The Relationship Between Urinary Stone Components and Visceral Adipose Tissue Using Computed Tomography—based Fat Delineation

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OBJECTIVE To determine the relationship between body mass index (BMI), visceral adipose tissue (VAT), and stone components.

METHODS A cross-sectional study has been done for urinary stone cohort between 2010 and 2012. Data on patient's age, gender, BMI, urinary pH, stone components, and VAT using computed tomography—based delineation were collected. Obesity was defined as BMI $\geq$ 25 kg/m^2 or as VAT $\geq$ 100 cm^2. To compare the differences between the types of stones, multinomial logistic regression analyses were conducted.

RESULTS Of 203 cases, 49.3% patients were obese based on BMI, and 65.5% were obese using VAT criteria. Multinomial logistic regression analysis revealed that obesity defined by VAT was found to be associated with uric acid stones compared with calcium phosphate stones (odds ratio [OR] 6.544, 95% confidence interval [CI], $P = .030$) and mixed calcium oxalate phosphate stones (OR 5.582, 95% CI, $P = .038$). Similar results were observed in calcium oxalate stones over calcium phosphate stones (OR 2.984, 95% CI, $P = .032$) and calcium oxalate phosphate stones (OR 2.542, 95% CI, $P = .041$). On the contrary, obesity defined based on BMI has no correlation over all types of urinary stone components.

CONCLUSION This result implies that VAT has a more important role in uric acid and calcium oxalate stone formation than total body fat, represented by BMI. UROLOGY 84: 27–31, 2014.

The etiology of urinary stone disease is multifactorial.[1] Multiple studies have demonstrated that people who are overweight or obese might be prone to an increased urinary stone formation.[2-4] Obesity is associated with insulin resistance and compensatory hyperinsulinemia, metabolic derangements that may result in acidic urine,[3,4] which results in the frequent formation of uric acid (UA) or calcium oxalate (CO) stones.[1,5,6]

Visceral adipose tissue (VAT) is strongly associated with insulin resistance, which represents central or visceral obesity that has a greater impact compared with body mass index (BMI) on metabolic disease incidence and its related mortality.[7] There is no doubt that abdominal anthropometric indexes provide important information about abdominal obesity in relation to metabolic syndrome.[8] However, most of the studies trying to reveal the relation between obesity and stone components have dealt with BMI as a proxy of obesity.[5,9-11] A recent study showed that obesity has little effect on stone components unless the BMI is over 40 kg/m^2.[11]

To overcome this limitation, we performed a study to verify the link between stone components and obesity defined by VAT. To measure VAT together with subcutaneous and total fat, we analyzed computed tomography (CT)-based fat delineation using a fat measurement program, which is a useful method of fat measurement.[12]

MATERIALS AND METHODS

Patients

Between 2010 and 2012, 215 consecutive adult patients with urinary stones (ureteral or renal) who underwent surgical intervention (ureteroscopy, percutaneous nephrolithotomy, and laparoscopic ureterolithotomy) at Soonchunhyang University Hospital located in Seoul, South Korea, performed stone composition analysis and preoperative abdominal CT with delineation fat analysis with approval by our Institutional Review Board. The patients' data, including age, gender, BMI, urinary pH before surgical intervention, and urinary stone composition, were recorded in a retrospective database. VATs of

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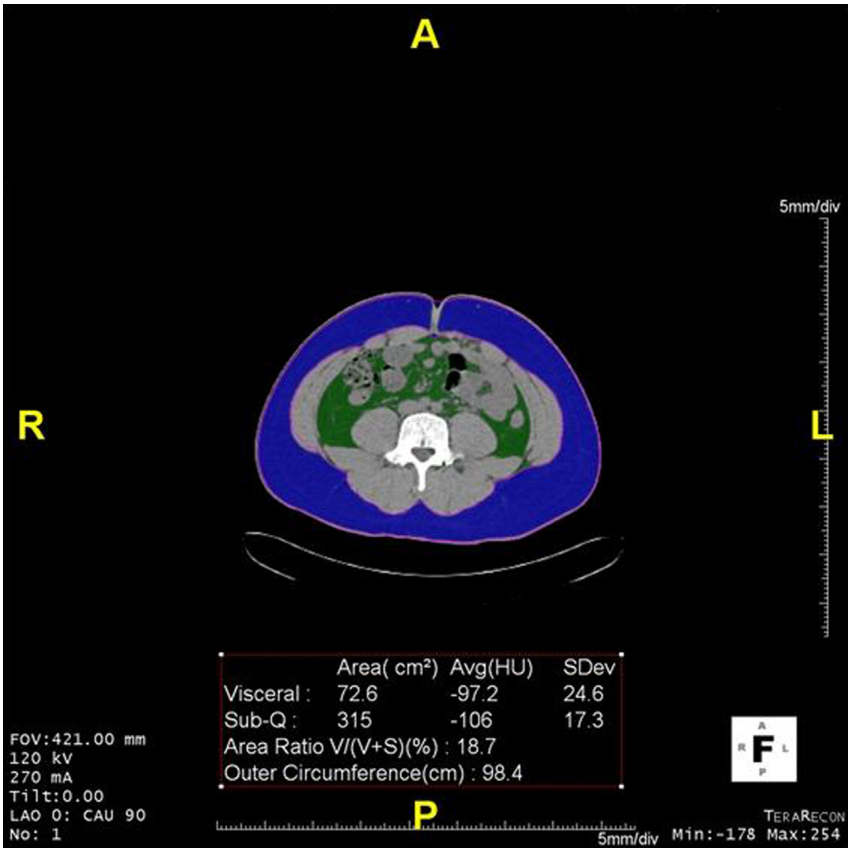

Figure 1. Computed tomographic fat delineation in a male patient with overall obesity but without visceral obesity. The visceral fat was 72.6 cm^2, and body mass index was 32.3 kg/m^2. Green color indicates visceral fat, and blue color indicates subcutaneous fat.

each patient were measured using CT-based delineation. BMI was calculated by dividing the weight (kilograms) by the square of the height (meters). Individual BMI values were stratified into 2 categories (obese $\geq$25 kg/m^2, nonobese <25 kg/m^2) developed for Asia Oceanian populations.[13] After CT-based fat delineation, visceral obesity was defined as a VAT $\geq$ 100 cm^2.[14]

Stone Analysis and Definition of Composition

Each stone sample was washed and dried. A small portion (1 mg) of each stone sample was mixed with potassium bromide (200 mg KBr), which was powdered and pressed into a small tablet; the tablet was then analyzed using spectroscopy. We classified the specimens as CO stones, calcium phosphate (CP) stones, and mixed calcium oxalate phosphate (COP) stones according to the results of the analysis, which indicated the presence of calcium, oxalate, or phosphate regardless of mixed UA components. If the results revealed the presence of UA components only, those stones were classified as UA stones.

CT-based Fat Delineation

CT scans were performed with all patients in the supine position using a 64-slice multidetector computed tomography scanner (Sensation 64, Siemens Medical Solutions, Forchheim, Germany). From each patient, one slice of CT data was collected at the location of the umbilicus between the fourth and fifth lumbar vertebrae (L4-L5), as shown in Figure 1. For CT-volume data, 6 additional CT images were collected from above and below the umbilicus of each patient. VAT was quantified by multidetector computed tomography using a dedicated workstation (Aquarius 3D Workstation, TeraRecon, San Mateo, CA). The semiautomatic segmentation technique was developed for quantification of fat volumes. We traced the region of interest manually and defined fat tissue as pixels within a window of -195 to -45 HU and a window center of -120 HU. Considering the background noise of CT images, all regions below -900 HU were subtracted to remove air compartments. Then, unnecessary areas such as the bed and sheets were removed by labeling all regions followed by removing all regions except the largest region, the body. With all the background removed, the segmentation and assessment of body fat were performed. A thresholded binary image shows visceral fat surrounded by subcutaneous fat, with bones and other organs removed by the thresholding process. The segmentation mask of nonsubcutaneous fat area was made to separate regions of visceral fat and subcutaneous fat using color-mapping segmentation (Fig. 1).

Statistical Analysis

Statistical analysis was performed using SPSS 20.0 version for windows (IBM Co., Chicago, IL). The mean, standard deviation, and proportion were described. The Pearson chi-square test was used for the correlation of continuous variables. Multinomial logistic regression was used to determine the associated factors for each urinary stone component. All statistics were 2-tailed, and *P* value of <.05 was considered statistically significant.