Original Research Article

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Evaluation of cardiac performance among asymptomatic obese subjects in comparison with normal individual

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ABSTRACT

Background: Obesity constitutes a major health issue in the modern world. The purpose of this prospective study was to assess the effect of obesity on ventricular function by conventional 2D echocardiography and echocardiogram for assessment of early cardiac changes.

Methods: In the present study, 50 asymptomatic obese subjects having BMI >30 were compared with 50 normal individuals having BMI in the range 20-24.9 to assess cardiac performance. The study was conducted over a period of 2 years, from 2009 to 2011.

Results: There were 20(40%) males and 30(60%) females in both the groups. The ejection fraction was not significantly affected in obese subjects $(60.86\pm1.34\%)$ than normal individual $(60.42\pm1.18\%)$ which was found to be statistically not significant. So, in this study systolic function was not affected. The thickness of left ventricle was significantly increased in obese subjects $(1.016\pm0.113 \text{ cm})$ than normal individual (0.77+0.073 cm) which was found to be statistically significant.

Conclusions: The current study revealed increased wall thickness and mass of Left Ventricle (LV), significantly increased risk of LV diastolic dysfunction, evidence of Left Atrial (LA) enlargement associated with diastolic dysfunction, evidence of subclinical LV systolic dysfunction and Right Ventricular (RV) dysfunction among obese subjects in comparison with normal individuals.

Keywords: 2D Echocardiography, Body mass index, Echocardiogram, Obesity, Ventricular function

INTRODUCTION

Overweight and obesity are defined as abnormal or excessive fat accumulation that may impair health. The prevalence of overweight and obesity is increasing worldwide. Obesity has emerged as a major public health threat for all strata of the society worldwide. Worldwide obesity has nearly tripled since 1975. Individuals from so called disadvantaged communities is not exempted from the epidemic. They are also at the risk of obesity and its complications. Obesity is perhaps the

most prevalent form of malnutrition.³ Epidemiologic studies have identified high Body Mass Index (BMI) as a risk factor for an expanding set of chronic diseases, including cardiovascular disease, diabetes mellitus, chronic kidney disease many cancers and an array of musculoskeletal disorders.⁴⁻⁷

In recent years obesity has attracted the attention of medical fraternity. Obesity has now become an important health problem in developing countries particularly India which is a country experiencing rapid epidemiological

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transition. Serial National surveys in India have demonstrated an increasing trend in the prevalence of obesity.^{8,9}

Obesity affects more than 135 million individuals in India. According to the nationwide, population-based Indian Council of Medical Research-India Diabetes (ICMR-INDIAB) study, the prevalence of generalized obesity (defined as BMI \geq 25 kg/m²), varied from 11.8% in Jharkhand (east India)to 31.3% in Chandigarh (north India). 10 Recent study conducted on rural, urban-poor and urban-middle class women reported the prevalence of overweight/obesity (BMI >25 kg/m²) as 22.5, 45.6 and 57.4%, respectively.¹¹ Risk factors for Coronary Artery Disease (CAD) were not formally established until the initial findings of the Framingham Heart Study in the early 1960s. Obesity not only increases morbidity and mortality but is also a significant predictor of coronary artery disease, and congestive heart failure independent of other standard risk factors for ischemic cardiac disease. Definitions of "metabolically healthy obesity" vary, and over time, a substantial proportion of those with metabolically healthy obesity transition to metabolically unhealthy. The risk of CVD events, particularly HF, may be increased with obesity even in the absence of metabolic risk factors.12 A wealth of clinical and epidemiological evidence has linked obesity to a broad spectrum of Cardiovascular Diseases (CVD) including coronary heart disease, heart failure, hypertension, stroke, atrial fibrillation and sudden cardiac death.

Obesity can increase CVD morbidity and mortality directly and indirectly. Direct effects are mediated by obesity-induced structural and functional adaptations of the cardiovascular system to accommodate excess body weight, as well as by adipokine effects on inflammation and vascular homeostasis. Indirect effects are mediated by co-existing CVD risk factors such as insulin resistance, hyperglycemia, hypertension and dyslipidemia.¹³

The INTERHEART study reported the importance of conventional risk factors associated with CAD.¹⁴ The present study was undertaken with the aim of assessing cardiac profile of asymptomatic obese patient, to quantify the clinical spectrum to achieve the following objectives,

- To study distribution of cardiovascular disease in asymptomatic obese individuals.
- To study the electrocardiogram and Echocardiography findings of all the selected subjects for assessment of early cardiac changes.
- To compare cardiac performance between asymptomatic obese individual and normal individuals.

METHODS

Hospital based cross-sectional study was undertaken at medicine department of Dr. V.M. Government Medical

College, Solapur, a tertiary care health center located at Maharashtra, central India. Study was carried out from the 2009 to 2011, for a period of two years. Total 50 Asymptomatic obese cases and 50 normal individuals, age andgender matched, were enrolled in the present study. Asymptomatic subjects having BMI more than 30 and normal matched healthy individuals having normal BMI (18.5 to 25 kg/m²) willing to participate in the study were enrolled in the present study. Symptomatic subjects from any disease or abnormalities were excluded from study.

Anthropometric measurements

Height was measured by wall-mounted stadiometer (Model 206, Seca, Hamburg Germany) up-to the nearest centimeter. Subjects were asked to stand upright without shoes, with their back against the wall, heels together and eyes directed forward. Weight was measured with aportable electronic weighing scale (Model HN 283, Omron Corporation, Shimogyo-ku, Kyoto, Japan) kept on a firm horizontal surface.

The subjects were asked to wear light clothing and remove footwear. Weight was recorded in kilograms to the nearest 0.5 kg. Body mass index was calculated as weight in kg/m²(height in meter squared). Waist circumference was measured using a non-stretchable measuring tape. The subjects were asked to stand erect in a relaxed position with both feet together. Waist girth was measured at the midpoint between the iliac crest and the lower margin of the ribs at the end of expiration, to the nearest centimeter.

Blood pressure

Blood pressure was recorded with electronic apparatus (model 1A2, Omron Corporation, Shimogyo-ku, Kyoto, Japan) in sitting position, on the left arm resting on a table at heart level, after the subject having rested for at least 15 min. Three readings were taken 3 min apart and the mean of the last two readings was recorded as the BP. Heart rate was also recorded. Resting 12 lead Electrocardiograms (ECG) was performed on all subjects by trained technicians with three-channel digital ECG recorders with facility for display and measured parameters. Parameter used to define L.V.H is, Sokolow-Lyon index SV1 +(RV5 or RV6> 3.5 mV) RaVL>1.1mV 79

Electrocardiogram

For each lead, five consecutive complexes were recorded. Minnesota coding and application of CAD criteria were performed by an experienced cardiologist for the respective region; those subjects diagnosed to have CAD were re-evaluated by another cardiologist in a blinded manner. Disagreements were resolved by consensus. ¹⁶

X- ray chest

The most common method of describing the heart size is by the use of cardiothoracic ratio. The cardiothoracic ratio expressed as percentage of the heart size with respect to internal thoracic diameter. Types includes Normal <0.45, Mild cardiomegaly 0.45-0.55 and Moderate/severe >0.55.18

Echocardiography examination

All subjects underwent 2D echocardiography for the evaluation of left ventricular function, thickness of left ventricle, right ventricle and interventricular septum. Subject examined in left lateral recumbent position using standard parasternal long axis, short axis, apical four and five chamberview. Echocardiography was performed according to the guidelines of American Society of Echocardiography.

Ethical clearance

The present study was in compliance with the Helsinki Declaration. The study was approved by the Institutional Ethics Committee. Informed written consent was obtained from all participants. Questionnaire does not contain any identification details of the participant and confidentiality was maintained throughout the study.

Data collection and procedure

A structured self-administrative questionnaire was developed with the aid of available evidences by the researchers for data collection to fully meet the demands of this research. The purpose of the study was explained to the participants prior to the study. The developed questionnaire is corrected, revised and validated by clinicians. It was pretested before its use in this study. This tool contained questionnaire includes the following component - age of patients, sex, height, weight, chest X-ray, ECG findings, 2D echocardiography.

Statistical analysis

Each completed questionnaire was coded on pre-arranged coding by the principal investigator to minimize errors. Data was checked for completeness and correctness. Data was analyzed using excel, windows 2007 and using SPSS V18. Statistical tools applied were mean, SD, percentage and Z Test as a test of significance.

RESULTS

Table 1 depicts, gender wise distribution of cases and normal individuals revealed 20(40%) males and 30(60%) females in both the group as it was a gender matched study.

Table 2 depicts, most of the study population among cases belonged to first two subgroups i.e. mild and

moderate obese consisting 30(60%) and 16(32%) cases respectively. Severe obesity had less contribution as 04(08%) cases respectively. Out of 30 cases of mild obese subgroup, 12 were males (40%) and 18 were females (60%). While, number of males and females in moderate obesity subgroup were 07(43.75%) and 09(56.25%) respectively out of 16. Among severe obese subgroup out of 04 cases, 01(25%) was male and 03(75%) were females.

Table 1: Gender wise distribution of obese subjects and normal individual.

Gender	Obese subjects (n=50)	Normal individual (n=50)
Male	20	20
Female	30	30
Total	50	50

Table 3 shows, out of 50 cases 04 individuals have mild cardiomegaly on X-ray chest and 08 individuals have left ventricular hypertrophy on ECG.

Table 4 shows diastolic dysfunction among study population were more in obese class 2 and obese class 3 as compared to obese class 1.

Table 5 shows findings of study variables which are significantly increased in cases than normal individuals, but findings of few variables like ejection fraction, A value are not statistically significant i.e. p>0.05.

Table 2: Gender wise distribution of obese subjects as per grades of obesity.

Subgroup (n=50)	Male	Females	
Mild obese (n=30)	12(40%)	18(60%)	
Moderate obese (n=16)	07(43.75%)	09(56.25%)	
Severe obese (n=04)	01(25%)	03(75%)	

Table 3: X-chest PA view and electrocardiography finding in obese subject.

Subgroup [total cases -50]	X-ray chest [MCM]	ECG [LVH]
Mild obese	00	00
Moderate obese	02	05
Severe obese	02	03

[MCM- Mild Cardiomegaly; LVH- Left Ventricular Hypertrophy]

Table 4: Diastolic dysfunction in obese subjects as per grade of obesity.

Classification	BMI (kg/m²)	Diastolic dysfunction [n-50]
Obese class 1	30.00-34.99	02
Obese class 2	35.00-39.99	06
Obese class 3	>40	04

Table 5: Comparison of cardiac parameters among obese subjects and normal individual.

Parameter	Obese subjects		Normal s	Normal subjects		p value
	Mean	SD	Mean	SD		
Systolic blood pressure	132	10.887	116.72	5.218	8.948	< 0.0001
Diastolic blood pressure	82.92	5.830	75.08	4.902	7.278	< 0.0001
Body Mass Index	34.41	2.963	22.58	1.030	26.689	< 0.0001
Waist circumference	96.04	9.444	71.54	6.065	15.44	< 0.0001
Serum cholesterol	207.40	35.54	119.04	19.43	15.42	< 0.0001
Serum HDL	36.2	2.58	41.86	4.41	7.88	< 0.0001
Serum triglyceride	194.84	68.72	95.12	24.27	9.67	< 0.0001
Serum LDL	99	27.29	63.86	8.03	7.24	< 0.0001
Ejection fraction	60.86	1.34	60.42	1.18	1.75	0.0846
E value	0.879	0.363	1.3	0.082	8.24	< 0.0001
A value	0.840	0.267	0.842	0.103	0.049	0.960
E/A value	1.051	0.25	1.55	0.17	11.46	< 0.0001
Thickness of left ventricle	1.016	0.113	0.77	0.073	13.01	< 0.0001
Thickness of right ventricle	0.376	0.072	0.313	0.043	5.31	< 0.0001
Thickness of Inter-ventricular septum	0.855	0.089	0.751	0.078	6.64	< 0.0001

DISCUSSION

Indices of LV systolic and diastolic function did not show any significant difference between males and females. Gender was not considered for correlation of LV function indices as per the literature.²²⁻²⁵ Pascual et al, studied 27 cases of which 09 were males and 18 females while Wong et al, studied 109 cases of which 53 were males and 56 females but gender wise analysis was not done in both the studies.^{23,26} Present study also followed the same norms of previous two studies by including 20(40%) males and 30(60%) females out of 50 cases (Table 1). But gender wise analysis for LV systolic and diastolic function was not done. In present study, mean age of the population was 34.78±7.195 years and 34.66±7.156 years in obese subjects and normal individuals respectively. It included middle aged individuals similar to Stoddard et al, and Wong et al, study population ages.^{26,27} Pascual et al, 11 also considered 17 overweight, 20 mild obese and 11 severe obese in their study of 48 cases.²³ Wong et al, study carried out in 26 overweight, 37 mild obese and 46 severe obese.²⁶ Both of these studies defined severe obesity when BMI was >35 kg/m² while present study made three subgroups as mild obese (BMI= 30.00-34.99 kg/m²) ,moderate obese (BMI= 35-39.99 kg/m²) and severe obese (BMI >40 kg/m²) as per WHO based classification of obesity (Table 4).2 It was observed that LV dysfunction was more prevalent in moderate to severe obesity (Table 3). Results of the study conducted by, Wong et al, was significant increase in mean WC in all obese subgroups as compared to controls (p<0.001).²⁶ The results of the present study are well correlated with the above study. Mean WC of obese subjects (96.04±9.44 cm) were significantly more than normal individuals (71.54±6.064) with p<0.001. Edward k kasper et al, reported significant increase in systolic BP in obese (134 ± 24) than in lean subjects $(124\pm22; p<0.007)$ favoring present study.²⁸ The results of the present study were similar to them but the study population in present study was normo-tensive (BP <140/90) still the mean systolic blood pressure in obese subjects (132±10.88 mmHg) was significantly increased than normal individuals (116.72±5.21 mmHg) with p<0.001. The relationships between body fatness and several biochemical measurements was systematically explored in 104 patients free of known metabolic diseases.^{29,30} Abnormalities were common, elevated serum-cholesterol levels being encountered in 60% and elevated serumtriglyceride levels in 31% of the sample. A strong association was demonstrated between body fatness and elevations of serum triglycerides.²⁹ The Serum Cholesterol was significantly increased in obese subjects than normal individuals. In present study the serum triglyceride was significantly increased in obese subjects (194.84+68.72)mg%) than normal (95.12+24.27mg %) with p<0.001 (Table 5). In case of LV Systolic function, left ventricular wall thickness was significantly increased in obese subjects than normal individuals (Table 5). This finding was suggestive of increase in LV thickness due to increase in LV stress. On the contrary EF was not significantly changed in obese subgroups than normal (60.86±1.34 % v/s 60.42±1.17 %; p=1.75) in the present study (Table 5). Other studies like Stoddard et al, and Pascual et al, also noted significant increase in EF in all obese cases than controls suggesting increase in LV systolic function in obesity.^{23,27} In contrast, Martin A. Alpert et al, reported significant decrease in EF in 13 out of 23 subjects having extreme obesity.31 This was due to depressed cardiac function in extreme obesity as this study included only extreme obese subjects. EF is a relative index but, is relatively insensitive to LV contractile function so its value may be maintained within normal limits even when there is substantial compensatory modification of contractile state. As far as Left Ventricular Diastolic dysfunction was concerned, Zarich et al, reported that peak early mitral velocity (E) was significantly decreased in obese subjects than controls (75 cm/s v/s 98 cm/s; p<0.001) due to abnormal relaxation of LV in early diastole.³² Similar finding was also observed in present study in which E velocity was significantly decreased in obese subjects $(0.879\pm0.363 \text{ m/s})$ than normal $(1.3\pm0.082 \text{ m/s}; p<0.001)$ (Table 5). Zarich et al, and Wong et al, have reported no change in A velocity in obese subjects than controls. 26,32 Similar finding was also seen in present study population in which a velocity not significantly differed in obese subjects compared to normal (Table 5). On the contrary result of the most of studies like Chakko et al, Stoddard et al, and Pascual et al, revealed an increase in a velocity in obesity due to increase LA pressure than controls. 23,33,34 Present study finding did not corroborate with these studies. Zarich et al, in their study has demonstrated, abnormal diastolic filling pattern in 06(38%) cases out of 16 obese subjects.³² Pascual et al, demonstrated 12% of mild, 35% of moderate and 45% of severely obese patients had diastolic dysfunction, whereas no patient had met the criteria of systolic dysfunction.²³ Overall diastolic dysfunction was present in 29% of obese population as it was 38.33% in present study indicating higher prevalence in this study group. In Franz H. Messarli et al, studies, left ventricular hypertrophy was considered when posterior wall thickness was more than 1.1 cm and it was observed in 50% of all obese subjects in their study population.³⁵ In present study similar finding obtained with thickness of left ventricle was significantly increased in obese subjects [1.016+0.113 cm] than normal [0.77+0.073 cm] with p < 0.001 due to LV stress. Wong et al, reported that RV cavity size and wall thickness were mildly increased in obese subjects compared with a normal-weight reference group.³⁶ In present study the thickness of Right ventricle was significantly increased in obese [0.376+0.072 cm] than normal [0.313+0.043 cm] with p<0.001. In a study done by Franz H Messerli M.D. et al, septal wall thickness (p<0.0001) is significantly increased in obese group than controls.³⁵ In present study the thickness interventricular septum was significantly increased in obese subjects [0.855+0.89 cm] than normal individual [0.751+0.078 cm] with p <0.001 and associated with increased thickness of LV wall.

Limitation of the study was although the duration of obesity has previously been shown to be a determinant of cardiac changes from obesity, authors were unable to demonstrate such a relation in this study. Reversibility of left ventricular dysfunction (diastolic) after treatment modality (weight reduction and drugs) was not assessed in the present study since it was beyond scope of the study. Gender wise analysis of LV systolic and diastolic functions was not done. Due to limiting small size and other variables that could potentially predict alterations in LV structure and function, could not be evaluated. Newer echocardiographic techniques like tissue doppler imaging

which are load independent are found to be better in assessment of diastolic dysfunction.

CONCLUSION

LVH is an important predictor of cardiovascular morbidity and mortality in obese patients. Considering the adverse outcomes which are associated with LVH, it becomes essential to diagnose it at an early stage. Among the various diagnostic tools, echocardiography is a relatively simple and a non-invasive test with a good predictive value. Regression of LVH can significantly reduce adverse cardiovascular events. The present study, therefore, recommends an echocardiography screening of obese and hypertensive subjects, to diagnose potential cardiac dysfunction and early institution of treatment.

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Institutional Ethics Committee

REFERENCES

- Roberto CA, Swinburn B, Hawkes C, Huang TT, Costa SA, Ashe M, et al. Patchy progress on obesity prevention: emerging examples, entrenched barriers, and new thinking. Lancet. 2015 Jun 13;385(9985):2400-9.
- World Health Organization. Health topics: Obesity. Available at: https://www.who.int/topics/obesity/en/. Accessed 5 September 2014.
- Park K. Park's Textbook of Preventive and Social Medicine. 25th Ed. Jabalpur: Bhanot Publishers; 2015:426.
- 4. Singh GM, Danaei G, Farzadfar F, stevens GA, Woodward D, Wormser D, et al. The age-specific quantitative effects of metabolic risk factors on cardiovascular diseases and diabetes: a pooled analysis. PLoS One. 2013 Jul 30;8(7):e65174.
- 5. Wormser D, Kaptoge S, Di Angelantonio E, Wood AM, Pennells L, Thompson A, et al. Emerging Risk Factors Collaboration. Separate and combined associations of body-mass index and abdominal adiposity with cardiovascular disease: collaborative analysis of 58 prospective studies. Lancet. 2011;377:1085-95.
- 6. Lauby-Secretan B, Scoccianti C, Loomis D, Grosse Y, Bianchini F, Straif K. Body fatness and cancerviewpoint of the IARC Working Group. N Engl J Med. 2016 Aug 25;375(8):794-8.
- 7. Jiang L, Rong J, Wang Y, Hu F, Bao C, Li X, et al. The relationship between body mass index and hip osteoarthritis: a systematic review and meta-analysis. Joint Bone Spine. 2011 Mar 1;78(2):150-5.
- India. National Family Health Survey (NFHS-3). 2005-06 Key Findings. Available at: www.measuredhs.com/pubs/pdf/SR128/SR128.pdf. Accessed 19 April 2019.
- Kumar A, Kalra S, Unnikrishnan AG. Metabolic state of the nation: Results of the national family health survey-4. Indian J Endocrinol Metab. 2016; 20:429-31.

- Pradeepa R, Anjana RM, Joshi SR, Bhansali A, Deepa M, Joshi PP, et al. Prevalence of generalized and abdominal obesity in urban & rural India-the ICMR-INDIAB Study (Phase-I)[ICMR-INDIAB-3]. Ind J Medica Res. 2015 Aug;142(2):139-50.
- Mohan I, Gupta R, Misra A, Sharma KK, Agrawal A, Vikram NK, et al. Disparities in prevalence of cardiometablic risk factors in rural, urban-poor, and urban-middle class women in India. PloS One. 2016 Feb 16;11(2):e0149437.
- 12. Benjamin EJ, Blaha MJ, Chiuve SE, Cushman M, Das SR, Deo R, et al. Heart disease and stroke statistics-2017 update: a report from the American Heart Association. Circulation. 2017 Mar;135(10):e146-603.
- Koliaki C, Liatis S, Kokkinos A. Obesity and cardiovascular disease: revisiting an old relationship. Metabo. 2018;92:98-107.
- Yusuf S, Hawken S, Ounpuu S, Dans T, Avezum A, Lanas F, et al. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. Lancet. 2004 Sep 11;364(9438):937-52.
- WHO STEPS Manual. Available at: http://www1.paho.org/hq/dmdocuments/2009/STEPS manual.pdf. Accessed 18 September 2019.
- Prineas RJ, Crow RS, Zhang ZM. The Minnesota code manual of electrocardiographic findings. Springer Sci Business Media. 2009 Oct 26:111-33.
- 17. Wilde P, Callaway M. The Acquired Heart Disease 1: The chest radiograph anatomy and techniques of examination. In: Sutton D., Allan P.L., editors. A Textbook of Radiology and Imaging.7th Ed. New York: Churchill Livingstone; 2003:265-282.
- Dahnert W. Radiology review manual. 5th edition Philadelphia, USA: Lippincott Williams and Wilkins; 2002:574
- Bengur AR, Snider AR, Vermilion RP, Freeland JC. Left ventricular ejection fraction measured with Doppler color flow mapping techniques. Am J Cardiol. 1991 Sep 1;68(6):669-73.
- Otto CM, Pearlman AS. Normal cardiac anatomy, tomographic views, ADN intracardiac flow patterns. Textbook of Clinical Echocardiography. WB Saunders Co:Washington;1995:29-63.
- Joyner CR Jr, Reid JM, Bond JP. Reflected ultrasound in the assessment of mitral valve disease. Circulation. 1963;27(4 Pt 1):503-11.
- 22. Lavie CJ, Amodeo C, Ventura HO, Messerli FH. Left atrial abnormalities indicating diastolic ventricular dysfunction in cardiopathy of obesity. Chest. 1987 Dec 1;92(6):1042-6.
- Pascual M, Pascual DA, Soria F, Vicente T, Hernandez AM, Tebar FJ, et al. Effects of isolated obesity on systolic and diastolic left ventricular function. Heart. 2003 Oct 1:89(10):1152-6.
- 24. Peterson LR, Waggoner AD, Schechtman KB, Mayer T, Gropper RJ, Barzilap B, et al. Alterations of LV structure and function in young healthy women:

- Assessment by 2D Echo and Tissue Doppler imaging. J Am Coll Cardiol. 2004; Apr.21,43(8)1399-404.
- Alaud-Din A, Meterissian S, Lisbona R, MacLean LD, Forse RA. Assessment of cardiac function in patients who were morbidly obese. Surgery. 1990 Oct;108(4):809-18.
- Wong CY, O'Moore-Sullivan T, Leano R, Byrne N, Beller E, Marwick TH. Alterations of left ventricular myocardial characteristics associated with obesity. Circulation. 2004 Nov 9;110(19):3081-7.
- Stoddard MF, Tseuda K, Thomas M, Dillon S, Kupersmith J. The influence of obesity on left ventricular filling and systolic function. Am Heart J. 1992 Sep 1;124(3):694-9.
- 28. Kasper EK, Hruban RH, Baughman KL. Cardiomyopathy of obesity: a clinicopathologic evaluation of 43 obese patients with heart failure. Am J Cardiol. 1992 Oct 1;70(9):921-4.
- 29. Hollister LE, Overall JE, Snow HL. Relationship of obesity to serum triglyceride, cholesterol, and uric acid, and to plasma-glucose levels. Am J Clini Nutrition. 1967 Jul 1;20(7):777-82.
- Katzel LI, Busby-Whitehead MJ, Goldberg AP. Adverse effects of abdominal obesity on lipoprotein lipids in healthy older men. Experimental Gerontol. 1993 Jul 1;28(4-5):411-20.
- Alpert MA, Singh A, Terry BE, Kelly DL, El-Deane MS, Mukerji V, et al. Effect of exercise and cavity size on right ventricular function in morbid obesity. Am J Cardiol. 1989 Dec 1;64(19):1361-5.
- 32. Zarich SW, Kowalchuk GJ, McGuire MP, Benotti PN, Mascioli EA, Nesto RW. Left ventricular filling abnormalities in asymptomatic morbid obesity. Am J Cardiol. 1991 Aug 1;68(4):377-81.
- Chakko S, Mayor M, Allison MD, Kessler KM, Materson BJ, Myerburg RJ. Abnormal left ventricular diastolic filling in eccentric left ventricular hypertrophy of obesity. Am J Cardiol. 1991 Jul 1;68(1):95-8.
- 34. Lewis RP, Rittogers SE, Froester WF, Boudoulas H. A critical review of the systolic time intervals. Circulation. 1977 Aug;56(2):146-58.
- Braunwald E. Assessment of cardiac function. In: Braunwald E. ed. Heart disease. A Textbook of Cardiovascular Medicine. 5th ed. Philadelphia: WB Saunders Company;1992:635.
- Wong CY, O'Moore-Sullivan T, Leano R, Hukins C, Jenkins C, Marwick TH. Association of subclinical right ventricular dysfunction with obesity. J Am Coll Cardiol. 2006 Feb 7;47(3):611-6.

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