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Ultrasonography for the evaluation of visceral fat and the metabolic syndrome

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Abstract

Association between abdominal obesity and cardiovascular disease has been related with visceral adiposity, through the predisposition of developing type 2 diabetes mellitus and metabolic syndrome (MS). Sonography is a simple and reliable method to measure both subcutaneous and visceral fat. To analyze the relationship of anthropometric measurements with abdominal adiposity measured by sonography and to analyze the utility of sonography in the prediction of insulin resistance (IR) and the other components of MS. Visceral fat measurements by sonography correlated better with components of MS than did subcutaneous fat measurements. Preperitoneal circumference (PC) was strongly correlated with all components of MS and with IR expressed as a homeostasis model assessment (HOMA) index for IR. PC was better than waist circumference (WC) in predicting triglyceride levels, apolipoprotein B levels, and HOMA index, but WC was better than PC in predicting high-density lipoprotein cholesterol levels. The area under the receiver operating characteristic curve was 0.699 for PC and 0.684 for WC, in subjects with body mass index 25 kg/m^2 or greater (P = .024 and .015, respectively). PC and WC showed good correlation with HOMA index (Spearman correlation coefficient = 0.306, $P < .001$ and .206, $P < .001$, respectively). Abdominal visceral fat is better correlated with MS than subcutaneous fat; sonography is a useful method to evaluate the abdominal fat; PC is the best sonography parameter correlated with components of MS, and in overweight and obese subjects, PC is better than WC at predicting components of the MS.

1. Introduction

Obesity, especially of abdominal distribution, is an international health problem that has been on the increase, especially in occidental countries, in recent years [1,2]. It has been clearly established that abdominal obesity is strongly associated with cardiovascular disease (CVD). The association between abdominal obesity and CVD has been related with visceral adiposity, through the predisposition of developing type 2 diabetes mellitus and metabolic syndrome (MS) [3,4]. The mechanism of this association has not been clearly established. However, adipose tissue with abdominal visceral distribution is very active in the production of several molecules such as tumor necrosis factor, resistin, plasminogen activator inhibitor 1, and interleukin 6, with potent proatherogenic and insulin resistance (IR) activities [5].

Along these lines, abdominal visceral adiposity measured by computed tomography scan or magnetic resonance imaging is well correlated with IR [6,7]. However, these procedures are, for the moment, reserved for research purposes.

The measurement of abdominal obesity through waist circumference (WC) has been established as a simple, inexpensive, and useful method for the diagnosis of abdominal obesity. For this reason, WC has been proposed

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as a key element for the diagnosis of MS. It has been proposed as a part of the routine general physical examination in clinical practice [8]. Moreover, WC is well correlated with visceral obesity, and in clinical studies, it has been associated with cardiovascular risk [9]. However, IR among subjects with elevated WC is highly variable, probably for a number of reasons, including genetic factors predisposing to IR and the lack of accuracy in the measurement of WC in subjects with a pendulous abdomen [10]. In addition, WC is highly correlated with both subcutaneous and visceral abdominal fat, the latter being much more closely related to IR than the former [11].

Sonography is a simple and reliable method for measuring both subcutaneous and visceral fat having been demonstrated to show a strong correlation with both adiposities measured with computed tomography scan [12]. The clinical use of abdominal sonography in the prediction of IR has not been previously compared with WC.

The purpose of this study was to analyze the relationship of anthropometric measurements, including WC, with abdominal adiposity measured by sonography, and to assess the value of sonography in the prediction of IR and other components of the MS.

2. Materials and methods

2.1. Subjects

We studied 177 volunteers, 68 men and 109 women, who underwent a routine medical examination. Exclusion criteria were age younger than 25 or older than 65 years, previous abdominal surgery, excessive alcohol consumption, current acute illness, and current use of drugs that modify lipid or glucose metabolism, including antidiabetic, antihypertensive, and hypolipidemic drugs, and estrogen replacement therapy. All subjects gave written informed consent. The local research committee approved the study.

Anthropometric measurements included age, sex, weight, height, body mass index (BMI), and WC. All measurements were made while the subjects were wearing a hospital gown with minimal underwear and no shoes. The weight was measured to the nearest 0.1 kg with a calibrated physician's office scale, and the height was measured to the nearest 1 mm with a wall-mounted stadiometer. Waist circumference was measured with a heavy-duty inelastic plastic fiber tape measure (Gulick II, Country Technology, Inc, Gays Mills, Wis) placed directly on the skin while the subject stood balanced on both feet, with the feet touching each other and both arms hanging freely. The measurement was taken immediately above the iliac crest and at end expiration [13]. Before taking a reading, specific attention was given to placing the tape perpendicular to the long axis of the body and horizontal to the floor. Blood pressure (OMRON M4-I, OMRON Matsusaka Co, Ltd, Matsusaka, Japan) was measured as recommended by the seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure [14].

2.1.1. Biochemical measurements

Samples were obtained after at least 10 hours' fasting between 8 and 9 AM. Plasma glucose was determined by the glucose-oxidase method. Cholesterol content of lipoprotein fractions, serum triglycerides (TG), and uric acid were measured enzymatically. Apolipoprotein A-I (apo A-I), apolipoprotein B (apo B), and high-sensitivity C-reactive protein (hs-CRP) were measured by immunonephelometry. Low-density lipoprotein cholesterol (LDL-C) was calculated with the Friedewald formula. Insulin was measured with a commercial radioimmunoassay kit (Linco Research Inc, St Charles, Mo). As an indicator of IR, a homeostasis model assessment (HOMA) index for IR was used [15], which was calculated as follows:

$$\text{HOMA index} = [\text{fasting plasma glucose (mmol/L)} \times \text{fasting serum insulin } (\mu\text{U/mL})]/22.5$$

Sonography measurements were performed using a linear-array probe (Aloka SSD-900, Tokyo, Japan) (7.5 MHz and 42 mm) in supine position. It was kept perpendicular to the skin on the upper median abdomen, and longitudinal scan was done in the midpoint between the xiphoid appendix and the navel along the alba line with regard to the surface of the liver, to be almost parallel to the skin. Subcutaneous fat thickness (STh) and area (SA) were measured on the xiphoumbilical line in both longitudinal and transverse views. Measurements were taken 3 times directly from the screen using the electronic calipers at the inner edge of the skin and at the outer edge of the alba line and the fat-muscle interfaces for area. Preperitoneal fat thickness or visceral-fat thickness (VTh) and area (VA) were measured in the same sites and views (Fig. 1). In this case, measurements were taken at the inner edge of the alba line and at the peritoneal line for thickness and area. Then mean values were calculated. Preperitoneal circumference (PC) was calculated as WC $-$ ($2\pi \times$ STh). This measurement assumes that WC is a circumference, hence after measuring WC and STh, the intra-abdominal radius and PC can be easily calculated with the formula cited previously. All the subjects were asked to hold their breath during the examination. Special care was taken to keep the probe just touching the skin to prevent compression of the fat layers. All measurements were performed by the same physician.

2.2. Statistical analysis

Statistical analysis was performed using the SPSS software package (version 11.0). Mean values, SD, and ranges of the anthropometric, biochemical, and sonographic measurements were calculated. The Spearman correlation test was applied to assess the association of sonographic measures and the rest of studied variables.