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Association between Abdominal Wall Fat Index (AFI) on Ultrasonography with Carotid Intima Media Thickness (CIMT) and Lipid Profile

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Abstract

Background: Many international organizations have recognized obesity as a chronic disease, with significant contribution to the global mortality and morbidity. Besides, obese patients are at higher risk of death than non-obese individuals. Obesity is a major driver for disability, early retirement, and psychological disorders as well.

Abdominal wall fat index (AFI) is a widely utilized sonographic measure for regional fat accumulation; it is calculated as a ratio of the highest to lowest preperitoneal and subcutaneous fat thicknesses, respectively. Carotid Intima Media Thickness (CIMT) is a well-established marker for early atherosclerosis.

In this study we investigated the relationship between abdominal wall fat index (AFI) and Carotid Intima Thickness (CIMT) with lipid profile among overweight and obese patients.

Aim of Study: Investigating the relationship between abdominal wall fat index (AFI) and Carotid Intima Media Thickness (CIMT) as measured by ultrasonography with lipid profile among overweight and obese patients.

Patients and Methods: We conducted a cross-sectional study on 60 adult participants ranging from 22 to 66 years old of both genders. The patients were divided into three groups according to the AFI value into: Group I (AFI <0.7), group II (AFI <1.4), and group III (AFI ≥1.4). AFI and CIMT measured using ultrasonography and lipid profile was obtained.

Results: Participants in group III (mean=53.7±11.0 years old) were significantly older than other studied groups; and were more likely to be hypertensive and diabetic. There was a statistically significant difference between studied groups regarding body mass index (BMI; p=0.001), the highest level was among group III (mean BMI=34.1 ±5.8Kg/m^2). There were positive correlations between lipid profile parameters and the AFI. Furthermore, there was a statistically significant difference between groups regarding CIMT (p=0.001). CIMT was the highest among group III (mean of 1.4 ±0.3mm), followed by group II (mean of 1.2±0.3mm), and group I (mean of 0.7±0.3mm).CIMT was positively correlated with AFI (r=0.747, p=0.001). BMI was highest among group III (mean of 34.1±5.8), followed by group II (mean of 30.3±4.0), and group I (mean of 25.0±2.2) BMI was positively correlated with AFI (p=0.001).

Conclusions: AFI has a significant positive correlation with CIMT and preperitoneal fat thickness. AFI can be a useful marker in evaluating and predicting disorders of metabolism, circulation and atherosclerosis.

Key Words: *Abdominal wall fat index – Carotid intima media thickness – Obesity.*

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Introduction

BY the end of the first decade of 2000s, many international organizations have recognized obesity as a chronic disease, with significant contribution to the global mortality and morbidity **[1]**. The global epidemiology of obesity has witnessed dramatic increase in the past few decades to the extent of reaching a pandemic levels and being declared as "the single greatest threat to public health for this century" **[2]**; the recent international figures demonstrated that the prevalence of obesity has reached 10.8% and 14.9% of the global male and female adult population, respectively **[3]**. The steady increase in the prevalence of obesity was observed even among developing and low-income countries, with the highest incremental increase observed in Eastern Europe, Latin America, and Middle East **[4]**. According to World Health Organization (WHO) estimations, nearly 1.9 billion of the adult global population are overweight and 650 million are obese **[5]**. Obesogenic lifestyle behaviors (such as excessive junk foods, excessive sweets, limited physical activities, and sedentary habits) combined with genetic susceptibility are widely thought to be the major contributor to the current obesity pandemic **[6]**. The pathogenesis of obesity is multifactorial and involve imbalance in caloric intake/consumption, dysregulation in hormonal status (such as excessive release of adipokines and gut hormones), and chronic inflammatory process leading to proinflammatory cytokines such as interleukin-6 (IL-6) and tumour-necrosis factor alpha (TNF-α) [4]. In return, such factors lead to excessive deposition of visceral fat, which is the hallmark for obesity [7]. The cumulative body of evidence shows that obesity is an independent risk factors for wide range of metabolic and non-metabolic disorders, including impaired glycaemic control and diabetes, hypertension, cardiovascular disease, non-alcoholic fatty liver, osteoarthritis, stroke, as well as neurological and cognitive impairments [8]. Besides, obese patients are at higher risk of death than non-obese individuals. Obesity is a major driver for disability, early retirement, and psychological disorders as well [9].

Clinically, obesity is recognized as a Body Mass Index (BMI) of more than $30Kg/m^2$ [4]. BMI is widely utilized clinical measure as a marker of percentage fat mass for defying and classifying obesity, previous reports showed that BMI is simple and reliable tool for assessment and follow-up of obese individuals [10]. Nonetheless, BMI, as well other anthropometric measures such Waist Circumference (WC), suffers for many limitations; firstly, the BMI-based obesity definition is based on statistical cut-off values without consideration of the age and ethnicity [11]. Besides, the BMI does not take into account the presence and impact of comorbidities on affected patients [10]. Thus, continuous efforts were devoted to develop direct measures of body fat accumulation. Visceral adipose tissue has emerged as an active, reliable, surrogate for body fat accumulation; through its distinct biochemical features, the visceral adipose tissue demonstrated significant involvement in many pathological processes in obese patients. Over the recent years, several quantitative measures were proposed for visceral adipose tissue assessment, such as bioelectrical impedance analysis and imaging-based analysis, with variable accuracy [12]. Abdominal wall fat index (AFI), firstly described bySuzuki et al. [13], in early 1990s, is a widely utilized sonographic measure for regional fat accumulation; it is calculated as a ratio of the highest to lowest preperitoneal and subcutaneous fat thicknesses, respectively [14]. Several reports demonstrated that AFI is a simple and reliable tool for regional fat assessment; besides, it was found to significantly correlated with the risk of metabolic disorders, such as dyslipidemia, cardiovascular diseases, and diabetes [15].

On the other hand, Carotid Intima Media Thickness (CIMT) is a well-established marker for early atherosclerosis, as well as other vascular abnormalities, in children and adults. Previous reported indicated higher thickness of CIMT in pediatric population with hypertension [16] and other cardiovascular diseases [17]. Moreover, the current body of evidence suggests that CIMT is significantly positively correlated with the degree of obesity and other metabolic abnormalities in children [18].

To our knowledge few reports have focused on the measurements of lipid profile and its relation with the abdominal wall fat index (AFI) and Carotid Intima Media Thickness (CIMT). In this report, we aimed to investigate the relationship between AFI and CIMT with lipid profile among obese patients.

Aim of the work:

Investigating the relationship between abdominal wall fat index (AFI) and Carotid Intima Media Thickness (CIMT) as measured by ultrasonography with lipid profile among obese patients.

Patients and Methods

We performed a cross-sectional study on participants aged 22-66 years old of both genders at Department of Radiology, Abassia Fever Hospital, Egypt from January 2020 to June 2020.

The study was conducted only after obtaining approval of Ethical Committee of Ministry of Health and written informed consent from all the participants.

Study participant:

Participants were recruited from obesity clinic if they had a BMI of more than $18Kg/m^2$. We excluded participants with history of upper abdominal surgery to minimize errors in AFI measurements. Participants were collected by simple random method.

Eligible participants were divided into three equal groups according to the AFI: Group I included participants with an AFI value of less than 0.7; group II included participants with an AFI values of $\geq$0.7 to <1.4; and group III included participants with an AFI values of $\geq$ 1.4. Mean age of group I was 34.6, mean age of group II was 48.7 and mean age of group III was 53.7.

Data collection:

We collected the following data from eligible participants: Age, gender, alcohol consumption, smoking status, history of comorbidities, family history of obesity, anthropometric measures, lipid profile parameters, and sonographic measures of AFI and CIMT.

To measure the BMI, a trained nurse asked the participants to wear light clothes only and be barefooted. Then, the weight and height were measured according to the standards of the institution. The BMI was calculated from the following equation: Weight in Kg/(height in m) ^{2}.

On the other hand, the B-mode ultrasound machine was used to assess the AFI and CIMT. For AFI, participants were instructed to lay on supine position; while 12-MHz linear transducer probe was placed at 90 degrees vertically on the epigastrium. Then, the examination was continued from the xiphoid process to the umbilicus. The ratio between the maximum thickness of preperitoneal fat (Pmax) at the anterior surface of the liver to the minimum of the subcutaneous fat (Smin) of the abdomen was calculated. Concerning the CIMT measurement, the distance between the media-adventitia interface and the lumen-intima interface is measured.

Fig. (1): Showing AFI being measured using ultrasound.

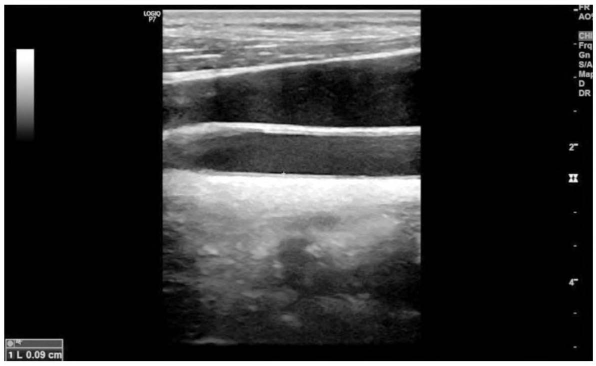

Fig. (2): Showing the CIMT being measured using ultrasound.

Statistical analysis:

Data were analyzed using Statistical Program for Social Science (SPSS) version 20.0. We employed descriptive analysis (mean ± Standard Deviation [SD] and frequency for quantitative and qualitative data, respectively) to describe different parameters of the study. The independent t-test or Mann-Whitney test were used to assess the association between erectile index and different parameters.

Results

A total of 60 participants (20 participants per group) were included. The mean AFI in group I, II, and III was 0.7±0.1, 1.2±0.2, and 2±0.2, respectively. Patients in group III had significantly higher age than group I and II (53.7±11 versus 34.6±12.9 and 48.7±14.3 years old, respectively; *p*=0.001). However, the gender distribution was similar across the three groups (*p*=0.247). Concerning comorbidities, 50% and 45% of the group II and III suffered from both hypertension and diabetes, respectively, compared to only 5% in group I (*p*=0.006). Besides, group III had the highest level of smoking (40%; *p*=0.001). There was no statistically significant difference between groups regarding alcohol consumption [*p*=0.221; Table (1)].

Regarding the association between AFI and BMI, participants in group III had significantly higher BMI value (34.1 ±5.8Kg/m^2) than group I (25±2.2Kg/m^2) and group II (30.3 ±4Kg/m^2; *p*= 0.001). Besides, patients in group II significantly higher BMI value than group I Fig. (3). As expected, there was a positive correlation between the AFI and all lipid profile parameters; participants in group III had significantly higher total cholesterol (*p*=0.001), low-density lipoprotein (*p*=0.001), triglyceride (*p*=0.001), and lower high-density lipoprotein (*p*=0.001) than group I and II (Table 2).

With regard to the primary outcome of the present study, we found that the group III had the highest level of CIMT (1.4±0.3mm), followed by group II (1.2±0.3mm), and finally group I [0.7± 0.3mm; *p*=0.001; Table (3)]. Table (4) shows the correlation between the CIMT, lipid profile, BMI, and AFI. There was a statistically significant positive strong correlation with total cholesterol (*r*= 0.849, *p*=0.001), low-density lipoprotein (*r*=0.815, *p*=0.001), and triglycerides (*r*=0613, *p*=0.001). Besides, there was a statistically significant negative strong correlation between CIMT and high-density lipoprotein (*r*=–0.815, *p*=0.001). There was a statistically significant positive strong correlation between CIMT and BMI (*r*=0.544, *p*=0.001). Notably, there was a statistically significant positive strong correlation between CIMT with AFI (r= 0.747, p=0.001). Regarding the correlations between AFI and lipid profile, there was a statistically significant positive correlation between AFI and lipid profile parameters.

Table (1): Characteristics of the studied groups.

Characteristics	Group I (n=20)		Group II (n=20)		Group III (n=20)		χ^2	p
Age:								
Mean ± SD	34.6±12.9		48.7±14.3		53.7±11		12.008	0.001 *
Range	22-59		28-70		30-66			
Gender:								
Female	9	45.0%	13	65.0%	8	40.0%	2.800	0.247
Male	11	55.0%	7	35.0%	12	60.0%		
Medical history:								
No hypertension nor diabetes	19	95.0%	10	50.0%	7	35.0%	18.200	0.006*
Hypertension	0	0.0%	2	10.0%	3	15.0%		
Diabetes	1	5.0%	2	10.0%	1	5.0%		
Both	0	0.0%	6	30.0%	9	45.0%		
Smoking status:								
Non-smoker	20	100.0%	20	100.0%	12	60.0%	18.462	0.001 *
Smoker	0	0.0%	0	0.0%	8	40.0%		

χ^2: Chi square.
* : Statistically significant.

Table (2): Difference in lipid profile parameters according to the studied groups.

Group	Lipid profile		F	p
	Mean ± SD	Range		
Total cholesterol (TC):				
Group I	171.3±21.8	147.0-233.0	19.031	0.001 *
Group II	204.6±26.9	165.0-240.0		
Group III	214.1±19.9	165.0-230.0		
Low density lipoprotein:				
Group I	91.9±18.7	80.0-140.0	25.256	0.001 *
Group II	120.8±23.5	82.0-155.0		
Group III	144.4±27.2	83.0-178.0		
High density lipoprotein:				
Group I	51.2±6.7	3 8.0-68.0	14.752	0.001 *
Group II	42.2±6.6	33.0-52.0		
Group III	40.2±7.1	35.0-55.0		
Triglycerides:				
Group I	96.3±25.6	40.0-160.0	14.689	0.001 *
Group II	124.1±48.0	33.0-185.0		
Group III	156.9±28.4	88.0-177.0		

F: One way Analysis of Variance (ANOVA).
*: Statistically significant.

Table (3): The difference in CIMT according to the studied groups.

Group	Carotid intima media thickness		F	*p*
	Mean ± SD	Range		
Group I	0.7±0.3	0.5-1.4	40.315	0.001*
Group II	1.2±0.3	0.7-1.6		
Group III	1.4±0.3	0.8-1.6		

F: One way Analysis of Variance (ANOVA).
*: Statistically significant.

Table (4): Correlation analysis.

Correlation	CIMT mm	AFI
Total cholesterol (TC):		
r	0.849	0.636
p	0.001*	0.001*
Low density lipoprotein:		
r	0.815	0.68
p	0.001*	0.001*
High density lipoprotein:		
r	–0.677	–0.597
p	0.001*	0.001*
Triglycerides:		
r	0.613	0.6
p	0.001*	0.001*
Body mass index (BMI):		
r	0.544	
p	0.001*	
AFI:		
r	0.747	
p	0.001*	

r: Pearson correlation.
*: Statistically Significant.

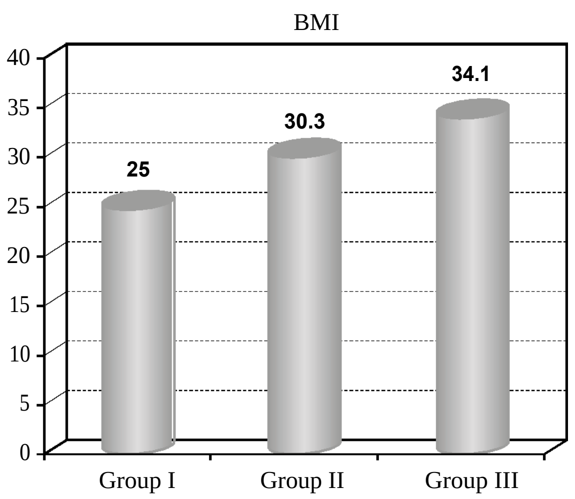

Fig. (1): BMI.

Discussion

In this report, we provide an insight about the role of AFI in assessing visceral obesity, as well as its correlation with the extent of carotid atherosclerosis as measured by CIMT. We found that the AFI significantly correlated with BMI and lipid profile parameters, confirming its role as a surrogate for obesity and excessive fat accumulation. The AFI also tended to be higher with participants suffering with both hypertension and diabetes, as well as smokers. Notably, we found that the AFI positively correlated with the degree of carotid atherosclerosis, as measured by CIMT. Patients with high increase in AFI demonstrated higher CIMT values than patients with normal or moderate increase in the AFI; likewise, patients with moderate increase in the AFI had higher CIMT than patients with normal AFI.

Although BMI is universally utilized as an indicator of obesity, the use of BMI solely to assess obese patients had many disadvantages concerning its reliability to reflect body compositions, especially visceral fat deposit **[19]**. On the other hand, the use of Dual-Energy X-ray Absorptiometry (DEXA) in the setting of obesity assessment is limited by its high cost and hazards of radiation exposure, despite its reliability **[20]**. The lack of standardized parameters for various DEXA devices is another limitation **[21]**. Recently, ultrasound-based measurements were proposed as cheap, widely-available, and simple tools for assessment of body fat, mainly abdominal-fat. These measurements have proven their validity and reducibility in monitoring abdominal fat; besides, previous reports demonstrated that ultrasound-based measurements correlated significantly with the risk of obesity-associated metabolic disorders **[22]**. AFIis a surrogate for regional obesity that was found to correlate with the risk of metabolic disorders, such as dyslipidemia, cardiovascular diseases, and diabetes **[15]**. In the present study, we found that the AFI significantly correlated with BMI, presence of comorbidities, and lipid profile parameters, confirming its role as a surrogate for obesity and excessive fat accumulation. In agreement with our findings, Kwon et al., demonstrated that higher AFI was independent predictor of higher BMI **[23]**. Another report showed similar findings **[24]**. On the same line, Kotani et al., showed a significant positive correlation between AFI and diastolic blood pressure **[25]**. Another report on 62 patients found positive correlation between AFI and serum triglyceride levels **[26]**.

As previously stated, CIMT is a well-established marker for early atherosclerosis and correlated with the risk of metabolic disorders **[16,17]**. In the present study, we confirmed that the AFI positively correlated with the degree of carotid atherosclerosis, as measured by CIMT. The CIMT correlated with the preperitoneal fat thickness and AFI ratio. We also found that the CIMT tended to be higher in participants with higher BMI. Similar to our findings, a study on 297 non obese male patients showed linear association between AFI and CIMT; the AFI was a significant independent contributing factor to carotid atherosclerosis **[27]**. Another study conducted by previous study authors but included only women with BMI more than 22kg/m^2. Multiple regression analysis yielded similar results, AFI was a predictor for carotid atherosclerosis [OR= 2.995; 95% CI, 1.106-8.109] **[28]**. Likewise, Cetin et al., showed that AFI was correlated with CIMT **[29]**. On contrary, in Jung et al., the AFI was not correlated with CIMT in either men or women. It worth notice that all study participants had type 2 diabetes mellitus **[30]**. On the other hand, a cross-sectional study showed that visceral fat thickness, not subcutaneous fat thickness, was associated with carotid atherosclerosis **[31]**.

Our result was consistent with previous studies but used different indicators for visceral obesity other than AFI. For example, Oike et al., showed that abdominal visceral fat area was independently associated with CIMT changes **[32]**. Likewise, Tripathy et al., showed that visceral fat was the strongest independent predictor of CIMT **[33]**. Kawamoto et al., also found that the interaction between BMI and visceral obesity was significantly associated with CIMT **[34]**. All mentioned studies focused on visceral fat alone accumulation, Bouchi et al., investigated the risk of high visceral fat accumulation with low subcutaneous fat on progression of atherosclerosis. Results showed high visceral fat accumulation with low subcutaneous fat was as important determinant of carotid atherosclerosis. Furthermore high subcutaneous fat could be protective against atherosclerosis **[36]**.

The main limitation of this study, it was an observational, non-randomized cohort of patients. Results of the current study reflects the situations of a single-center which may hinder the generalizations of the results on all populations. We did not follow-up the included patients for long duration. Also, only 60 patients met our inclusion criteria. However, this is still, to the best of our knowledge, our study provided further insight in the associated between visceral fat and carotid atherosclerosis.

Conclusion:

AFI has a significant correlation with carotid intima media thickness along with preperitoneal fat thickness. Furthermore, low subcutaneous fat might have a protective effect on carotid atherosclerosis progression.

AFI is a significant independent contributing factor along with known risk factors such as age, systolic blood pressure, total-cholesterol, and HDL-cholesterol. AFI can be useful in evaluating disorders of metabolism, circulation and atherosclerosis.

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قيمة مؤشر دهو ن جدار البطن بإستخدام جهاز الموجات فوق الصوتية مع سماكة الوسط الداخلى للشريان السباتى وملف الدهون بالدم

فى هذه الدراسة قمنا بدراسة العلاقة بين مؤشر دهون جدار البطن وسماكة بطانة الشريان السباتى مع ملف الدهون بالدم بين المرضى الذين يعانون من زيادة الوزن والسمنة.

الهدف من هذه الدراسة: هو دراسة العلاقة بين مؤشر دهون جدار البطن وسمك الوسط الداخلى للشريان السباتى كما تم قياسه بالتصوير بالموجات فوق الصوتية مع بروفيل الدهون لدى مرضى زيادة الوزن والسمنة.

المرضى والطرق: أجرينا دراسة مقطعية على ٦٠ مشاركاً بالغاً تتراوح أعمارهم بين ٢٢ و٦٦ عاماً من كلا الجنسين. تم تقسيم المرضى إلى ثلاث مجموعات وفقاً لقيمة مؤشر جدار البطن بحيث أن المجموعة الأولى أقل من ٠.٧ والمجموعة الثانية أقل من ١.٠٤ والمجموعة الثالثة أكثر من أو يساوى ١.٠٤ وتم الحصول على سماكة الوسط الداخلى للشريان السباتى وملف تعريف الدهون بالدم.

النتائج: فى المجموعة الثالثة كانوا أكبر سناً بشكل ملحوظ من المجموعات الأخرى وكانوا أكثر عرضة لمرض إرتفاع ضغط الدم والسكر. كان هناك فرق ذو دلالة إحصائية بين المجموعات المدروسة فيما يتعلق بمؤشر كتلة الجسم وكان أعلى مستوى بين المجموعة الثالثة. كانت هناك إرتباطات إيجابية بين ملف تعريف الدهون بالدم ومؤشر دهون جدار البطن. علاوة على ذلك كان هناك فرق معتد به إحصائياً بين المجموعات فيما يتعلق بسماكة بطانة الشريان السباتى والتى كانت الأعلى بين المجموعة الثالثة تليها المجموعة الثانية والمجموعة الأولى. إرتبطت سماكة بطانة الشريان السباتى بشكل إيجابى مع مؤشر دهون جدار البطن. كان مؤشر كتلة الجسم أعلى بين المجموعة الثالثة تليها المجموعة الثانية والمجموعة الأولى. كان مؤشر كتلة الجسم مرتبط بشكل إيجابى مع مؤشر دهون جدار البطن.

الخاتمة: مؤشر دهون جدار البطن له علاقة إيجابية مع سماكة بطانة الشريان السباتى. يمكن أن يكون مؤشر دهون جدار البطن علامة مفيدة فى تقييم والتنبؤ بإضطرابات التمثل الغذائى والدورة الدموية وتصلب الشرايين.