRP values [38, 39]. In the SardiNIA study, serum leptin together with hs-CRP was a significant independent risk factor for arterial stiffness, regardless of age, sex or traditional cardiovascular risk factors [40]. Our previous study [16] and several reports also found similar results of high serum leptin levels correlating positively with the number of stenotic coronary arteries, indicating that hyperleptinaemia plays an important role in the occurrence, severity and extent of CAD [41, 42]. Our study also revealed elevated CRP levels and hypertriglyceridaemia as independent predictors of hyperleptinaemia among hypertensive patients. Taken together, these associations of leptin with pro-atherogenic blood lipids, along with the pro-inflammatory activity of leptin and its role in insulin resistance and endothelial dysfunction, are the major mechanisms to trigger and aggravate the progression of cardiovascular diseases [35].

Hyperleptinaemia is observed in patients with renal function impairment [43] and in patients receiving peritoneal dialysis or hemodialysis [44, 45]. In addition, serum leptin levels of patients with end-stage renal disease decreased early after renal transplantation [46]. These studies provide a strong evidence of circulating leptin being removed from plasma via the kidneys. Our study also showed a consistent finding of association between decreased GFR and serum leptin levels.

Although several medications used by patients with cardiometabolic syndrome may influence the underlying inflammatory status, our study showed that ACEi, ARB, β-blockers, CCB and fibrates had no influence on serum leptin levels

in hypertensive patients. In addition their use in the treatment of hyperlipidaemia, several studies have reported that statins had pleiotropic effects of modulation of circulating leptin and adiponectin levels [47]. Treating with atorvastatin lowered circulating leptin levels in patients with type 2 diabetes mellitus [48] and CAD [49]. A recent study also revealed that a low dose of atorvastatin had beneficial effects on arterial stiffness and central aortic pressure in patients with mild hypertension and hypercholesterolaemia [50]. The results of the present study also demonstrated that statin use negatively correlated with serum leptin levels in hypertensive subjects, suggesting that statins can be used for the prevention of cardiometabolic syndrome in addition to its lipid-lowering effect.

The limitation of this study is its cross-sectional design with a limited number of hypertensive patients conducted at a single centre. Therefore, the findings of this study need to be confirmed by further longitudinal studies before a cause-and-effect association between serum leptin and cardiometabolic syndrome can be established in the hypertensive population.

In conclusion, leptins have been postulated to be strong predictors of cardiovascular, metabolic and other chronic disease outcomes. Hypertensive patients with cardiometabolic syndrome have higher serum leptin levels compared with individuals without the syndrome, indicating that leptin might be a useful diagnostic surrogate of metabolic and cardiovascular diseases in hypertensive patients.

Acknowledgements

This study was supported by a grant from the Buddhist Tzu Chi General Hospital, Hualien, Taiwan (TCRD101-03).

Disclosure of conflict of interest

None.

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