May Ultrasonography Diagnosed Hepatic Steatosis be Predictor of Metabolic Syndrome Among Aviators?

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Abstract

Patients with nonalcoholic fatty liver disease (NAFLD) have higher cardiovascular morbidity and mortality rates compared with the general population. Because of several periodic examinations, in general, aviators are healthier than general population. We aimed to evaluate whether ultrasonography diagnosed hepatic steatosis (HS) may be a noninvasive predictor of metabolic syndrome (MetS) among aviators. About 32 aviators with NAFLD and 32 healthy aviators were included in the study. Age, body mass index (BMI), systolic blood pressure (SBP) and diastolic blood pressure (DBP), laboratory parameters (fasting blood glucose [FBG], total cholesterol [TC], low-density lipoprotein-cholesterol [LDL-C], and high-density lipoprotein-cholesterol [HDL-C], very LDL-C [VLDL-C], triglyceride [TG]), TC/HDL-C ratio were obtained from the medical history, physical examination and laboratory result chart of medical recordings. The prevalence of HS was 16.9% (n = 32) in the aviators who were performed abdominal ultrasonography as an annual routine test. BMI (26.1 ± 1.9 vs. 24.0 ± 1.9, \( P < 0.001 \)), SBP (119.1 ± 11.2 vs. 110.7 ± 7.5, \( P = 0.001 \)), and DBP (76.6 ± 7.6 vs. 70.1 ± 6.9, \( P = 0.001 \)), FBG (97.7 ± 9.1 vs. 90.1 ± 13.3, \( P = 0.010 \)), TC (219.9 ± 42.3 vs. 191.2 ± 30.1, \( P = 0.003 \)), LDL-C (140.2 ± 34.3 vs. 117.9 ± 22.2, \( P = 0.003 \)) and VLDL-C (32.1 ± 14.5 vs. 23.9 ± 12.5, \( P = 0.019 \)), TC/HDL-C ratio (4.5 ± 0.9 vs. 3.9 ± 0.8, \( P = 0.011 \)) were significantly higher in aviators with HS compared to healthy ones. MetS (≥3 criteria) was significantly higher in aviators with HS compared to healthy ones (53.1% vs. 18.8%, \( P = 0.004 \)). HS may be a reliable representative of MetS, which can be non-invasively screened among aviators. Moreover, HS may be a clinical indicator of MetS among aviators who need further cardiovascular evaluation and also counseling for lifestyle and dietary changes, and exercise activity programing.

Introduction

Because of the increasing prevalence of overweightness, obesity, and metabolic syndrome (MetS), and Type 2 diabetes associated metabolic abnormalities, nonalcoholic fatty liver disease (NAFLD) has become the most common liver disease (1,2). NAFLD is closely associated with insulin resistance (IR) and its metabolic consequences and portrays a spectrum of liver damage ranging from simple HS, as a more benign condition, to nonalcoholic steatohepatitis (NASH) which may progress to cirrhosis (3,4). Increasing prevalence of obesity and MetS up to 33.8% and 23.7% among adults in the United States adults raised the significance of HS (5,6). Since the prevalence of NAFLD; a novel determinant for cardiovascular disease (CVD); initiated to increase and...
varied between 2.8% and 46% (2,7). NAFLD is a low-grade chronic inflammatory state which potentiates and contributes the development of atherosclerosis related CVD (8). Patients with NAFLD, especially those with obesity and MetS, have higher cardiovascular mortality, and liver-related mortality compared with the general population (9,10). Thus, it may be crucial to screen the NAFLD and related metabolic disorders among aviators who have a lower coronary risk profile compared to general population (11).

Because of remaining asymptomatic until late stages of liver disease, the diagnosis of NAFLD is still under recognized. Although the liver biopsy is the gold standard in diagnosing and determining the severity of NAFLD, it is an invasive procedure with potential to serious complications (3,9,12). Ultrasonography (USG), a non-invasive imaging modality, provides high-quality images at a low cost and has an important role in diagnosing NAFLD (13). Hence, it will be irresistibly preferred by the aviators, who care the flight hours, as someone else. Because of several periodic and aviation examinations, aviators are healthier than general population. In our country, USG is performed to military aviators as an annual screening tool to detect asymptomatic intra-abdominal pathologies. In this study, we aimed to explore whether USG diagnosed HS may be a noninvasive predictor of MetS among aviators.

Methods

Study population

The present study was conducted at Aviation Medical Examination Center of Etimesgut Military Hospital, Ankara, Turkey carrying out an evaluation for military aviators and it the study was approved by the local Ethic Committee. Informed consent was acquired from all the participants. This research involved retrospective analysis of abdominal USG conducted within 1-month period. The study population consisted of 189 male military aviators who underwent routine annual flight medical examinations. Subjects, who were previously diagnosed as NAFLD, were excluded from the study. 32 aviators with ultrasound-diagnosed NAFLD and 32 healthy aviators were compared in view of clinical features and laboratory parameters.

Ultrasound examination

USG examination was carried out, and sonographic views were recorded by a single board-certified radiologist. The USG equipment was a GE Logiq P5 (GE Ultrasound, Korea) scanner with a 3.5-MHz convex array transducer. The sonographic examination was carried out with same probes. The sonographic findings were recorded on thermal printing paper, and a written report was generated for each aviator. Bright hepatic echoes, increased hepatorenal echogenicity, vascular blurring of the portal, or hepatic vein are accepted as characteristic sonographic findings for NAFLD.

Clinical features

Age, height, weight, systolic blood pressure (SBP) and diastolic blood pressure (DBP) were recorded from the medical archives. Body mass index (BMI) was calculated for each aviator according to the standard formula: BMI = weight (kg)/height (m)^2. BMI categories were determined as normoweight (<25 mmHg kg/m^2), overweight (25-30 mmHg kg/m^2), and obesity (≥30 mmHg kg/m^2). Blood pressure categories were determined as normotension (SBP < 120 mmHg and DBP < 80 mmHg), prehypertension (SBP 120-139 mmHg and/or DBP 80-89 mmHg), and hypertension (SBP ≥ 140 mmHg and/or DBP 90 mmHg).

Laboratory data

Blood samples had been obtained from all of the patients by a venous route at a 12 h fasting state in the morning 08 00 AM. Serum levels total cholesterol (TC), low-density lipoprotein-cholesterol (LDL-C) and high-density lipoprotein (HDL-C) cholesterol, very LDL-C (VLDL-C), triglyceride (TG) were measured from the serums derived from the venous blood sample by centrifuging at 4000 rpm for 4-min period. In addition, serum levels of fasting blood glucose (FBG), aspartate amino transferase (AST), and alanine amino transferase (ALT), γ-glutamyltransferase, and blood urea, creatinine had been studied. Dyslipidemia was defined as LDL > 160 mg/dL, HDL ≤ 40 mg/dL, TG ≥ 150 mg/dL. Impaired FBG was determined as FBG > 100 mg/dL.

Serum levels of all the laboratory parameters were measured through auto-analyzing and auto-calculating by the device with brand Olympus AU640 (Beckman Coulter).

Complete blood count was studied from the blood sample drained at a 12 h fasting state in the morning period and performed in the device branded with Mindray Auto Hematology Analyzer-BC-6800 (A. Menarini Diagnostics, PRC).

Definition of MetS

MetS was diagnosed as the presence of at least three criteria of dyslipidemia (HDL ≤ 40 mg/dL,
TG ≥ 150 mg/dL), impaired FBG (>100 mg/dL), and abnormal blood pressure SBP ≥ 130 or DBP ≥ 85 mmHg, BMI ≥ 30 kg/m² (14,15). In this study we used BMI > 30 kg/m², an identifier of central obesity, instead of waist circumference ≥ 94 cm for male subjects, since waist circumference has not been measured and obtained from medical recordings.

**Statistical analysis**

A statistical analysis was performed using SPSS 15.0. Normality of distribution for continuous variables was tested by Kolmogorov–Smirnov test and histogram analysis. Numerical variables were expressed as a mean ± standard deviation. Then, numerical variables with normal distribution were analyzed by parametric test (Independent sample t-test, one-way ANOVA test). Categorized variables were analyzed by Chi-square test. Correlation analyses of parametric and nonparametric data were performed by Pearson and Spearman’s correlation test, respectively. P < 0.05 was accepted as statistically significant.

**Results**

The frequency of ultrasound-diagnosed HS was 31.69 (n = 32) among 189 male aviators. Age of HS group was significantly higher than normal ones (Table 1). Body weight (74.6 ± 7.0 vs. 81.2 ± 7.8, P = 0.001), BMI (24.0 ± 1.9 vs. 26.1 ± 1.9, P < 0.001), and SBP (110.7 ± 7.5 vs. 119.1 ± 11.2, P = 0.001) and DBP (70.1 ± 6.9 vs. 76.6 ± 7.6, P = 0.001) of the aviators with HS were significantly higher than healthy aviators. In addition, the frequency of prehypertension (37.5% vs. 3.1%) and hypertension (6.3% vs. 0%) was significantly higher, whereas frequency of normotension (56.3% vs. 96.9%) was lower in HS group compared to normal aviators (p < 0.001) (Table 1). Overweight (65.6% vs. 34.4%) was higher in frequency HS group whereas normoweight (34.4% vs. 65.6%) was lower (p = 0.012). On the other hand, frequency of impaired FBG (40.6% vs. 12.5%) was higher in aviators with HS (p = 0.011). Frequency of MetS (≥3 criteria) (53.1% vs. 18.8%) was significantly higher among aviators with HS (p = 0.004) (Table 1).

Serum levels of ALT (25.7 ± 11.1 vs. 44.7 ± 18.1, P < 0.001), AST (23.6 ± 5.0 vs. 29.50 ± 7.3, P < 0.001), and γ-GT (22.6 ± 15.1 vs. 34.1 ± 22.3, P < 0.05) were significantly elevated in HS group. Serum levels of FBG (90.1 ± 12.8 vs. 97.7 ± 9.1, P < 0.05), TC (191.2 ± 30.1 vs. 219.9 ± 42.3, P < 0.05), LDL-C (117.9 ± 22.2 vs. 140.2 ± 34.3, P < 0.05), VLDL-C (23.9 ± 12.5 vs. 32.1 ± 14.5, P < 0.05) were significantly higher among aviators with HS (Table 2). As a cardiovascular morbidity and mortality risk factor, TC/HDL-C ratio was significantly increased in aviators with HS (p = 0.011) (Table 2).

Comparison of laboratory parameters and distribution of MetS criteria among aviators with normal USG and Grades I and II HS were presented in Table 3. The frequency of MetS was significantly higher in aviators with Grades II and I HS compared to ones with normal USG (57.1% vs. 50% vs. 18.8%, P < 0.015). In multiple variable linear regression analysis performed with stepwise model, we found that BMI (β=0.321, P = 0.008), LDL-C (β=0.325, P = 0.003), and SBP (β=0.256, P = 0.031) were significantly associated with MetS.

**Table 1: Comparison of demographic features including categories of BMI, blood pressure, and dyslipidemia, FBG abnormality, and also criteria for metabolic syndrome among the aviators with normal USG and hepatic steatosis**

| Demographic features and laboratory parameters | Normal USG (n=32) | Hepatic steatosis (n=32) | P value |
|-----------------------------------------------|------------------|------------------------|---------|
| **Demographic features**                      |                  |                        |         |
| Age (years)                                   | 31.2±6.8         | 37.7±7.5               | 0.001   |
| Height (m)                                    | 1.72±0.1         | 1.71±0.1               | 0.930   |
| Weight (kg)                                   | 74.6±7.0         | 81.2±7.7               | 0.001   |
| BMI (kg/m²)                                   | 24.0±1.9         | 26.1±1.9               | <0.001  |
| SBP (mmHg)                                    | 110.7±7.5        | 119.1±11.2             | 0.001   |
| DBP (mmHg)                                    | 70.1±6.9         | 76.6±7.6               | 0.001   |
| **BMI category**                              |                  |                        |         |
| Normoweight                                   | 21 (65.6)        | 11 (34.4)              | 0.012   |
| Overweight                                    | 11 (34.4)        | 21 (65.6)              |         |
| **Blood pressure category**                   |                  |                        |         |
| Normotension                                  | 31 (96.9)        | 18 (56.3)              | <0.001* |
| Prehypertension                               | 1 (3.1)          | 12 (37.5)              |         |
| Hypertension                                  | 0                | 2 (6.3)                |         |
| **Dyslipidemia**                              |                  |                        |         |
| LDL-C≤160 mg/dL                               | 31 (96.9)        | 24 (75.0)              | 0.013*  |
| HDL-C≥40 mg/dL                                | 11 (34.4)        | 8 (25.0)               |         |
| Normal triglyceridemia                        | 28 (87.5)        | 12 (37.5)              |         |
| Hypertriglyceridemia                          | 7 (21.9)         | 12 (37.5)              |         |
| **FBG abnormality**                           |                  |                        |         |
| Normal (<100 mg/dL)                           | 28 (87.5)        | 19 (59.4)              | 0.011*  |
| Impaired FBG (≥100 mg/dL)                     | 12 (37.5)        | 13 (40.6)              |         |
| **Mets**                                      |                  |                        |         |
| Not present                                   | 26 (81.8)        | 15 (46.9)              | 0.004*  |
| MetS (≥3 criteria)                            | 6 (18.8)         | 17 (53.1)              |         |

HDL-C: High-density lipoprotein-cholesterol, MetS: Metabolic syndrome, FBS: Fasting blood glucose, BMI: Body mass index, LDL-C: Low-density lipoprotein-cholesterol, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, USG: Ultrasonography, P: Independent Samples t-test; *P: Chi-square test.
were significantly associated with HS diagnosed on liver USG \((R = 0.615, R^2 = 0.378, \text{Adj.} R^2 = 0.347, P = 0.031)\). The age difference between study groups was not correlated with HS on liver USG (Table 3).

Comparison of aviators with and without ultrasound-diagnosed NAFLD in view of age, BMI, systolic and diastolic blood pressure was shown in Fig. 1. Comparison of aviators with and without ultrasound-diagnosed NAFLD in view of FBG, TC, LDL, and VLDL- was shown in Fig. 2.

**Discussion**

Medical screening at an annual or several years periodicity is well-established in aviation worldwide. As a special skilled population of aviators, medical screening is advocated to focus on the middle-aged person with the likelihood of age-related and also occupational biological and pathological changes \((16,17)\). Since myocardial infarction (MI) or a sudden death (SD) may be the initial presentation of a coronary artery disease, MI or SD may consequence with acute incapacitation of a pilot during the flight. Such a clinical scenario will definitely challenge flight safety and cause fatal aviation accidents. It has been documented that coronary artery disease is the most leading autopsy finding on post-mortem investigations of fatal aviation accidents \((18)\). Similarly, HS was found in 15.6% of the aircrew in those studies following aviation accidents \((12)\). For this reason, great interest has been concentrated on screening for especially CVD and related disorders among aviators.

It has been reported that, in Europe, nearly half of all deaths are due to cardiovascular diseases (CVD) \((19)\). Well-defined traditional risk factors for CVD are older age, male gender, and hypertension, smoking, and HDL and LDL cholesterol, and diabetes mellitus (DM) \((20)\). Moreover, increased total body adiposity and BMI, and visceral fat accumulation increase the risk of CVD through mechanisms of chronic inflammation and atherogenesis. Therefore, specific screening of high-risk aviators is necessary.

### Table 2: Comparison of laboratory parameters and complete blood components among the aviators with normal USG and hepatic steatosis

| Laboratory parameters | Normal USG (n=32) | Hepatic steatosis (n=32) | P value |
|-----------------------|-----------------|-------------------------|---------|
| FBC (g/L)             | 90.1±13.3       | 97.7±29.1               | 0.010   |
| ALT (IU/L)            | 25.7±11.1       | 44.7±18.1               | <0.001  |
| AST (IU/L)            | 23.6±5.0        | 29.5±7.3                | <0.001  |
| GGT (IU/L)            | 22.6±15.1       | 34.1±22.3               | 0.019   |
| Total-C (mg/dL)       | 191.2±30.1      | 219.9±42.3              | 0.003   |
| LDL-C (mg/dL)         | 117.9±22.2      | 140.2±34.3              | 0.003   |
| HDL-C (mg/dL)         | 49.3±8.3        | 49.3±7.0                | 0.987   |
| VLDL-C (mg/dL)        | 23.9±12.5       | 32.1±14.5               | 0.019   |
| Triglyceride (mg/dL)  | 119.8±62.8      | 150.5±69.5              | 0.009   |
| TC/HDL-C              | 3.9±2.0         | 4.5±2.0                 | 0.011   |
| Urea (mg/dL)          | 28.9±5.8        | 30.6±6.7                | 0.238   |
| Uric acid (mg/dL)     | 5.3±1.1         | 5.8±2.0                 | 0.085   |
| Creatinin (mg/dL)     | 1.1±0.1         | 1.1±0.1                 | 0.863   |
| Complete blood cell count |                |                        |         |
| White blood cell (×10³) | 6.4±1.7         | 6.7±1.7                 | 0.459   |
| Hemoglobin (g/dL)     | 16.3±0.7        | 16.2±0.8                | 0.697   |
| Hematocrit (%)        | 48.4±2.3        | 48.2±2.5                | 0.748   |
| Platelet count (×10³) | 229.5±25.2      | 259.3±49.5              | 0.023   |
| Mean platelet volume (fl) | 10.2±1.0       | 9.9±1.1                 | 0.349   |
| Neutrophil (%)        | 58.2±9.6        | 53.8±5.5                | 0.028   |
| Lymphocyte (%)        | 32.2±8.6        | 35.2±7.5                | 0.143   |
| Eosinophil (%)        | 2.4±1.6         | 2.8±1.8                 | 0.304   |
| Basophil (%)          | 0.4±0.2         | 0.4±0.3                 | 0.407   |
| Monocyte (%)          | 6.3±2.3         | 6.2±2.2                 | 0.758   |
| Neutrophil to lymphocyte ratio | 2.15±1.0        | 1.92±2.2                | 0.766   |

USG: Ultrasonography, p: Independent samples t, TC/HDL-C, Total cholesterol to HDL ratio, LDL-C: High-density lipoprotein-cholesterol, MetS: Metabolic syndrome, FBS: Fasting blood glucose, BMI: Body mass index, LDL-C: Low-density lipoprotein-cholesterol, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, GGT: γ-glutamyltransferase, AST: Aspartate amino transferase, ALT: Alanine amino transferase.

### Table 3: Comparison of laboratory parameters and distribution of metabolic syndrome criteria among aviators with normal USG and Grades I and II hepatic steatosis

| Laboratory parameters | Normal USG (n=32) | Grade I USG (n=18) | Grade II USG (n=14) | P value |
|-----------------------|------------------|-------------------|-------------------|---------|
| FBC (g/L)             | 90.1±13.3        | 98.6±21.8         | 96.6±20.6         | 0.032†  |
| ALT (IU/L)            | 25.8±11.2        | 39.0±12.8         | 52.1±21.5         | <0.001‡ |
| AST (IU/L)            | 23.6±5.0         | 27.4±6.2          | 32.7±6.7          | <0.001‡ |
| GGT (IU/L)            | 22.7±15.1        | 32.7±25.5         | 35.9±18.3         | 0.060   |
| Total-C (mg/dL)       | 191.3±30.1       | 219.7±48.0        | 220.3±36.2        | 0.012†  |
| LDL-C (mg/dL)         | 117.9±22.2       | 141.1±32.8        | 139.2±23.0        | 0.015†  |
| HDL-C (mg/dL)         | 49.3±8.3         | 49.5±28.0         | 49.0±25.9         | 0.934   |
| VLDL-C (mg/dL)        | 23.9±12.5        | 32.1±16.2         | 32.1±12.6         | 0.066   |
| Triglyceride (mg/dL)  | 119.8±62.7       | 142.8±75.1        | 160.4±63.0        | 0.147   |
| TC/HDL-C              | 3.9±2.0          | 4.4±2.0           | 4.5±2.0           | 0.041   |
| MetS (n, %)            | Not present      | 26 (81.3)         | 9 (50.0)          | 6 (42.9) | 0.015*  |
| MetS (≥2 criteria)    | 6 (18.8)         | 9 (50.0)          | 8 (57.1)          |         |

p: One-way ANOVA test; †p: Chi-square test; ‡p: post hoc analysis ‘Normal versus Grade I US ‘Normal Grade II US, †Grade I versus II US, ‡Grade I: High-density lipoprotein-cholesterol, MetS: Metabolic syndrome, FBS: Fasting blood glucose, BMI: Body mass index, LDL-C: Low-density lipoprotein-cholesterol, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, GGT: γ-glutamyltransferase, AST: Aspartate amino transferase, ALT: Alanine amino transferase, HS: Hepatic steatosis
IR (21). NAFLD and CVD unfavorably share the same mechanisms; chronic inflammation and IR; on the way progressing to atherosclerosis (22). It has been speculated that HS play an important role in the pathogenesis.
of CVD via the overexpression and increased systemic release of various inflammatory and oxidative stress mediators (23). In addition, chronic inflammation results with IR which produces atherogenic dyslipidemia and also contributes to NAFLD and CVD and encircles a vicious cycle (24,25). Several researches have reported that NAFLD is clearly associated with coronary artery disease (22,24). Assy et al. documented that patients with NAFLD had a higher prevalence of coronary atherosclerotic plaques by using computed tomography coronary angiography (26). They stated that it was a strong predictor for coronary atherosclerosis probably due to IR, systemic inflammation, and lipotoxicity, and etc. It has been also documented that NAFLD was strongly associated with carotid intima media thickness and carotid atherosclerosis in a large populated meta-analysis (27). Recently, Dogan et al. reported that NAFLD fibrosis score was positively correlated with Framingham risk score which had been frequently used in risk stratification of coronary artery disease and liver biopsy will not be required so on (28). Furthermore, it has been reported that Framingham risk score indicated that patients with NAFLD had higher 10 years coronary heart disease risk compared to age and sex-matched population and earlier management could prevent cardiovascular events (29). Thus, presence of NAFLD has been proposed to be a novel component of MetS (30). From the point of those abovementioned mechanisms, we suggest that NAFLD may be used as a novel coronary risk factor which indicates the subjects requiring further cardiovascular screening tests (e.g. exercise stress test) among aviators. Hence, screening for NAFLD may be clinically critical to identify the aviators at high risk for coronary heart disease. USG is a convenient, widely available and noninvasive method for evaluating and diagnosing the NAFLD (13).

In our Aviation Medical Examination Center, abdominal USG has been performed as a routine standard procedure study annually. Although the main purpose of this examination was to evaluate the structural or functional wellness of intra-abdominal organs, tracts, and mass or cystic lesions which could complicate the pilot health and consciousness and also the flight safety. However, evaluation and diagnosis of HS during liver examination by USG may identify the pilot or aviator who is at risk for atherosclerotic cardiovascular disease and IR metabolic abnormalities. In our study, we found the frequency of ultrasound-diagnosed NAFLD as %16.9 (32/189). In a previous study of Chadha et al., they reported the frequency of USG-diagnosed fatty liver in defense aircrew as 6/1211 (0.004%) for Evaluation Center I and 14/760 (0.01%) for Evaluation Center II (31). Besides, they noted a higher prevalence of USG-diagnosed HS in the civil aviation aspirants. Increasing body weight, difference of race, inappropriate dietary and eating habitual consisting high calorie intake, and inadequate physical activity may explain the difference in frequency of HS between civilian and military aviators. However, the presence of HS may be a clinical feature which indicates the necessity of dietary and lifestyle management in apparently healthy aviation population. It has been stated that pilots are in general healthy individuals and have obviously a lower prevalence of obesity, hyperlipidemia, and hypertension, diabetes except the overweightness (11,32). As we know, the criteria of blood pressure and glycemia for the diagnosis of hypertension and diabetes are higher than those in the definition of MetS. Thus, MetS has the ability to identify a subject at a pre-hypertensive and pre-diabetic stage. In our current study, frequency of MetS was found to be higher in aviators with HS, which was positively correlated with BMI, LDL-C, and SBP. Hence, HS on liver USG may be novel coronary risk factor or, at least, a clinical feature indicating metabolic abnormalities related with IR among the aviators who seem healthy in appearance. Overweightness, increased BMI, and Type 2 diabetes are the consequences of IR and its metabolic complications. Aviators with HS were not only at risk for cardiovascular disease but also at risk for Type 2 diabetes which could be a reason for the disqualification from the flight duty. In a review of Steinakraus et al., they reported that, between years 1975 and 2000, 70 US aviators was diagnosed as DM and over 95% were aviators with DM Type 2. The mean BMI for aviators with DM was 26.2 (33). In our study population, the BMI was 26.1 and FBG were higher in aviators with HS compared to ones without HS. We may conclude that aviators with HS has the potential to progress to Type 2 diabetes and medically disqualification from flight unless HS and MetS are managed or treated by lifestyle and dietary changes, losing weight, physical activity.

Shima et al. reported that age and Type 2 diabetes was closely associated with NAFLD and its progression to NASH (34), we similarly observed that HS group was older than those without HS in our study. Although the age was not among the variables which were positively
correlated with HS, this may be consequence of a limited number of our study population.

Hypercholesterolemia is an independent well-established risk factor for the development of atherosclerosis and endothelial dysfunction (35). Aterogenic dyslipidemia, a result of IR, is characterized with high levels of LDL-C and VLDL-C, low levels of HDL-C, and high levels of TG (36). We documented that TC, LDL-C, and VLDL-C were significantly higher, and TG was tended to be higher in HS group. Serum levels of TC, LDL-C, and TG are closely associated with AP from the initial stage of fatty streak to its vulnerable stage (37). Although HDL-C levels were not different between group, TC/HDL-C ratio which was reported to be more predictive for morbidity and mortality in cardiovascular diseases was significantly higher in HS group (38). In addition, TC/HDL-C ratio could predict the presence and severity of coronary artery disease and also existence of IR in non-diabetic patients with acute coronary syndromes (39,40). Chiu et al. reported that TC/HDL-C ≥ 4.2 independently indicate CAD in patients with MetS (41). In this study, we found that TC/HDL-C was 4.5 ± 0.9 in HS group and its co-existence with increased number of MetS criteria among HS group probably indicate increased risk for CVD.

Conclusion

Aviation has some occupational properties which may challenge pilot and public safety, and economical concerns. Hence, aviators are the special occupational groups who are delicately and periodically screened for various types of diseases. HS may easily diagnosed on liver USG and its close relationship with chronic inflammation and IR may indicate the aviators at high risk for atherosclerosis and who need lifestyle and dietary changes to prevent any cardiovascular event.

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