Dual Bioelectrical Impedance Analysis Correlates Well with Computed Tomography to Estimate Visceral Fat in Grade I-II Obese Mexican Patients

Ernesto G. Cardona Muñoz, Fernando Grover Páez, Carlos Gerardo Ramos Becerra, Sylvia E. Totsuka Sutto, Guillermo Adrián Alanis Sánchez, Jesús Ricardo García Corral, Catherine A. García Aguilar, Assen Ognianov Iantchoulev, José Rafael Villafán Bernal, Ana Leticia Milanés Barajas

ABSTRACT

Objective: To correlate visceral fat using bioelectrical impedance analysis (Dual BIA) with computed tomography (CT) in Grade I-II Obese Mexican Patients.

Research Design and Methods: We recruited 30 Mexican patients from the western part of the country (15 men and 15 women, aged 50-65 years) with class I-II obesity (body mass index [BMI] 30-39.9 Kg/m²). To evaluate the IAFA by Dual BIA comparing with CT. The dual BIA instrument consists of a bioelectric impedance component that measures the physical size of the abdomen. The truncal impedance is measured by applying electrical currents between the upper and lower limb leads and reading the voltage from the electrodes around the abdominal circumference. The surface impedance is measured by applying and measuring the voltage from the abdominal circumference electrodes. We took computed tomography (CT) at the umbilical level and calculated the visceral fat area (VFA). BMI was calculated as body weight (in kilograms) divided by the squared height (in meters). Waist circumference (WC) was measured at the level of the umbilicus to the nearest 0.1 cm in the standing position at the end of expiration.

Results: We observed a strong correlation between both methods used to calculate IAFA (BIA and CT; Pearson’s r² = 0.659, p < 0.001). Though both groups had significantly correlating values, the female group had a clearly stronger correlation than the male group (Pearson’s r² = 0.667 vs. 0.501). This method exhibited a high level of reproducibility and a strong correlation with the CT results.

Keywords: obesity, intra-abdominal fat area, visceral fat, dual bioelectrical impedance analysis
INTRODUCTION

Obesity and being overweight have become two of the most important modifiable cardiovascular (CV) risk factors in Mexico. Currently, 71.3% of Mexican adults fall into one of these two categories, with a slightly higher prevalence among women and the fourth and fifth decades of life (ENSANUT, 2012; Barquera, 2013). In recent years, studies have demonstrated that the human body stores fat either subcutaneously or viscerally, and that both types increase CV risk. However, visceral fat has been shown to play a much more important role in increased CV risk than its subcutaneous counterpart (Fox, 2007). Currently, computerized axial tomography is considered the “gold standard” for measuring visceral fat (Carneiro, 2010), but its uses are limited in the clinical and epidemiological fields due to instrumentation, cost, and patient exposure to harmful radiation. Intra-abdominal fat area (IAFA) is a measure that can be used to estimate abdominal adiposity and has been used to accurately estimate visceral fat (Nagai, 2010).

Due to the high rate of obesity in Mexico and the need for an accessible method of realizing epidemiological studies in order to fully evaluate the impact of different interventions and reduce CV risk associated with elevated abdominal adiposity, the present study validated the DUALSCAN, HDS-2000 OMRON machine. This instrument was used to measure IAFA using bioelectrical impedance analysis (Dual BIA) in the Mexican population, demonstrating its clinical practicality (Ida, 2013).

RESEARCH DESIGN AND METHODS

This cross sectional study was performed according to the protocol approved by the Ethics in Research Board of the Institute of Clinical and Experimental Therapeutics, University of Guadalajara (CEI/097/2014). The patients provided written consent to participate in this study at the Institute of Clinical and Experimental Therapeutics, University of Guadalajara. We recruited 30 Mexican patients from the western part of the country (15 men and 15 women, aged 50-65 years) with class I-II obesity (body mass index [BMI] 30-39.9 Kg/m²).

To evaluate the IAFA, we asked our patients to wear comfortable attire with cotton undergarments (with no synthetic material or metal) to a morning appointment after fasting with an adequately emptied bladder and rectum. The patients were then asked to remove their clothing, except the undergarments, and given a disposable patient gown to wear during the procedures.

DUAL BIA METHOD AND INSTRUMENTATION

Dual BIA calculates the cross sectional area of intra-abdominal fat at the level of the umbilicus based on the electrical potentials resulting from the application of small electrical currents in the two different body compartments. The principles of IAFA determination by the dual BIA instrument were described previously (Shiga, 2007, 2009; Yoneda, 2007). Briefly, the dual BIA instrument consists of a bioelectric impedance component that measures the physical size of the abdomen. The two sets of electrodes are for limb and truncal placement. The limb electrodes consist of four clip-on electrodes placed on the wrists and ankles. The truncal electrodes are eight pairs of electrodes 6 cm apart longitudinally that are fixed to a belt in pairs, one each for front and back and positioned at an equal distance. The belt is adjustable, allowing the electrodes to be centered on the mid-sagittal line at the level of the umbilicus in the supine position. The truncal impedance is measured by applying electrical currents between the upper and lower limb leads and reading the voltage...
from the electrodes around the abdominal circumference. The surface impedance is measured by applying and measuring the voltage from the abdominal circumference electrodes. Other details of the study method were described previously (Ida, 2013).

We performed computed tomography (CT) at the umbilical level and calculated the visceral fat area (VFA) using the image analysis software SINGO CT 2006A (Siemens, Somaton Emotion). The VFA demonstrated a strong correlation with the total volume of visceral fat (Ryo, 2014). We found a strong correlation (Pearson’s $r^2 = 0.987$, $p < 0.001$) between the first and second measurements taken within a month of one another (data not shown).

BMI was calculated as body weight (in kilograms) divided by the squared height (in meters). Waist circumference (WC) was measured at the level of the umbilicus to the nearest 0.1 cm in the standing position at the end of expiration while breathing gently at the time of Dual BIA measurement.

**Statistical Analysis**

All values were expressed as an average ± the standard deviation (SD). The correlation between visceral fat areas obtained with dual BIA and CT was analyzed using Pearson’s correlation coefficient. The Bland-Altman method was used to examine the mean difference and 1.96 SD between IAFA observed by Dual BIA and that estimated by CT (Bland, 1986). We calculated the sensitivity and specificity at VFA ≥ 100 cm$^2$ using the regression equation (Oda, 2002). All p-values were two-tailed, and $p < 0.05$ was accepted as significant.

**Results**

A total of 30 patients (15 men and 15 women) were included in this study, but four were eliminated from each group for not meeting the necessary selection criteria. Thus, after the selection process, 22 patients (11 per group) were eligible for VFA analysis. The average age was 54.4 ± 4.3 years with a BMI of 32.47 ± 3.4 kg/m$^2$ and a waist circumference (WC) of 102.4 ± 10.6 cm. For the measurement of VFA by bioelectric impedance (BI), two consecutive measurements were made within a 5-minute interval (IB1 = 126.4 ± 35.5 cm$^2$ vs. IB2 = 127.3 ± 36.6 cm$^2$). The reproducibility can be measured by correlating the values through Pearson’s $r^2$ in (Figure 1).
In stage 2, the average VFA values of the 22 patients obtained via (IAFABIA = 126.8 ± 35.7 cm²) were contrasted against CT measurements obtained using a planimetric estimation of Hounsfield Units (HU) (CT = 143.5 ± 42.7 cm²)(Figure 2).

Results were analyzed based on gender. The average characteristics of the female group (n=11) were as follows: age 54.7 ± 4.8 years, BMI 32.3 ± 2.8 Kg/m², WC 107.3 ± 2.8 cm, VFA by BI 142.3 ± 22.0 cm², VFA by CT 161.9 ± 35.7 cm². When comparing the VFA values obtained by the two different methods, we found a significant correlation (Figure 3).

The average characteristics of the male group (n=11) were as follows: age 54.4 ± 4.3 years, BMI 32.4 ± 3.4 Kg/m², WC 102.4 ± 10.5 cm, VFA by BI =126.8 ± 35.7 cm², VFA by CT = 143.5 ± 42.7 cm². Similar to the female group, when comparing the values obtained for the male group, we found a significant correlation between the two methods for calculating VFA (Figure 4).

**DISCUSSION**

In this study we demonstrated that IAFAB estimates obtained using dual BIA with the DUALSCAN, HDS-2000, OMRON instrument have high reproducibility (Pearson’s r² = 0.982, p< 0.001). We observed a strong correlation between both methods used to calculate IAFABIA (BIA and CT; Pearson’s r² =0.659, p < 0.001). This data is consistent with the literature; Nagai (2010) also demonstrated a strong correlation between tetra polar multifrequency bioelectric impedance analysis and CT for estimating VFA (r=0.904, p <0.01). On the other hand, when the group data was analyzed based on gender, we observed that the correlation persists when comparing both methods of measurement. Though both groups had significantly correlating values, the female group had a clearly stronger correlation than the male group (Pearson’s r² = 0.667 vs. 0.501). This phenomenon could possibly be explained by the diminished interference in the measurement of subcutaneous fat when the electrodes are placed on the abdomen (Scharfetter, 2001). Notably, although no large difference was found in average age and BMI between the groups, the IAFABIA values estimated via dual BIA had greater significance in the male group, which corroborates the idea that an increase in visceral fat is a good indicator of abdominal adiposity (Cornier, 2011). On the other hand, large collaborative studies using BMI to
define obesity have shown that the mortality risk associated with obesity markedly declines with age (Whitlock, 2009; Berrington, 2010). For this study we decided to include patients < 65 years due to the fact that visceral fat stops being the sole predicting factor of CV risk, independent of CV mortality, starting from 65 years of age (Thomas, 2013). In contrast, other authors have shown that the risk persists in even the highest age categories when using WC to define obesity (Jacobs, 2010; Pischon, 2008). These discrepant results may be explained by the limitations of the criteria used to define obesity in clinical practice. BMI is based on body weight and height only and does not directly reflect adiposity. WC is strongly related to central adiposity (Janseen, 2002) and is associated with CV risk factors, such as hypertension, dyslipidemia, and glucose intolerance (Eckel, 2010). We found a significant correlation between WC and IAFA estimated by both methods (BI: \( r^2 = 0.704, p<0.001 \); CT: \( r^2 = 0.637, p= 0.001 \)).

Our study had various limitations. Firstly, the measurement of IAFA via dual BIA and CT was not done consecutively, and included postponing the second measurement for periods of up to 24 hours for logistical reasons. This factor should be considered in future studies due to the impact it could have on outcomes as various factors may change with time, such as the state of hydration, quantity of abdominal gas, and residual urine in the bladder. The small population of patients could also be considered a possible limitation of this study due to the fact that, as the number of patients increases, the distribution curve tends to normalize, which translates into a higher level of reliability.

**Conclusions**

This is the first study of its kind performed on Mexican patients with class I-II obesity using the DUALSCAN, HDS-2000, OMRON instrument to estimate IAFA via dual BIA. This method exhibited a high level of reproducibility and a strong correlation with the CT results. Thus, we demonstrated the instrument’s reliability, safety, operability, and cost effectiveness compared to conventional CT or magnetic resonance imaging.

**Acknowledgement**

We thank all of the volunteers who took part in the study, and OMROM de México S.A. de C.V. for use of the dual BIA instrument.

**Conflict Interests**

The authors have no conflicts of interest to report.

**References**


---

**ABC-JAR!!!**

“Speedy publication service, Online archives, Paperless, web-based peer review system, Open access policy, Indexing in world known citation databases, Global circulation, Broad international readership and authorship, Online submission system, Minimum publication charge”
Asian Business Consortium (ABC) is a multi-disciplinary research, training, publishing, digital library supporting and service house. Though founded in 2010 as the Business and Computing organization of Asia, it was reconstituted as the ABC in 2011. It has been working for creating and nurturing talents in USA, Malaysia and Bangladesh since its inception. The objectives of consortium are solely centered round the welfare and humane attitude of the founders who enthusiastically took up this noble cause and materialized it with a view to promote research and educational activities for the encouragement of scholars to develop their knowledge, to publish their analysis oriented scientific researches in international Journals, books, the task of organizing workshops, seminars, conferences, training, personality development programs and allied services.

In addition to research activities, ABC provides a good number of scholarships to the poor and meritorious students at various levels of education throughout the world. It plays an important role in the field of research by funding research projects and publishing the research papers. This consortium will unquestionably become the mouth-piece of the dark horses and unacknowledged scholar whose endowed and commendable contributions shall be provided an outlet keeping in mind the greater good of the larger society of the world.

ABC runs the following international referred journals for creating a platform to share the thoughts of professionals, scholars and academicians throughout the world.

**ABC Publications (ABC Journals)**

- Asian Accounting and Auditing Advancement (4A Journal)
- Asian Business Review (ABR)
- Asian Journal of Applied Sciences and Engineering (AJASE)
- Global Disclosure of Economics and Business (GDEB)
- ABC Journal of Advanced Research (ABC-JAR)
- International Journal of Reciprocal Symmetry and Theoretical Physics (IJRSTP)
- American Journal of Trade and Policy (AJTP)
- Asian Journal of Humanity, Art and Literature (AJHAL)
- Malaysian Journal of Medical and Biological Research (MJMBR)
- Asia Pacific Journal of Energy and Environment (APJEE)
- Engineering International (EI)
- ABC Research Alert (Online)

Each journal home page provides specific information for potential authors and subscribers. Open access policy, the quick review process, rich editorial boards and quality publications have already made ABC Journals unique. **ABC Journals** are published under the direct supervisions of renowned academicians of the world. Collaboration in Conference: ABC considers high-quality conference papers for publication. Please contact us for detailed information.

Collaboration in Publishing: If you like to start writing a book, propose a new journal or advertise in ABC journals, please feel free to contact us.