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The correlation between controlled attenuation parameter and metabolic syndrome and its components in middle-aged and elderly nonalcoholic fatty liver disease patients

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Abstract

This study aims to investigate the correlation between controlled attenuation parameter (CAP) and metabolic syndrome (MetS) and its components in middle-aged and elderly nonalcoholic fatty liver disease (NAFLD) patients.

Middle-aged and elderly patients with NAFLD, who visited our hospital from June 2016 to May 2017, were enrolled as study subjects, whereas middle-aged and elderly patients without liver disease were enrolled as controls in the same period. The prevalence of MetS, MetS components, and the different numbers of MetS components were compared among patients with different CAP values.

As the CAP value increased, the prevalence of MetS, MetS components, and the different numbers of MetS components significantly increased. The CAP value was positively correlated with the prevalence of MetS, obesity, hypertriglyceridemia, hypertension, hyperglycemia, hyperuricemia, and the number of MetS components, and was negatively correlated with the prevalence of hypo–high-density-lipoprotein cholesterolemia.

CAP values are closely correlated to MetS and its components in middle-aged and elder NAFLD patients. CAP may be an indicator of risk of MetS and the severity of metabolic disorders in middle-aged and elderly NAFLD patients.

Abbreviations: BMI = body mass index, CAP = controlled attenuation parameter, DBP = diastolic blood pressure, FBG = fasting blood glucose, hepatocellular carcinoma, HDL-C = high-density lipoprotein cholesterol, IQR = interquartile range, LDL-C = low-density lipoprotein cholesterol, MetS = metabolic syndrome, MRI = magnetic resonance imaging, NAFLD = nonalcoholic fatty liver disease, NASH = nonalcoholic steatohepatitis, SBP = systolic blood pressure, SCD = skin-capsule depth, TC = total cholesterol, TG = triglyceride.

Keywords: controlled attenuation parameter, correlation, metabolic syndrome, nonalcoholic fatty liver disease

1. Introduction

Nonalcoholic fatty liver disease (NAFLD) has become the most common chronic liver disease in the world,[1] which is often combined with cardio-renal-metabolic diseases, increased risk of liver cancer, or extrahepatic cancer.[2] Furthermore, it is closely correlated to metabolic syndrome (MetS) and hyperuricemia.[3–5] In European and American countries, the prevalence of NAFLD is close to 25% to 30% in common populations, and reaches up to 80% to 90% in selected populations with metabolic disorders.[6,7] NAFLD patients combined with MetS are more likely to have

severe hepatic steatosis and portal inflammation, and MetS is associated with nonalcoholic steatohepatitis (NASH).[8] The controlled attenuation parameter (CAP) is a new technology based on the principle of the ultrasonic attenuation of liver transient elastography for the quantitative detection of liver fat content. Compared with B ultrasound, this technology improves the sensitivity and specificity of the diagnosis of fatty liver, and can be used for universal screening, diagnosis, and follow-up in NAFLD populations.[9–11] Furthermore, it is a noninvasive method that can replace needle biopsy to assess liver steatosis and fibrosis.[12] CAP values are associated with metabolic disorders.[13] However, there are few reports on the quantitation of liver fat and metabolic factors in middle-aged and elderly patients. The aging of the world is becoming more and more significant. Therefore, it is necessary to further explore the correlation between CAP values and metabolic disorders in middle-aged and elderly populations. In the present study, the clinical data of elderly patients were collected and analyzed the correlation between the CAP value of the liver and MetS and its components was investigated, to provide a new early warning strategy for preventing and delaying the progress of NAFLD in middle-aged and elderly patients.

2. Subjects and methods

2.1. Subjects

Patients who visited the Geriatric Department of the First Affiliated Hospital of Kunming Medical University from June

2016 to May 2017 were selected as study subjects. Patients with the following conditions were excluded: patients with a history of alcohol consumption, in which the amount of alcohol consumed was >140 g/week for men (>70 g/week for women); patients with specific diseases that may induce fatty liver, such as viral hepatitis, drug liver disease, total parenteral nutrition, hepatolenticular degeneration, and autoimmune liver disease; patients who were <45 years old, patients with cardiac pacemakers, patients with an unhealed wound at the upper right abdomen, and patients with ascites; and patients with serious liver, kidney, heart, and brain diseases and malignant tumors. This study was conducted with approval from the Ethics Committee of the First Affiliated Hospital of Kunming Medical University. This study was conducted in accordance with the declaration of Helsinki. Written informed consent was obtained from all participants.

2.2. Research method

2.2.1. General information. The age, sex, and history of disease of these patients were recorded.

2.2.2. MetS indexes.
The height and body mass of patients were measured, and the body mass index (BMI) was calculated. The blood pressure of these patients was measured in a fasting state in the morning, and 5 mL of blood was extracted from the elbow vein of each patient under aseptic conditions. Alanine aminotransferase, aspartate aminotransferase, total bilirubin, gamma-glutamyltransferase, total cholesterol (TC), triglyceride (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), fasting blood glucose (FBG), and blood uric acid were detected in blood using an automatic biochemical analyzer. Diagnostic criteria for MetS and its components: According to the 2007 Guidelines for the Diagnosis and Treatment of NAFLD in the Asia Pacific Region, the diagnosis should meet 3 or more of the following 5 items: obesity, BMI >25 kg/m^2 and (or), male waist >90 cm or female waist >80 cm; elevation of TG: TG ≥1.7 mmol/L, or the patient received special treatment for lipid abnormalities; decrease in HDL-C: LDL-C <1.03 mmol/L in men and LDL-C <1.29 mmol/L in women; elevation of blood pressure: systolic blood pressure (SBP) ≥130 mm Hg and (or) diastolic blood pressure (DBP) ≥85 mm Hg, or the patient was diagnosed with hypertension and previously received medication; and elevation of FBG: FBG ≥5.6 mmol/L, or the patient was diagnosed with type 2 diabetes mellitus and previously received medication. Diagnostic criteria for hyperuricemia: uric acid ≥420 μmol/L in men and uric acid ≥360 μmol/L in women.

2.2.3. CAP examination.
The quantitative determination of liver fat was performed by a skilled operator using FibroScan (502 model, M probe; Echosens, France). The result was represented in CAP value, and the unit used was dB/m. During the examination, the patient was instructed to lie in the supine position and hold their head using their right hand, and the intercostal space was expanded as much as possible. The detection area was from the right anterior axillary line to the seventh, eighth, and ninth intercostal space of the midaxillary line. The probe was kept perpendicular to the skin surface in the ribbed space. The detection began when the pressure indicator became green, the M waves on the display were uniform and evenly distributed, and the A waves were linear. Each subject was required to be successfully tested for >10 times, and the median of all effective measurements was defined as the final result. An effective measurement should meet the following requirements: the ratio of the interquartile range (IQR) to the median (IQR/

med) of all measurements was <30% and the success rate (successful detection number/total test number) was ≥60%. According to the results of the multicenter clinicopathological study conducted by a French scholar, Sasso, the CAP values were divided into 4 grades: <238 dB/m (without hepatic steatosis), 238 to 258 dB/m (mild hepatic steatosis), 259 to 291 dB/m (moderate hepatic steatosis), and ≥292 dB/m (severe hepatic steatosis).

2.3. Statistical analysis

Statistics analysis was performed using SPSS 20.0 software. Non-normally distributed measurement data were expressed as median and IQR, intergroup comparison was conducted using Mann-Whitney U test, and the comparison among multiple groups was conducted using the Kruskal-Wallis test. Count data were compared among groups using the X^2-test. Correlation analysis was conducted using Spearman correlation analysis. $P < .05$ was considered statistically significant.

3. Results

The present study involved 984 middle-aged and elder patients. Among these patients, 664 patients were men and 320 patients were women. Furthermore, among these patients, 536 patients had a CAP value of <238, 150 patients had a CAP value of 238 to 258, 160 patients had a CAP value of 259 to 291, and 138 patients had a CAP value of ≥292. Furthermore, 256 patients (26%) had obesity, 344 patients (35%) had hypertension, 362 patients (36.8%) had hyperglycemia, 280 patients (28.5%) had hypertriglyceridemia, 190 patients (18.3%) had hypo–high-density-lipoprotein cholesterolemia, 324 patients (32.9%) had hyperuricemia, 204 patients (20.73%) had diabetes, and 198 patients (20.12%) had cardiovascular disease. With CAP ≥238 dB/m as the threshold, these patients were divided into 2 groups: NAFLD group and non-NAFLD group. BMI, SBP, DBP, TG, TC, LDL-C, and fasting plasma glucose were higher in the NAFLD group than in the non-NAFLD group, whereas HDL-C was lower in the NAFLD group than in the non-NAFLD group. Furthermore, the incidence of diabetes, hypertension, and cardiovascular disease was higher in the former than in the latter, and the differences were statistically significant ($P < .05$, Table 1).

A total of 308 patients (31.3%) were diagnosed with MetS, whereas 676 patients (68.7%) were not diagnosed with MetS. The CAP value was significantly higher in the MetS group than in the non-MetS group, and the difference was statistically significant ($P < .001$, Table 2).

A total of 324 patients (32.9%) were diagnosed with hyperuricemia, whereas 660 patients (67.1%) were not diagnosed with hyperuricemia. The CAP value was significantly higher in the hyperuricemia group than in the nonhyperuricemia group, and the difference was statistically significant ($P < .001$, Table 2).

With CAP at <238, 238 to 258, 259 to 291, and ≥292 dB/m as boundary values, these patients were divided into 4 groups: nonfatty liver, mild-fatty liver, moderate-fatty liver, and severe-fatty liver groups. The incidence of MetS components (obesity, hypertension, hyperlipidemia, hypertriglyceridemia, and hypo–high-density lipoprotein cholesterolemia) significantly increased with the increase in severity of fatty liver ($P < .05$). Furthermore, the prevalence of MetS was 21.3%, 34.7%, 43.8%, and 52.2% in the nonfatty liver, mild-fatty liver, moderate-fatty liver, and severe-fatty liver groups, respectively. These significantly

Table 1

Characteristics of patients with non-alcoholic fatty liver disease and without non-alcoholic fatty liver disease [$P_{50}(P_{25}-P_{75})$].

Parameters	NAFLD (n = 448)	Non-NAFLD (n = 536)	Total (n = 984)	P
Sex (male/female)	300/148	364/172	664/320	.847
Age, y	68 (52–76)	65 (50–75)	66 (50–75)	.058
BMI, kg/m^2	24.8 (23.0–27.1)	22.7 (21.1–24.7)	23.1 (21.7–25.4)	<.001
WC, cm	88.0 (83.0–94.0)	79.0 (75.0–86.0)	84.0 (78.0–90.0)	<.001
SBP, mm Hg	144 (136–154)	134 (124–144)	138 (124–150)	.031
DBP, mm Hg	88 (80–92)	78 (70–85)	78 (73–90)	.026
ALT, U/L	26.4 (17.0–39.0)	20.1 (15.2–29.3)	22.0 (15.4–34.1)	.053
AST, U/L	25.8 (16.7–39.1)	21.3 (15.4–29.7)	22.4 (14.9–35.2)	.063
TBil, mmol/L	14.2 (11.3–17.4)	14.0 (11.2–17.3)	14.1 (11.2–17.3)	.916
GGT, IU/L	20.6 (17–26.3)	20.1 (16.8–27.1)	20.4 (16.7–26.8)	.834
TG, mmol/L	1.85 (1.24–2.63)	1.03 (0.76–1.39)	1.20 (0.83–1.76)	<.001
TC, mmol/L	4.87 (4.22–5.54)	4.60 (4.08–5.17)	4.66 (4.10–5.27)	.031
LDL-C, mmol/L	2.81 (2.32–3.38)	2.65 (2.22–3.13)	2.70 (2.24–3.17)	.029
HDL-C, mmol/L	1.27 (1.11–1.51)	1.46 (1.30–1.68)	1.40 (1.21–1.66)	.03
FPG, mmol/L	6.0 (5.5–6.6)	5.2 (4.7–5.5)	5.5 (5.0–5.9)	<.001
SUA, μmol/L	392 (306–478)	327 (255–401)	361 (280–439)	<.001
Diabetes (%)	136 (30.36%)	68 (12.69%)	204 (20.73%)	<.001
Hypertension (%)	180 (40.18%)	164 (30.60%)	344 (35.0%)	.029
Cardiovascular disease (%)	116 (37.66%)	82 (12.13%)	198 (20.12%)	<.001

ALT = alanine aminotransferase, AST = aspartate aminotransferase, BMI = body mass index, DBP = diastolic blood pressure, FPG = fasting plasma glucose, GGT = gamma-glutamyltransferase, HDL-C = high-density lipoprotein cholesterol, LDL-C = low-density lipoprotein cholesterol, NAFLD = nonalcoholic fatty liver disease, SBP = systolic blood pressure, TBil = total bilirubin, TC = total cholesterol, TG = triglyceride, WC = waist circumference.

Table 2

Comparison between metabolic syndrome and nonmetabolic syndrome and hyperuricemia and nonhyperuricemia.

Parameters	Male/female	Age, y	CAP, dB/m
MS (n = 308)	204/104	67 (51–78)	257 (233–290)
Non-MS (n = 676)	460/216	66 (50–74)	221 (190–259)
Hyperuricemia (n = 324)	212/112	68 (50–79)	261 (235–292)
Nonhyperuricemia (n = 660)	452/208	65 (51–75)	220 (192–259)
Total (n = 984)	664/320	65 (50–76)	223 (188–255)
P^*	.756	.068	<.001
$P^\dagger$	.749	.059	<.001

CAP = controlled attenuation parameter, MS = metabolic syndrome.
* Comparison between MS group and non-MS group.
† Comparison between hyperuricemia group and nonhyperuricemia group.

increased with the increase in CAP value, and the difference was statistically significant (P < .001, Table 3).

According to the number of MetS components (0–5), these patients were divided into 6 groups: MS0 (n = 414), MS1 (n = 130), MS2 (n = 122), MS3 (n = 200), MS4 (n = 80), and MS5 (n = 28) groups. The CAP value was 210 (173–261), 225 (220–238), 233 (230–257), 235 (232–267), 291 (265–295), and 304 (275–326) dB/m in the MetS0, MetS1, MetS2, MetS3, MetS4, and

MetS5 groups, respectively. The CAP value significantly increased with the increase in the number of MetS components. The differences in CAP value between the MetS0 and MetS1, MetS1 and MetS2, MetS2 and MetS3, MetS3 and MetS4, and MetS4 and MetS5 groups were statistically significant (P < .05). Spearman correlation analysis revealed that CAP was positively correlated with the number of MetS components (r = 0.437, P < .01), MetS (r = 0.373, P < .01), obesity (r = 0.405, P < .01), hyperglycemia (r = 0.206, P < .01), hypertension (r = 0.208, P < .01), hypertriglyceridemia (r = 0.385, P < .01), and hyperuricemia (r = 0.453, P < .01), and negatively correlated with hypo–high-density lipoprotein cholesterolemia (r = −0.197, P < .01).

4. Discussion

NAFLD is becoming one of the most important public health problems in the world. It has been estimated that the prevalence of NAFLD is approximately 25% in the world,[14] making it the second major cause of liver transplantation in the United States of America. NAFLD is not only closely correlated to hepatocellular carcinoma, liver failure, and the recurrence of NASH in transplanted livers, but also significantly increases the incidence of diabetes, arteriosclerotic heart, brain and renal vascular

Table 3

The prevalence of metabolic syndrome and its individual components according to different controlled attenuation parameter level.

	CAP				χ^2	P
	Normal (n = 536)	Mild (n = 150)	Moderate (n = 160)	Severe (n = 138)		
Obesity (%)	84 (15.7%)	40 (26.7%)	60 (37.5%)	72 (52.2%)	89.851	<.001
Hypertension (%)	158 (29.5%)	56 (37.3%)	68 (42.5%)	62 (44.9%)	17.487	.001
Hyperglycemia (%)	166 (31.0%)	66 (44.0%)	68 (42.5%)	62 (44.9%)	17.333	.001
Hypertriglyceridemia (%)	94 (17.5%)	50 (33.3%)	66 (41.3%)	70 (50.7%)	79.620	<.001
Low-HDL (%)	78 (14.6%)	26 (17.3%)	38 (23.8%)	38 (27.5%)	16.187	.001
Hyperuricemia (%)	100 (18.7%)	48 (32.0%)	82 (51.3%)	94 (68.1%)	151.17	<.001
MS (%)	114 (21.3%)	52 (34.7%)	70 (43.8%)	72 (52.2%)	65.369	<.001

CAP = controlled attenuation parameter, HDL = high-density lipoprotein, MS = metabolic syndrome.

disease, and extrahepatic malignant tumors such as colorectal adenocarcinoma.[15–17]

MetS is a constellation of central obesity, hypertension, hyperglycemia, and dyslipidemia. Obesity and insulin resistance are believed to be at the core of most cases of MetS, although further research is required to truly understand the pathophysiology behind the syndrome.[18] A significant difference in the brain metabolite ratios of patients with MetS compared to volunteers, and patients with severe obesity compared to mild obesity, may be attributed to visceral obesity, insulin resistance, atherogenic dyslipidemia, and endothelial dysfunction, as well as a constellation of independent factors that mediate specific components of the MetS.[19]

MetS is closely correlated to NAFLD, and is an important predictor for NASH, which is a serious type of NAFLD. Furthermore, diabetes is a risk factor for cirrhosis and HCC in NASH patients.[1]

Hyperuricemia is closely correlated to NAFLD, and is an independent risk factor for NAFLD. The liver is an important organ for the synthesis of uric acid. Therefore, NAFLD also significantly increases the risk for hyperuricemia.[20–22]

Although liver biopsy is still the criterion standard for the diagnosis of NAFLD, noninvasive and quantitative methods such as diffusion-weighted magnetic resonance imaging (MRI), dynamic contrast-enhanced MRI, MR elastography, and MR spectroscopy (MRS) are increasingly found to have high diagnostic accuracy for the detection or grading of hepatic steatosis and fibrosis not only in adults but also in children.[23–26] Complications of cirrhosis such as esophageal varices and minimal hepatic encephalopathy can be predicted and detected in patients with diffusion-weighted MRI of the abdomen and diffusion-weighted MRI and proton MRS of the brain.[27,28] Diffusion-weighted MRI also can detect hepatic and splenic infiltration and disease severity in inherited metabolic liver disease such as Gaucher disease.[29] However, these MR-based methods are impractical or too expensive for large-scale case finding.

The advent of CAP technology has provided a method for the standardized, rapid, convenient, noninvasive, and quantitative measurement of hepatic steatosis in NAFLD patients, which can also be regularly reviewed and followed up. A meta-analysis of 2735 patients conducted by Thomas et al[30] revealed that there is a good correlation between CAP and the grade of steatosis in liver histology. The best critical value and 95% confidence interval of CAP were 248 (237–261), 268 (257–284), and 280 (268–294) dB/m, which correspond to >S0, >S1, and >S2 of hepatic steatosis, respectively. The values of CAP in patients with S1, S2, and S3 NAFLD were 264 ± 45, 298 ± 48, and 331 ± 37 dB/m, respectively. The CAP values of S2 and S3 NAFLD patients were significantly higher than patients with other grades. Caucasian and Chinese have similar CAP values in the same grade of steatosis.[11]

CAP can not only reproduce the grade of liver steatosis established by histology, but also closely correlate this to MetS, and reflex the severity of metabolic disturbance in MetS patients. The analysis results of 5323 tests in 4451 patients with suspected chronic liver disease revealed that CAP values significantly increased with the increase in the number of MetS components, BMI, waistline, the prevalence of diabetes, and the prevalence of hypertension. Furthermore, the CAP value of NAFLD patients was significantly higher than that of patients with alcoholic liver disease, chronic viral hepatitis B, and chronic viral hepatitis C.[31] A study on a population that underwent physical examinations

revealed that the CAP value was positively correlated with the number of MetS components, and that the CAP value increased with the increase in the number of MetS components. Similarly, with the increase in CAP level, the prevalence of MetS and its components increased. Relative to populations without fatty liver, the risk of MetS increased by 1.8, 2.9, and 4.3 times in patients with mild, moderate, and severe fatty liver, respectively.[13] The results of the present study revealed that among middle-aged and elderly NAFLD patients, CAP values were positively correlated with the prevalence of MetS, MetS components, obesity, hypertriglyceridemia, hypertension, hyperglycemia, and the number of MetS components, and was negatively correlated with the prevalence of hypo–high-density lipoprotein cholesterolemia. These results reveal that CAP values are closely correlated to MetS and its components in middle-aged and elderly NAFLD patients. In the present study, as the CAP value increased, the prevalence of MetS and its components in middle-aged and elderly NAFLD patients also increased. This suggests that CAP may serve as an indicator of risk for MetS in middle-aged and elderly NAFLD patients. In the present study, for the 154 middle-aged and elderly MetS patients, as the CAP value increased, the number of MetS components also increased. This suggests that a higher CAP value indicates a more severe metabolic disturbance in middle-aged and elderly patients with NAFLD complicated with MetS. CAP values may serve as an indicator of the severity of metabolic disturbance in middle-aged and elderly patients with NAFLD and MetS.

Approximately 50% to 70% of NAFLD patients are accompanied by hyperuricemia. In middle-aged and elderly community populations of >45 years old, the prevalence of NAFLD and hyperuricemia was 33.1% and 17.1%, respectively, and the prevalence of NAFLD complicated with hyperuricemia was 23.5%. Furthermore, the serum uric acid level of patients with NAFLD was higher than that of patients without NAFLD, the level of fat in the liver was positively correlated with the level of uric acid in blood, and a level of fat in the liver of >10% was correlated to the risk of hyperuricemia.[32] Therefore, NAFLD and hyperuricemia are reciprocal causation, and these 2 mutually increase the risk for each other, forming a vicious circle. The present study revealed that CAP values are closely correlated to the level of uric acid in blood, and as the CAP value increased, the serum level of uric acid exhibited an upward trend. Furthermore, the different degrees of increase in CAP value are closely correlated to the prevalence of hyperuricemia. The prevalence of hyperuricemia was 18.7%, 32.0%, 51.3%, and 68.1% in patients with normal CAP values and a mild, moderate, and severe increase in CAP values, respectively. The serum level of uric acid is closely correlated to the CAP value, and the CAP value in patients with hyperuricemia is significantly higher than that in patients with normal blood uric acid.

Therefore, for middle-aged and elderly patients with elevated CAP values, attention should be given to the possibility of hyperuricemia, blood uric acid should be detected in time, and early intervention should be performed to delay the disease process. The study of the relationship between hyperuricemia and NAFLD provides a new idea for the prevention and treatment of NAFLD, and the intervention of decreasing blood uric acid may play a positive role in the prevention and treatment of NAFLD.

According to statistics, the failure rate in determining the CAP value was 7.7%. Multivariate analysis revealed that this was correlated to the female sex, BMI, and MS. In populations with a BMI of 30 to 40 and $\geq$40 kg/m^2, the failure rate of CAP determination reached up to 19.4% and 58.4%, respectively.[31]

Furthermore, a study revealed that the best critical value for the diagnosis of hepatic fat content >10% using the FibroScan M probe was higher in populations with a BMI of ≥28 kg/m^2 than in populations with a BMI of <28 kg/m^2. The reason may be that the skin-capsule depth (SCD) in populations with a BMI ≥28 kg/m^2 is thick and beyond the interval of 25 to 65 mm. Thus, the liver fat content is overestimated.[33] In addition, the excessive thickness of SCD caused the detection area to expand to the hepatic capsule or even out of the liver, resulting to a nonstandard image quality, and prompting the software to automatically cancel the elastography. In addition, overweight or obese patients often have stenosis in the intercostal space, which also reduces the feasibility and accuracy of the measurement. At present, the measurement of CAP can only be carried out using the M probe, which has some limitations. In the present study, we attempted to steer the location of fat accumulation. By squeezing the subcutaneous tissue using the fingers, the measurement point was patiently sought for in the area with thinner subcutaneous fat near the anterior axillary line. This allowed the detection in overweight or obese patients to be successful. The application of the XL probe will make up for the limitations of the M probe in populations with high BMIs. Lately, with biopsy results of the liver as controls, a French scholar compared the efficacy of FibroScan M and XL probes in the diagnosis of fatty liver. This study revealed that the critical value of FibroScan M and XL probes for the diagnosis of fatty liver were 246 and 242 dB/m, respectively, for patients with S ≥1269 and 267 dB/m, respectively, for patients with S ≥2, and 285 and 286 dB/m, respectively, for patients with S ≥3. These results indicate that the XL probe can effectively diagnose and follow-up the fatty liver disease in an obese population.[34]

Previous studies have revealed the relationship between NAFLD and MetS or hyperuricemia. However, most of these studies investigated the presence of NAFLD through ultrasonography, a crude method for detecting hepatic steatosis that requires more than 30% hepatic lipid for detection and is highly subjective with respect to operator's skill. In this study, we explored the relationship between NAFLD and MetS or hyperuricemia by using CAP that has significant correlation with hepatic steatosis and considerable diagnostic performance for grading the degree of steatosis. Moreover, this study focused on middle-aged and old people who are susceptible to cardiovascular disease, diabetes mellitus, and tumor to explore early warning strategy.

Few limitations are present in our study. First, there was a single-center cross-sectional study with the small sample size. Second, follow-ups were not conducted to observe the association of changes in CAP value with MetS and hyperuricemia. Therefore, to further explore the value of CAP as an early warning strategy, as well as for the monitoring and treatment of MetS and hyperuricemia, a large-scale and multicenter study with follows-ups of an adequate number of middle-aged and elderly NAFLD patients is needed to achieve statistically significant results.

In conclusion, CAP values are closely correlated to MetS and its components, as well as hyperuricemia in middle-aged and elder NAFLD patients. CAP may be an indicator of risk of MetS and the severity of metabolic disorders in middle-aged and elderly NAFLD patients.

Acknowledgments

Author contributions

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