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Impact of Obesity on Left Atrial Functions in Normal Hearts

AYAH T. ELSAYEGH, M.D.; OSAMA M.M. ASOUS, M.Sc. and AHMED MOHAMED EL MISIRI, M.D.

The Department of Cardiology, Faculty of Medicine, Ain Shams University

Abstract

Background: Impaired subclinical left atrial (LA) function may contribute to the risk of cardiovascular disease in obesity.

Aim of Study: To highlight the effect of obesity on LA strain in patients with a structurally normal heart.

Subjects and Methods: This is a prospective case-control study performed in El Demerdash Hospital echocardiography unit. This study included fifty nonobese subjects (BMI $<30kg/m^2$) as controls, and the other 50 obese subjects (BMI $>30kg/m^2$) as cases.

Results: On assessing left atrial measurements and functions, max and min LA volume by Biplane method by Speckle tracking echocardiography (STE), indexed volumes and LA EF by Biplane method showed no significant difference between the non-obese group and obese group ($p>0.05$). Moreover, there was no statistically significant difference between the two groups regarding all the LA strain values ($p>0.05$).

Conclusion: Obesity has no effect on the LA reservoir, contractile, or conduct strain by 2D speckle-tracking.

Key Words: *Obesity – Strain – Two-dimensional speckle tracking echocardiography.*

Introduction

OBESITY is a disease that is becoming highly prevalent nowadays and is steadily rising worldwidecausing a massive health issue owing to its association with morbidity, mortality, and cardiovascular diseases **[1]**.

Obesity or indirect effects of adipose tissue produce different hemodynamic changes that may cause changes in cardiac morphology, predisposing to left ventricular (LV) concentric and eccentric remodelling pattern **[2]**.

The waist-to-hip ratio, LV mass, and LV end-diastolic volume are all associated with the LV diastolic function **[3]**.

Correspondence to: Dr. Ayah T. Elsayegh,
E-Mail: ayahtarek_87@outlook.com

Many physiological variables affect the LVDF primarily including the rate of early myocardial lengthening in diastole and accordingly LV filling. Myocardial lengthening is determined by a mix of active (energy-utilizing) and passive forces. Impaired LV diastolic function includes a group of pathological processes, mainly impaired relaxation, increased myocardial stiffness, and elevated left atrial pressure **[4]**.

LV diastolic dysfunction represents an impairment of the filling capacity of the LV that was proven to be a predictor of the future occurrence of heart failure **[5]**. Accordingly, LV diastolic dysfunction could be a linkbetween an increased body weight and the future incidence of heart failure. Obesity/overweight is associated with cardiovascular risk factors and cardiac structural changes associated which is a main factor to determine LV diastolic function **[4]**.

The main role of the left atrium (LA) is to modulate left ventricular (LV) filling via its different reservoir, conduit, and booster functions. The left atrial function can now be assessed accurately by STE **[6]**.

Subjects and Methods

This is a prospective case-control study conducted on subjects presenting for elective transthoracic echocardiography in the echocardiography lab, cardiology department, Ain Shams University Hospitals during the time period between January 2022 till January 2023.

This study included fifty nonobese subjects (BMI $<30kg/m^2$) as controls, and the other 50 obese subjects (BMI $>30kg/m^2$) as cases. The 2 groups were age-matched to avoid age as a confounding factor as the effect of age on the LV diastolic function is well established.

We included subjects above 18 years with structurally normal hearts and excluded patients with structurally abnormal hearts, patients with atrial fibrillation, patients with congenital heart disease, and patients with systemic diseases that can affect myocardial function, e.g., chronic kidney disease.

Personal history including, general and local clinical examination was reported for all participants. Body Mass Index (BMI), Waist to hip ratio, and Body surface area (BSA) were also calculated. A basic laboratory panel including full lipid profile (LDL, HDL, TGS and HbA1c) was done.

All patients had full ECG-gated transthoracic echocardiography at rest in the left lateral decubitus by the most competent experts. Standard 2D TTE examinations were performed with a "Vivid E95" ultrasound machine. Routine echocardiographic parameters were estimated (Aortic root (AR) and Left atrium (LA) dimensions, Left ventricular dimensions systolic and diastolic (LVES,LVED), inter-ventricular septal diameter (IVSD), LV systolic function by M-mode and modified Simpson's method, Assessment of mitral valve inflow, The diastolic function assessment according to the criteria proposed by the European Association of Echocardiography, tissue doppler imaging (TDI) was recorded from the apical 4-chamber view to assess the Lateral wall and septal myocardial velocities [7].

Assessment of right ventricle byestimatingTricuspid annular plane systolic excursion (TAPSE).

Fractional area change (FAC) , PW tissue Doppler (S`, E`,A), and RV dimension.

Speckle tracking Echocardiography:

Apical four-chamber and two-chamber views were obtained using conventional two-dimensional grayscale echocardiography, during breath hold with a stable ECG recording. Particular attention was given to obtaining an adequate gray scale image, allowing reliable delineation of left atrial myocardial tissue and extracardiac structures. Three successive heart cycles were recorded and averaged. In particular, the left atrial endocardial surface was manually traced in a four-chamber view and two-chamber by a point-and-click approach. Surface tracing for the epicardium was then automatically postulated by the system to create the region of interest (ROI).

We used the R to R gating with zero reference point set at left ventricular end-diastole (R wave), while few studies in literature used the P to P gating with zero reference set at the onset of LA contraction (P wave). There is no consensus about which to use, unfortunately, lack of standardization is likely to slow the implementation of this potentially valuable technique.

LA reservoir strain (S-R) is the phase where the LA stores the pulmonary venous return during left ventricular (LV) isovolumetric contraction, ejection phase and isovolumetric relaxation, it extends from the mitral valve closure to the mitral valve opening.

Strain during early diastole reflects the atrial conduit function (S-CT) and strain during late diastole corresponds to the atrial contractile function (S-CT).

Data management and statistical analysis:

All data were collected, tabulated, and statistically analyzed usingthestatistical package of special science SPSS version 22 (SPSS Inc. Chicago, IL, U.S.A).

Results

Age and sex distribution and correlation between the 2 groups are listed in Table (1).

On measuring and comparing lipid profiles in the 2 groups, LDL, TGs, and HbA1c were significantly higher in the obese group compared to the non-obese group (p<0.001). While HDL levels were significantly lower in the obese group vs the non-obese group (p<0.001).

When measuring basic echocardiography findings between the 2 groups, LA diameter, aortic root diameter, LV systolic and diastolic volumes, EF% by M mode, EF % by Simpson, LV septal wall thickness and LV lateral wall thickness showed no statistically significant difference between non-obese group and obese group (p>0.05).

The Echocardiographic variables signaling diastolic dysfunction including meanseptal E', lateral E', E/E' ratio,and the TR jet velocity were assessed in all subjects. Mean values and correlation between the 2 groups are listed in Table (4) showing no statistically significant difference between the 2 groups, except for R jet velocity which was significantly higher in the obese group.

On assessing left atrial measurements and functions, max and min LA volume by Biplane method by S-T, indexed volumes, and LA EF by Biplane method showed no significant difference between the non-obese group the and obese group (p>0.05). Moreover, there was no statistically significant difference between the two groups as regards S-R, S-CD and S-CT (p>0.05).

Table (1): Demographic characters among the two studied groups.

Variable	Non-obese group (N=50) controls		Obese group (N=50) cases		Test value	*p*-value
	No.	%	No.	%		
Gender:	7	14.0	26	52.0	X^2 = 16.3	<0.001(HS)
Female	43	86.0	24	48.0		
Male						
Age (years):						
Mean ± SD	36.39±10.49		39.88±12.32		ZMWU = 1.465	0.143 (NS)
Median	33.0		37.0			
Range	20.0-63.0		20.0-69.0			

p-value below 0.05 denotes significance.
p-value below 0.01 denotes high significance.
SD: Standard deviation.
*Mann-Whitney U Test.
X^2: Chi-Square Test.

Table (2): Comparison of laboratory data between the studied groups.

	Non-obese group (N=50)					Obese group (N=50)					Mann-Whitney U Test/ Student *t*-test	
	Mean	SD	Median	Min.	Max.	Mean	SD	Median	Min.	Max.	Test value	*p*-value
LDL (mg/dl)	122.7	23.3	130.00	70.0	159.00	169.70	21.88	169.0	126.0	214.0	*t*=10.4	<0.001 (HS)
HDL (mg/dl)	50.06	7.72	49.00	40.0	68.00	40.10	5.61	40.0	30.0	51.0	ZMWU = 6.02	<0.001 (HS)
TGs (mg/dl)	70.12	17.54	70.06	29.0	101.0	214.92	47.07	199.5	144.0	307.0	ZMWU = 8.62	0.005 (HS)
HbA1c	5.20	0.71	5.15	4.10	7.1	5.65	0.57	5.50	4.90	7.50	ZMWU = 3.51	<0.001 (HS)

LDL: Low density lipoproteins.
HDL: High density lipoproteins.
TGs : Triglycerides.
HbA1c: Glycosylated hemoglobin.
p-value below 0.05 denotes significance.
p-value below 0.01 denotes high significance.
SD: Standard deviation.

Table (3): Comparison of echocardiography findings between the studied groups.

	Non-obese group (N=50)					Obese group (N=50)					Mann-Whitney U Test/ Student *t*-test	
	Mean	SD	Median	Min.	Max.	Mean	SD	Median	Min.	Max.	Test value	*p*-value
LA diameter (mm)	3.66	0.38	3.60	2.80	4.50	3.71	0.30	3.70	3.20	4.30	*t*=0.744	0.459 (NS)
Aortic root diameter (mm)	2.70	0.38	2.70	1.90	4.1	2.71	0.42	2.55	2.0	3.6	ZMWU = 0.48	0.634 (NS)
LV volume systole	38.47	11.1	37.73	16.0	69.0	38.56	9.07	37.0	22.0	63.0	*t*=0.045	0.965 (NS)
Indexed LV volume systole	19.28	5.65	19.35	7.69	33.29	18.33	4.29	18.14	10.5	27.45	*t*=0.944	0.348 (NS)
LV volume diastole	94.67	26.7	95.34	51.0	172.0	98.52	21.74	99.0	51.0	148.0	*t*=0.789	0.432 (NS)
Indexed LV volume diastole	47.41	13.46	48.13	27.51	84.38	46.82	10.36	46.86	24.44	71.9	*t*=0.245	0.807 (NS)
EF% by M mode	63.49	6.89	62.50	51.0	79.0	62.92	7.30	62.5	50.0	84.0	ZMWU = 0.26	0.798 (NS)
EF % by Simpson	59.44	5.67	59.00	50.0	72.0	58.36	7.49	59.0	36.0	71.0	ZMWU = 0.19	0.852 (NS)
LV septal wall thickness	1.77	4.10	1.20	0.70	30.0	1.14	.15	1.20	0.70	1.30	ZMWU = 0.70	0.482 (NS)
LV lateral wall thickness	0.78	2.43	1.10	–16.0	1.50	1.16	0.13	1.10	1.10	1.90	ZMWU = 0.49	0.624 (NS)

LV: Left ventricle.
LA: Left atrium.
EF : Ejection fraction.
p-value below 0.05 denotes significance.
p-value below 0.01 denotes high significance.
SD: Standard deviation.
*Mann-Whitney U Test.
X^2: Chi-Square Test.

Table (4): Comparison of echocardiography findings between the studied groups.

	Non-obese group (N=50)					Obese group (N=50)					Mann-Whitney U Test/ Student *t*-test	
	Mean	SD	Median	Min.	Max.	Mean	SD	Median	Min.	Max.	Test value	*p*-value
E' Septal	0.11	0.03	0.12	0.05	0.17	0.10	0.04	0.10	0.03	0.15	ZMWU=1.89	0.059 (NS)
E' Lateral	0.12	0.04	0.12	0.06	0.19	0.11	0.04	0.11	0.03	0.19	ZMWU=1.91	0.056 (NS)
E/E'	6.47	2.32	6.03	1.04	14.20	7.56	3.14	6.75	3.50	19.33	ZMWU=1.87	0.062 (NS)
TR jet velocity	1.91	0.57	1.90	0.76	3.90	2.27	0.63	2.25	1.30	3.80	ZMWU=2.73	0.006 (HS)

p-value below 0.05 denotes significance.
p-value below 0.01 denotes high significance.
SD: Standard deviation,
*Mann-Whitney U Test.
X^2: Chi-Square Test.

Table (5): Comparison of Speckle-tracking echocardiography (STE) findings between the studied groups.

	Non-obese group (N=50)					Obese group (N=50)					Mann-Whitney U Test/ Student *t*-test	
	Mean	SD	Median	Min.	Max.	Mean	SD	Median	Min.	Max.	Test value	*p*-value
LA volume (max) by Biplane method by STE	39.32	10.43	38.25	23.0	65.50	40.50	10.98	40.0	24.50	71.0	ZMWU=0.39	0.697 (NS)
LA volume (max)/ BSA	19.71	5.40	19.36	11.50	33.89	19.25	5.23	18.89	12.48	34.41	ZMWU=0.41	0.679 (NS)
LA volume (min) by Biplane method by STE	13.82	6.29	13.00	3.0	32.00	13.82	6.39	12.75	4.00	30.5	ZMWU=0.07	0.948 (NS)
LA volume (min)/ BSA	6.94	3.20	6.78	1.44	15.89	6.52	2.97	5.97	2.06	14.84	ZMWU=0.68	0.495 (NS)
LA EF by Biplane method	65.60	11.43	64.75	36.0	87.0	66.05	12.55	66.25	34.50	92.0	ZMWU=0.31	0.759 (NS)
S-R	30.10	8.63	30.05	10.0	45.0	30.02	7.29	30.0	13.0	47.0	*t*=0.051	0.959 (NS)
S-CD	-20.12	8.51	-19.50-	-38.0	-4.0	-18.18	6.78	-18.0	-38.0	-5.0	*t*=1.26	0.210 (NS)
S-CT	-9.94	4.18	-10.0	-19.0	-1.0	-11.52	4.56	-12.0	-20.0	-2.0	*t*=1.81	0.074 (NS)

LA : Left atrium.
BSA : Body surface area.
STE : Speckle tracking echocardiography.
S-R : Reservoir strain.
S-CT : Contractile strain.
S-CD : Conduit strain.

p-value below 0.05 denotes significance.
p-value below 0.01 denotes high significance.
SD: Standard deviation,
*Mann-Whitney U Test.
X^2: Chi-Square Test.

Discussion

In our study, the 2 groups were age-matched with a mean age of 36.39±10.49 years and 39.88± 12.32 years in controls and cases respectively. Female cases were significantly higher in the obese group compared to the non-obese group ($p<0.001$), this could be related to social economic status and unhealthy dietary habits. It is also worth noticing that Egypt is a developing country and the majority of females referred to the tertiary centres are from rural areas and are mostly housewives with sedentary life style.

Steele et al., [8] evaluated 331 participants (101 normal weight, 114 obese, and 116 T2DM) with good echocardiographic pictures to determine LA function, and their findings corroborated our findings. They discovered considerable racial and gender disparities among the groups. In the obese and T2DM groups, there were more female patients ($p=0.003$) and more patients of African American descent ($p=0.01$).

We concluded in our study, that in the absence of any cardiovascular abnormalities, LDL, TGs, and HbA1c levels were significantly higher in the obese group compared to the non-obese group. While HDL levels were significantly lower in the obese group compared to the non-obese group.

Abnormalities in lipid metabolism are very commonly observed in obese patients. Approximately 60-70% of patients with obesity are dyslipidemic. This could be explained by increased hepatic production of VLDL particles and a decrease in the clearance of triglyceride-rich lipoproteins [9].

In our study, we compared the basic echocardiography findings between 2 groups. We measured LA diameter, aortic root diameter, LV systolic and diastolic volumes, EF% by M mode and Simpson's method as well as the LV wall thickness, all the values showed no statistically significant difference between the non-obese group and obese group even when they were indexed to BSA (p>0.05). Similarly, RV dimensions and functions measured by FAC showed no significant difference between the 2 groups.

Jamilah AlRahim et al., [10] conducted a cross-sectional study that recruited 114 patients referred for echocardiographic study in King Faisal Cardiac Center. They included adults with a body mass index (BMI) of more than 25 kg/m^2, meanwhile, patients with cardiovascular risk factorsor those who use medications for chronic diseases were excluded. They concluded that cardiac function was not affected by isolated obesity. Yet the indexed cardiac measurements were correlating negatively with increasing BMI.

The effect of BMI on different left atrial indices is not yet well established and many studies show contradictory results. The discrepancy of results from different studies could be partly related to ethnic variations.

Regarding left atrial indices, maximum and minimum LA volume by the Biplane method by S-T, indexed volumes, and LA EF by the Biplane method showed no significant difference between the 2 groups with a p-value of >0.05.

Moreover, there was no statistically significant difference between the two groups as regards all strain value parameters (p>0.05).

Similar results were described by Russo C et al., [11] from the CABL (Cardiovascular Abnormalities and Brain Lesions) study. They included 629 subjects with a mean age of 71±9 years and females constituted 61% of the study group.

Patients were assessed by real-time 3D echocardiography with measurement of LA maximum (LAVmax) and minimum (LAVmin) volumes, and LA reservoir function, measured as total emptying volume index (LAEVI), the total emptying fraction (LAEF), and expansion index (LAEI). Those echocardiographic findings were correlated with BMI, WC (waist-circumference), and WHR (waist-to-hip ratio).

Limitation:

Obese individuals were not tracked in a longitudinal fashionfor the occurrence of morphological and functional effects on the heart. We didn't include patients with morbid obesity. Our sample size was modest.

Conclusion:

In conclusion, our findings suggest that: Obesity has no effect on the LA reservoir, contractile, or conduit functions and LA strain measured by 2D speckle-tracking. Age is an independent predictor of impaired LA strain by STE. There are no differences between standard echocardiographic measurements of dimensions, volumes, and functions between obese and non-obese individuals.

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تأثير السمنة على وظائف الأذين الأيسر فى القلوب الطبيعية

السمنة مرض ينتشر بشكل كبير فى الو قت الحاضر. تؤدى السمنة مباشرة أو غير مباشرة إلى تضخم البطين الأيسر وإعادة تشكيله.

ترتبط الوظيفة الانبساطية بكتلة الدهون ومستويات اللبتين فى الدم ونسبة الخصر إلى الورك وكتلة البطين الأيسر الانبساطى. هذه دراسة مستقبلية لمقارنة الحالات والضوابط أجريت على مرضى قادمون لتخطيط صدى القلب الاختيارى فى مختبر تخطيط صدى القلب، قسم أمراض القلب، مستشفيات جامعة عين شمس خلال الفترة الزمنية من يناير ٢٠٢٢ حتى يناير ٢٠٢٣.

تضمنت هذه الدراسة خمسين شخصاً غير مصابين بالسمنة (مؤشر كتلة الجسم <٣٠ كجم/م٢) كعناصر تحكم، و ٥٠ شخصاً يعانون من السمنة (مؤشر كتلة الجسم >٣٠ كجم/م٢) كحالات. كانت المجموعتان متطابقة العمر.

عند تقييم القياسات والوظائف الأذينية اليسرى، لم يظهر الحجم الأقصى والأدنى للأذين الأيسر من خلال تخطيط صدى القلب عن طريق تتبع البقعة (STE)، أحجام الأذين الأيسر مفهرسة وفقاً لمساحة سطح الجسم والكسر القذفى للأذين الأيسر أظهرت أن لا فرق بين المجموعة غير البدينة ومجموعة السمنة (p<٠.٠٥). علاوة على ذلك، لم يكن هناك فرق معتد به إحصائياً بين المجموعتين فيما يتعلق بجميع قيم الإجهاد للأذين الأيسر p<٠.٠٥.

نستنتج أن السمنة ليس لها أى تأثير على وظيفة الأذين الأيسر كخزان أو وظيفة مقلص أو وظيفة القناة عند قياسها بواسطة تتبع البقع ثنائية الأبعاد.