《Original Article》

The Relation of Visceral Adipose Tissue to the Metabolic Syndrome

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Summary

Current study was undertaken to examine metabolic abnormalities in subjects with excess visceral adipose tissue. Three hundred seventy-six subjects (345 men and 31 women) for medical check-up were enrolled in the present study. The amount of visceral and subcutaneous fat area (VFA and SFA) at umbilical level was determined by computed tomography. The number of subjects with 25>BMI and 100cm^2>VFA is 134 (113 men and 21 women), with 25>BMI and 100cm^2≦VFA is 102 (101 men and 1 woman), with 25≦BMI and 100cm^2>VFA is 27 (23 men and 4 women), with 25≦BMI and 100cm^2≦VFA is 113 (108 men and 5 women). Subjects with 100cm^2≦VFA had significant higher levels of body weight, body mass index, systolic blood pressure, diastolic blood pressure, fasting blood glucose, triglyceride, uric acid, ALT, and γ GTP than subjects with 100cm^2>VFA. Serum HDL-cholesterol and amylase are significantly lower in subjects with excess visceral fat. In the present study, male obese subjects have excess visceral fat. Hypertension, dyslipidemia and glucose intolerance occur more frequently in subjects with excess visceral fat than in non-obese subjects. The measurement of visceral fat area correlates more closely with the abnormalities of fasting blood glucose and uric acid than BMI.

Introduction

The metabolic syndrome is a common metabolic disorder that results from the increasing prevalence of obesity (1-3). The metabolic syndrome is also known as syndrome X, the insulin resistance syndrome, and the deadly quartet. The constellation of metabolic abnormalities includes glucose intolerance (type 2 diabetes, impaired glucose tolerance, or impaired fasting glycemia), insulin resistance, central obesity, dyslipidemia , and hypertension, all well documented risk factors for cardiovascular disease . These conditions co-occur in an individual more often than might be expected by chance. When grouped together, they are associated with increased risk of cardiovascular disease. Epidemiological studies often report a relation of excess visceral fat to metabolic syndrome. In moderate obesity, regional distribution appears to be an important indicator for metabolic and cardiovascular alterations since an inconstant correlation between body mass index (BMI) and their disturbances has been found (4-6).

In the present study, we investigated the correlation between visceral fat area and laboratory data of subjects examined for medical check-up, reflecting metabolic and cardiovascular diseases. We sought to identify associations between the amount of excess visceral fat and metabolic abnormalities.

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Subjects and Methods

Three hundred seventy-six subjects (345 men and 31 women) who visited the Chubu Health Center for medical check-up in 2001 were enrolled in the present study. Mean age of subjects was 51 years old (range 38 – 68).

The subjects' height and weight were measured with a portable standiometer and a digital scale to the nearest 1mm and 0.1kg respectively. Blood pressure (BP) was measured in the seated position on the right arm using an automated blood pressure recorder.

Blood samples were obtained from the antecubital vein of the subjects after overnight fasting. All subjects underwent the standard blood examination, including measurement of fasting glucose, hemoglobin A_{1C}(HbA_{1C}), total cholesterol, HDL cholesterol, triglyceride, uric acid, AST, ALT, γ GTP, amylase.

To determine the visceral intra-abdominal and subcutaneous abdominal areas, a simple CT scan was undertaken at the level of the umbilicus. CT was used to assess the degree liver steatosis. Liver CT attenuations were determined by calculating the mean Hounsfield unit (HU).

Data are expressed as means ± a standard deviation (SD). The difference of means between two groups was assessed by Student's t-test. Significance was taken as $p<0.05$. Statistical analyses were performed by using Stat View software (version 5; Japanese Edition, SAS Inc).

Result

The number of subjects with 25 > body mass index (BMI) and 100cm^2 > visceral fat area (VFA) is 134 (113 men and 21 women), with 25 > BMI and 100cm^2 ≦ VFA is 102 (101 men and 1 woman), with 25 ≦ BMI and 100cm^2 > VFA is 27 (23 men and 4 women), with 25 ≦ BMI and 100cm^2 ≦ VFA is 113 (108 men and 5 women). In men, the prevalence of subjects with BMI≧25 is 62%, and with VFA≧100cm^2 is 61%. In women, the prevalence of subjects with BMI≧25 is 29%, and with VFA≧100cm^2 is 19%.

Anthropometric and clinical laboratory data of subjects with VFA < 100cm^2 and VFA ≧100cm^2 are shown in Table 1. Subjects with VFA≧100cm^2 had significant higher levels of body weight, BMI, systolic blood pressure, diastolic blood pressure, fasting blood glucose, total cholesterol, triglyceride, uric acid, and ALT than those with VFA<100cm^2. Serum HDL-cholesterol, amylase and CT number of the liver are significantly lower in subjects with excess visceral fat.

Anthropometric and clinical laboratory data of subjects with BMI < 25 and BMI≧25 are shown in Table2. Subjects with BMI≧25 had significant higher levels of body weight, systolic blood pressure, diastolic blood pressure, total cholesterol, and triglyceride and ALT than those with BMI<25. Serum HDL-cholesterol and CT number of the liver are significantly lower in obese subjects. Subjects with BMI≧25 also had significant higher value of visceral fat area and subcutaneous fat area than those with BMI<25.

Discussion

In the present study, we analyzed anthropometric and laboratory data of subjects having a medical checkup, based on BMI and visceral fat area. Obesity is, of course, a great public health concern because it is directly related to the development of diabetes, hypertension, dyslipidemia, and ultimately, cardiovascular diseases. Obesity is usually based on the BMI. Several studies suggest that increased visceral adiposity is more likely to be associated with metabolic alterations than simply an increased BMI (1-7). A strong positive correlation

Table 1. Anthropometric and clinical laboratory data of subjects with VFS<100cm^2 and VFA ≧ 100cm^2

	Visceral fat area <100cm^2 (n=163)	Visceral fat area ≧100cm^2 (n=213)	P value
Body weight (kg)	64.0±7.4	72.6±8.4	<0.01
BMI (kg/m^2)	23.5±4.7	25.5±2.2	<0.01
Blood pressure (systolic) (mmHg)	124±16	135±18	<0.01
(diastolic) (mmHg)	77±10	83±10	<0.01
Fasting blood glucose (mg/dl)	96±17	106±31	<0.01
HbA1c (%)	5.2±0.7	5.3±0.9	NS
Total cholesterol (mg/dl)	198±31	208±42	<0.01
HDL-cholesterol (mg/dl)	57±15	50±12	<0.01
Triglyceride (mg/dl)	138±58	171±103	<0.01
Uric acid (mg/dl)	5.7±1.2	6.3±1.3	<0.01
AST (IU/l)	25±19	26±13	NS
ALT (IU/l)	23±22	31±21	<0.05
γGTP (IU/l)	36±37	49±43	NS
Amylase (IU/l)	111±34	98±37	<0.01
CT number of the liver (HF unit)	62.0±8.0	53.1±9.5	<0.01

Table 2. Anthropometric and clinical laboratory data of subjects with BMI<25 and BMI ≧ 25

	BMI<25 (n=236)	BMI≧25 (n=140)	P value
Body weight (kg)	62.6±7.5	75.6±7.8	<0.01
Blood pressure (systolic) (mmHg)	127±19	135±18	<0.01
(diastolic) (mmHg)	78±10	84±10	<0.01
Fasting blood glucose (mg/dl)	99±24	101±23	NS
HbA1c (%)	5.3±0.8	5.3±0.7	NS
Total cholesterol (mg/dl)	199±33	209±41	<0.01
HDL-cholesterol (mg/dl)	55±14	50±12	<0.01
Triglyceride (mg/dl)	132±108	156±96	<0.05
Uric acid (mg/dl)	5.9±1.3	6.0±1.2	NS
AST (IU/l)	25±15	26±11	NS
ALT (IU/l)	25±20	31±18	<0.05
γGTP (IU/l)	42±62	45±39	NS
Amylase (IU/l)	104±35	101±36	NS
CT number of the liver (HF unit)	60.6±8.7	53.0±9.4	<0.01
Visceral fat area (cm^2)	87.8±42.8	138.7±49.5	<0.01
Subcutaneous fat area (cm^2)	90.1±38.8	135.0±37.5	<0.01

exists between the amount of visceral adipose tissue and the health risks of obesity. Regional distribution of body fat appears to be an important indicator for metabolic alterations since an inconstant correlation between BMI and these disturbances has been found (4).

In this study, there are significant differences in serum level of blood pressure, total cholesterol, HDL-cholesterol, triglyceride, ALT and CT number of the liver between obese and non-obese subjects evaluated by BMI, and between subjects with excess and normal visceral fat. There is no significant difference in serum level of fasting blood glucose and uric acid between obese subjects and non-obese subjects evaluated by BMI. On the contrast, subjects with excess visceral fat have higher levels of fasting blood glucose and serum uric acid than those with less amount of fat, based on visceral fat area evaluated by abdominal CT scan. Excess visceral fat

seems to reflect glucose intolerance and abnormal uric acid metabolism more accurately than BMI. Matsuura et al (8) reported the relationship between uric acid metabolism and fat distribution. Visceral fat obesity was linked more closely to overproduction of uric acid than subcutaneous fat obesity. Therefore, estimating the visceral fat accumulation is important in terms of evaluating obesity with a higher risk of metabolic disorders.

Some metabolic abnormalities including glucose intolerance, central obesity, dyslipidemia and hypertension co-occur in an individual as metabolic syndrome, which is associated with an increased risk of cardiovascular diseases. The measurement of the waist circumstance provides an estimate of body fat distribution (in lieu of CT or MRI). In 2005, a committee of specialists from eight Japan Societies specified a diagnosis criterion of Japan-specific metabolic syndrome appropriate for Japanese. According to this diagnostic criterion for Japanese (9), abdominal obesity : waist circumstance: ≧85 cm in men and ≧90 cm in women was obligatory since central obesity, as opposed to BMI, may reflect the volume of fat around visceral organs. Excess fat in the intra-abdominal cavity is associated with an increased risk of hypertension, diabetes, dyslipidemia, and other complications, compared with the same amount of fat carried in the subcutaneous tissue. In the present study, the prevalence of excess visceral adiposity (VFA≧100cm^2) is 61% in men, and 19% in women. Urashima et al (10) reported that using data from the Health Science Center at Jikei University Hospital, the prevalence of abdominal obesity (waist circumstance: ≧85 cm in men and ≧90 cm in women) is 46.2% in men and 12.3% in women. One of the reasons of high prevalence of abdominal obesity in the present study is that the average age of subjects in the present study is relatively high compared with Japanese general population. Moreover, considerable controversy has arisen as to the waist circumference cut-off points for diagnosing metabolic syndrome for Japanese people (11, 12).

In conclusion, the estimation of visceral fat adiposity is more important to predict the aggravation of glucose intolerance and uric acid metabolism than that of BMI. Further studies must be performed to elucidate more suitable method for estimating visceral fat and appropriate criteria for metabolic syndrome for early detection of the risk of cardiovascular diseases.

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和文抄録

内臓脂肪型肥満とその合併症の検討

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2001年に中部健康管理センターにおいて腹部CT検査を含めた職域検診を受診した376例を対象にBMIと内臓脂肪面積（VFA）により群分けを行い、身体計測値、血圧、空腹時血糖、HbA1c、総コレステロール、HDLコレステロール、トリグリセリド、尿酸、AST、ALT、γGTP、アミラーゼについて比較検討した。BMI＜25･VFA＜100cm^{2}は134例、BMI<25･VFA≧100cm^{2}は102例、BMI≧25･VFA＜100cm^{2}は27例、BMI≧25･VFA≧100cm^{2}は113例であった。内臓脂肪型肥満患者では体重、BMI、収縮期血圧、拡張期血圧、空腹時血糖、総コレステロール、トリグリセリド、尿酸、ALTが有意に高値であった。一方、肝CT値、HDLコレステロール、アミラーゼは有意に低値であった。男性肥満患者では内臓脂肪型肥満の頻度が高かった。肥満患者のうちBMIによって判定した肥満者より内臓脂肪型肥満者に糖代謝異常、高尿酸血症を認める頻度が高かった。内臓脂肪型肥満者では生活習慣病の発症頻度が高く、糖尿病の合併症の発症に十分留意する必要がある。

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