Trial Evaluation of Visceral Fat Characteristics by Abdominal Bioelectrical Impedance Method

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Abstract

Aim: As the abdominal bioelectrical impedance method is changed by visceral fat area by CT (VFA) and quantity, we examined whether the abdominal bioelectrical impedance per measured area (V/A) as the visceral fat characteristics index is useful for diabetes care.

Methods: The subjects were 33 Japanese obese female outpatients. We investigated the correlations of V/A measured by the abdominal bioelectrical impedance method device and of VFA, for each measurement item. And we analyzed the related factors for HOMA-R as the insulin resistance index and for V/A as visceral fat characteristics index by stepwise multiple regression analysis.

Results: As there is no correlation between the V/A we used and VFA, we report that the visceral fat characteristics (density) from V/A is not directly associated with VFA (area). We investigated correlations of V/A and VFA for the measured items. There were significant correlations of V/A for peakVO/W, BS, IRI, HOMA-R, lean body. There were significant correlations of VFA for peakVO/W, IRI and HOMA-R, BMI, waist circumference, and body weight. We analyzed the related factors for HOMA-R and for V/A by stepwise multiple regression analysis. From the results of stepwise multiple regression analysis, the final independent variables V/A and VFA were chosen for HOMA-R, and peakVO/W was chosen for V/A.

Conclusion: We report that the visceral fat characteristics (density) from V/A are not directly associated with VFA (area). Hence the evaluation of visceral fat characteristics by V/A is important for diabetes care and treatment of obesity.

Keywords: Visceral fat characteristics; Bioelectrical impedance; Insulin resistance; HOMA-R; Visceral fat area

Abbreviations: VFA: Visceral Fat Area; WC: Waist Circumference; CT: Computed Tomography; V: Abdominal Visceral Fat Impedance; V/A: Abdominal Visceral Fat Impedance per Area

Introduction

It has been shown that abdominal visceral fat is associated with the onset mechanism for the metabolic syndrome caused by obesity, which induces prospective arteriosclerotic diseases such as diabetes, mellitus, hyperlipidemia and hypertension [1-4]. Abdominal visceral fat area (VFA) is reported to be negatively correlated with plasma adiponectin as adipocytokine for ordinary persons, and to increase the risk of arteriosclerotic and diabetes disease [5,6]. In the past, visceral fat has been evaluated only by area. However, visceral fat varies in weight and specific gravity. The difference in fat-specific gravity is associated with various physiologically activated functions, which adipose tissue induces. It is reported that visceral fat in particular induces adipocytokine more than does subcutaneous fat; visceral fat is therefore associated with insulin resistance and other conditions [3,7]. As visceral fat increases, internal secretion metabolism relationship disease is reported to increase disease incidence and severity of excess stored subcutaneous fat [2,4,8]. We therefore believe that the evaluation of visceral fat not only by area but also by quantitative characteristics analysis is very important in evaluating arteriosclerotic disease risk and diabetes care.

Bioelectrical impedance method can estimate constituent tissue and quantity of organism by bioelectrical impedance, which is measured by passing a low-level electrical current through the body [9,10]. Recently, the bioelectrical impedance method has been used in the abdominal area. Ryo measured abdominal visceral fat impedance and waist circumference (WC) and estimated abdominal VFA, which is called eVFA method. Ryo's studies indicate that eVFA method is highly correlated with VFA measured by computed tomography (CT) [11]. It was reported that estimated VFA by eVFA method is significantly associated with arteriosclerotic risk [12].

The eVFA method can be changed by VFA and quantity, which is associated with visceral fat tissue characteristics. Therefore, we divided the measured abdominal visceral fat impedance (V) by the measuring area, which means abdominal visceral fat impedance per area (V/A). The V/A can be expressed as the index of visceral fat characteristics and/or quantity. If we can evaluate V/A in relation to visceral fat characteristics, we can evaluate visceral fat function which corresponds to visceral fat characteristics.

In this study, we calculated V/A from the measured V using the eVFA method and investigated the correlation of VFA and of V/A in terms of motor abilities and humoral arteriosclerotic risk factors for the obese patients. Our purpose was to determine the usefulness of V/A analysis relative to the index of visceral fat characteristics.

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Received July 24, 2013; Accepted September 17, 2013; Published October 28, 2013


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Methods

The study subjects were obese female outpatients (n=33) at our university hospital in Osaka. They were obese women (age: 20- years old, BMI: 30-) without serious medical conditions. The exclusion criteria were diabetes insulin treatment, secondary obesity by endocrine disorders and mental illness drug treatment. The study period was from 15 February, 2011 to 31 October, 2012. The study was approved by the Human Ethics Committee of our university.

First, we identified V/A. The voltage, occurring at the flank by the flow of current between the umbilicus and the back, correlates significantly with VFA and is unaffected by subcutaneous fat area. The voltage becomes higher as visceral fat accumulates even in subjects with the same WC because the electrical resistance of intra-abdominal fat is greater than that of fat-free mass, and the density of the equipotential lines between the two ventral electrodes is greater [11] (Figure 1). In this study, we developed a measuring device based on Ryo’s et al. [11]

Figure 1: Abdominal bioelectrical impedance method
(1) The voltage occurring at the flank by the flow of current between the umbilicus and the back correlates significantly with VFA. (2) The voltage occurring is unaffected by subcutaneous fat, because it is located in abdominal cavity. (3) The voltage becomes higher as visceral fat accumulates even in subjects with the same WC because the electrical resistance of intra-abdominal fat is greater than that of fat-free mass, and the density of the equipotential lines between the two ventral electrodes becomes greater. (This figure is based on Ryo’s developed eVFA method [11])

Dotted lines indicate equipotential lines
The umbilicus
Visceral fat
Subcutaneous fat
Lean body mass
The back
Volttmeter
Current source

Figure 2: The definition of V/A by eVFA method
(1) The measured area is A
(2) The distance between the two ventral part electrodes is 10 cm.
(3) Assuming abdomen is circle, the radius is WC/2π. Therefore A is calculated as A=10*(W/π).
(4) We calculated B (visceral fat area ratio in A from CT). We compensated for the approximate value of visceral fat area in the measured area by multiplying. This can be expressed as:
V/A =V/[(B*10*WC)/3.14], where π is 3.14.
The correlations of V/A for measured items

i. Basic data for all subjects are shown in Table 1. To confirm whether V/A is an independent index of visceral fat characteristics, we investigated correlations of V/A for visceral fat area and subcutaneous fat area by CT, WC, and body weight. There were no significant correlations of V/A for their indexes.

ii. We show the correlations of V/A and VFA by CT for measured items (Table 2). As for V/A, there was a significant negative correlation for peakVO₂/W in motor abilities; significant positive correlations for BS, IRI and HOMA-R in fasting humoral factors; and significant negative correlation for lean body mass. As for VFA by CT, there was a significant negative correlation for peakVO₂/W in motor abilities; significant positive correlations for IRI and HOMA-R in fasting humoral factors; and significant positive correlations for BMI, WC, and body weight.

We indicate the only significant correlations of HOMA-R for measured items (n=33).

### Table 2: Correlations of V/A and VFA for measured items (n=33)

<table>
<thead>
<tr>
<th>Measure</th>
<th>Correlations for V/A (mΩ/cm²)</th>
<th>Correlations for VFA (cm²) by CT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
<td>p value</td>
</tr>
<tr>
<td>Body weight</td>
<td>-0.20</td>
<td>n.s.</td>
</tr>
<tr>
<td>BMI</td>
<td>-0.11</td>
<td>0.43</td>
</tr>
<tr>
<td>Waist circumference</td>
<td>-0.23</td>
<td>n.s.</td>
</tr>
<tr>
<td>Lean body mass</td>
<td>-0.64</td>
<td>p&lt;0.01</td>
</tr>
<tr>
<td>peakVO₂ (ml/kg/min)</td>
<td>-0.49</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>BS</td>
<td>0.52</td>
<td>p&lt;0.01</td>
</tr>
<tr>
<td>IRI</td>
<td>0.48</td>
<td>p&lt;0.01</td>
</tr>
<tr>
<td>HOMA-R</td>
<td>0.60</td>
<td>p&lt;0.01</td>
</tr>
</tbody>
</table>

We indicate the only significant correlations of V/A or VFA by CT. n.s.: no significance.

### Stepwise multiple regression analysis results for HOMA-R and V/A

There were significant correlations of HOMA-R for V/A, VFA by CT, baPWV, BS, and IRI (Table 3). As HOMA-R is calculated from BS and IRI, we excluded BS and IRI from stepwise multiple regression analysis items. The results of stepwise multiple regression analysis (dependent variable: HOMA-R; independent variables: V/A, VFA by CT, baPWV) indicated that final significant independent variables were V/A (standardization coefficient: 0.54, p<0.001) and VFA by CT (standardization coefficient: 0.30, p<0.05). Adjusted R² is 0.41. There were significant correlations of V/A for peakVO₂/W, BS, IRI, HOMA-R, lean body mass (Table 2). To confirm what is the most significant correlation of V/A except HOMA-R, BS, and IRI, we performed stepwise multiple regression analysis (dependent variable: V/A; independent variables: peakVO₂/W, lean body mass). As a result, we confirmed that the final significant independent variable was peakVO₂/W (standardization coefficient: -0.49, p<0.05). Adjusted R² is 0.21.

### Discussion

The results suggest that the measured abdominal bioelectrical impedance (V), in which the voltage occurs at the flank by the flow of current between the umbilicus and the back, correlates significantly with VFA according to Ryos’s developed eVFA method [11] and V significantly indicates visceral fat characteristics. Hence we estimate visceral fat characteristics from V in this study. As there is no correlation between the V/A we used and VFA measured by CT, we report that the visceral fat characteristics (density) from V/A is not directly associated with VFA according to Ryo’s developed eVFA method [11] and V significantly indicates visceral fat characteristics. Therefore, we confirmed that the final significant independent variable was peakVO₂/W (standardization coefficient: -0.49, p<0.05). Adjusted R² is 0.21.

For the 33 obese female outpatients, there were significant positive correlations of both V/A and VFA by CT with HOMA-R. However, we chose both the V/A and the VFA measured by CT as final significant independent variables based on the results of stepwise multiple regression analysis. We therefore suggest that HOMA-R is associated not only with VFA but also with visceral fat characteristics. This indicates.
that the evaluation of visceral fat characteristics from V/A is important in addition to the evaluation of visceral fat area, because we believe that high density in visceral adipose tissue increases insulin resistance in obese female outpatients. To confirm what is the most significant correlation of V/A except HOMA-R, we performed stepwise multiple regression analysis. As a result, we confirmed that the final significant independent variable was peakVO2/W. This indicates that low motor ability such as low peakVO2/W affects V/A and is associated with high density in visceral adipose tissue. The lower the functional capacity of the obese female outpatients, the less exercise they perform, and the lower the density of visceral adipose tissue, the more physiological activation they have.

We report that the visceral fat characteristics (density) from V/A are not directly associated with VFA by CT (area). Hence the evaluation of visceral fat characteristics by V/A is important for diabetes care and so on. We suggest that not only the application of dietary restrictions but also the development of functional capacity through exercise therapy is important in the treatment of obesity.

Acknowledgements
We are grateful to Panasonic Co., Ltd for providing a trial device that is based on Ryo’s eVFA method and to the staff of Health Science Center for their valuable assistance in measuring eVFA at Health Science Center, Kansai Medical University Hirakata Hospital.

References