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Original Article :

Assessment of visceral and subcutaneous fat using computed tomography and correlating with lipid profiles and body mass index among asymptomatic individuals attending a tertiary care hospital

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Abstract

Backround: This study was conducted to quantify the visceral and subcutaneous fat using Computed Tomography(CT) at the umbilicus level and to correlate between visceral/subcutaneous fat distribution and plasma lipids levels among asymptomatic individuals.

Aims: Correlation of visceral & subcutaneous fat with lipid profile and Body Mass Index among asymptomatic individuals attending a tertiary health care facility.

Settings and Design: cross sectional study

Material and method: 200 asymptomatic individuals attending the Radiology OPD of Government Medical College & Hospital, Aurangabad were selected as study participants. Single section abdomen CT scan was performed in these individuals at the level of umbilicus using 128 slices MDCT ("SOAMTOM AS^{+}) to quantify visceral and sub cutaneous fat .The Data obtained were processed using syngo.via workstation and statistical analysis was done using SPSS software version 21.

Results: BMI and subcutaneous fat levels increased with age (p=0.028) and this pattern was found predominantly in females however increased visceral fat levels were observed in male participants which did not correlate with age (p=0.712). Participants who were generally obese and with increased levels of visceral/subcutaneous fat exhibited increased levels of total cholesterol and triglycerides on lipid profile examination. High density lipoproteins levels significantly reduced in obese and subjects with visceral fat (p=0.001) & (p=0.002) and were not significant among subcutaneous obese subjects(p=0.49) furthermore, levels of low-density lipoproteins significantly increased in visceral obese subjects (p=0.001), and were not significant among subcutaneous and general obese subjects (p =0.066) & (p=0.20) respectively.

Conclusions: Our study throws light on the fact that visceral obese subjects had an indirect risk of coronary artery disease than subcutaneous and general obese subjects and also proposes computed tomography (CT) as an eminent diagnostic tool for quantitative measurement of visceral fat.

Keywords: visceral fat, subcutaneous fat, Body Mass Index, Computed Tomography, coronary artery disease.

INTRODUCTION

Plethora of literature have highlighted the emergence of lifestyle-related diseases like obesity and cardiovascular diseases that is regarded as the 5th leading cause of mortality,globally.[1],[2] Especially, in developing countries like India, the incidence of obesity-related non-communicable diseases (OR-NCDs) including dyslipidaemia, coronary heart disease (CHD), type 2 diabetes mellitus (T2DM) and hypertension are frequently reported even at younger age group.[2] Previous studies have noted that the amount of visceral fat is specifically associated with derangements of lipid and glucose metabolism specifically among obese population without any correlation to their degree of obesity.[3] Therefore it is imperative to evaluate the relative distribution of fat between visceral and subcutaneous sites using non invasive and accurate diagnostic tools like computed tomography (CT).Fig:1(a&b) rather than measuring general obesity by using conventional anthropometric measures like body mass index(BMI) and waist circumference(WC) as these anthropometric parameters does not quantify subcutaneous fat (SF) and visceral fat (VF) separately. [4] [5] & [6]

MATERIAL & METHODS

Study design and Selection of Subjects:

A cross-sectional study was planned among 200 subjects aged between 20–60 years, who were referred to the Department of Radio-diagnosis, Government Medical College & Hospital, Aurangabad for diagnostic evaluation of various abdominal indications using computerized tomography between january 2018 to june 2019 were selected**.** During subjects recruitment, asymptomatic subjects with otherwise normal abdominal findings were included and patients with obvious abdominal pathology,surgically treated scars ,prior history of any abdominal intervention and on anti hyperlipidemic drugs were excluded from the study. Moreover, terminally ill patients, pregnant females and highly irritable patients were excluded.

Anthropometric measurements

Each subject's body weight and height were measured from which BMI was calculated using the formula of weight (in kg) divided by the height in meter square (m^2).

Biochemical measurements

Lipid profile - Venous blood samples of all the study participants were collected after overnight fasting and analysis of plasma levels of Triglycerides(TGs) and total cholesterol(TC) were measured using enzymatic methods. High-density lipoprotein (HDL) and low-density lipoprotein (LDL) levels were measured using direct methods and Friedewald formula respectively.

Equipment and analysis Procedure

Estimation of abdominal adipose tissue cross-sectional areas were done by single-slice CT scan on **"SOAMTOM AS$^+$ 128 slices.** Single slice 5 mm thickness scan was performed at the umbilical level (between L4 and L5 vertebrae) using an abdominal scout radiograph to standardize the position of the scan to the nearest millimetre. Scan parameters were: 120kV, 250 mA, slice thickness 5mm, the field of view :500mm, window width: 500, window centre: 40. The umbilical region was selected due to ease of localization and this anatomical level has the maximum ratio of fat to the total tissue area which represents total fat content throughout the abdomen.[7] & [8] Axial section image was selected in the workstation (syngo.via) and with the use of inbuilt analysis software the segmentation of subcutaneous and visceral compartments were performed. Then each compartment comprising of adipose tissue area was calculated with selected attenuation range between –200 to -40 Hounsfield units.

For defining visceral and subcutaneous obesity , the cut off values for Indian population were considered as prescribed by Anoop Misra et al[9] which is >135 cm^2 and >110 cm^2 for males and > 75 cm^2 and >134 cm^2 for females respectively.

RESULTS

The present study included 200 asymptomatic subjects including 112 males and 88 females in the age group of 20 to 60 years and mean age of 43.9 ± 15.2 years(Table-1). General obesity based on BMI was significantly higher in females 48/79(61%) than males 31/79(39%). Among obese females, 22/31(70%) of them were in the post-menopausal age group (51- 60 yrs). Similarly, subcutaneous fat was also higher in females 38/62(61%) than males 24/62(39%), especially in the post-menopausal age group (51- 60 yrs). Both BMI and subcutaneous fat correlated significantly with age(*p*=0.028) & (*p*=0.033) and sex(*p*=0.001)& (*p*=0.001). Visceral fat was high among males 41/75(54%) and was more common in the age group between 41- 50 years than in females 34/75(46%). Presence of visceral fat was also high among post-menopausal age group 23/34(69%) however presence of visceral fat correlated only with sex (*p* =0.001), and not with age (*p* =0.712). (Table-2)

Table -1 Anthropometric, lipid Profiles and Abdominal fat distribution by CT (males versus females)

Variables	Mean (SD)		
	Male(n=95)	Female(n-105)	P values
Age	42.2 ± 9.1	45.5 ± 9.3	0.64
BMI	25.5 ± 3.2	26.3 ± 4.1	< 0.022
Visceral Fat	282 ± 78.3	250 ± .91.6	< 0.001
Subcutaneous Fat	248 ± 90.2	288 ± 122.9	< 0.001
Total Cholesterol	152 ± 54.8	155 ± 61.2	< 0.031
Triglycerides	168 ± 41.6	172 ± 57.5	< 0.001
HDL	41 ± 5.4.	48 ± 6.3	< 0.002
LDL	137 ± 39.0	126 ± 33.3.	0.20

Table:2 Correlation of visceral fat, subcutaneous fat, BMI with clinical & biochemical parameters

	Visceral Fat	Subcutaneous Fat	BMI
Age	0.72	0.028	0.033
Sex	0.001	0.001	0.001
Menstrual status	0.41	0.036	0.001
BMI	0.033	0.001	_
Total Cholesterol	0.001	0.024	0.001
Triglycerides	0.041	0.002	0.049
HDL	0.001	0.49	0.002
LDL	0.001	0.66	0.20

	BMI		Total Number (n-200)
	Normal	Abnormal	Total
Normal(SF+ VF)	92	11	103
Abnormal(SF + VF)	9	31	40
Only Subcutaneous Obesity	3	19	22
Only Visceral obesity	17	18	35
	121	79	= 200

Table 3- Correlation between adipose tissue distribution and BMI

Visceral fat, subcutaneous fat and BMI all showed a significant positive correlation with total cholesterol (TC) (p =0.001), (p=0.024) & (p =0.001) and triglyceride(TG) levels (p =0.041) (p =0.002) & (p =0.049). Visceral fat and BMI showed a significant negative correlation with HDL levels (p =0.001)& (p =0.002), but subcutaneous fat did not show any significant correlation with HDL(p =0.49). Visceral fat showed a significant positive correlation with LDL levels (p=0.001) however, subcutaneous fat and BMI did not show significant correlation with LDL levels respectively(p =0.066) & (p =0.20). (Table-2)

DISCUSSION

Computed tomography (CT) is a perfect diagnostic choice for quantitative measurement of visceral fat due to its value being reliable, reproducible and easily accessible.In the current study single section technique was followed as area-based measurements of visceral fat at the level of umbilicus were relevant rather than volumetric measurements of visceral fat from the entire abdomen (diaphragm to pelvis).The justifications of the techniques employed were in concordance with studies done by P Maurovich-Horvat[7], T Irlbeck[10] and Masato Mizui[1] who observed that there were no significant differences between the two methods, yet the radiation exposure to subjects significantly decreased from 2.7 mSv (volumetric method) to approximately 0.5 mSv (area-based single-slice technique) which is less than annual general population radiation exposure limits(1mSv).[1], [6], [7], [10], [11] & [12] Magnetic resonance imaging(MRI) is another cross-sectional diagnostic tool used for VF measurements. Although the modality does not use ionizing radiation, its long acquisition time, inaccessibility and cost were the disadvantages. And also it is difficult to derive a direct relationship between tissue property and pixel value using this modality. Considering all these facts mentioned above,the CT scan was preferred.[5] &[7].

Visceral obesity was more common in males, and subcutaneous & general obesity were mostly found in females, especially in the postmenopausal age groups (50-60yrs), which is in concordance to studies conducted by Steven R. Smith et al [13], Anne E Sumner et al[14] and Hideki Asakawa et al. [15] This post-menopausal prevalence of obesity was likely due to loss of protective role of oestrogen and increased amount of lipoprotein lipase levels & its activity in the gluteal and femoral subcutaneous regions.[16]

On lipid profile correlation, deranged total cholesterol, TGs, HDL, LDL levels were more common in subjects with abnormal abdominal fat content (VF & SF) than normal abdominal fat content (VF & SF). The positive correlation of total cholesterol & triglyceride levels with visceral & subcutaneous fat along with BMI were similar to the study conducted by Neha Jain[17]. Low level of HDL were found in both visceral and general obesity subjects, however the visceral obesity subjects had 2.5 times less HDL level when compared to general obesity subjects.These results were congruent to the study conducted by Jean-Pierre Despres.[18] Subcutaneous obesity subjects did not show any variations in HDL levels(Table-2), which was similar to the study conducted by Hideki Asakawa.[15]

Precisely increased LDL levels were found among visceral obesity subjects and were not associated with subcutaneous & general obesity subjects (p value=0.061) & (*p* value=0.121) (Table-2), which was similar to studies conducted by Shahram Mazaheri[19], Yuqi Luo et al[20], Simone Lemieux[21] and Jean-Pierre Despre´s.[22]

It is well established that both HDL and LDL are proatherogenic lipoproteins as decreased plasma level of HDL-C leads to impaired clearance of excess fat from the bloodstream and increased LDL- C levels, accelerates the development of atherosclerosis and plaque formation in coronary vessels.

There is a type of obesity which is prevalent in India called "thin fat obesity" which is excessive accumulation of fat in relation to the individual's BMI. This pattern seems different and is rarely seen in other countries. Due to these reasons, the standard global cut off for BMI by WHO is reduced for the Indian population from 25 to 23 for overweight category and from 30 to 25 for obese category. There is a surge in these type of cases in the last two decades owing to sedentary lifestyles including lack of physical activity, excessive intake of high fat and high carbohydrate food products.[2]& [23]

We report 17/ 79(21%) subjects with high visceral fat with normal BMI & subcutaneous fat levels. These subjects are called as Metabolic obese with normal weight (MONW) or simply called as thin fat obese.[24]& [25]
Fig:2 (a&b). Out of 15/17 (87%) of these MONW subjects had deranged lipid profile levels particularly,proatherogenic lipoproteins (HDL &LDL) (Table-3).

Likewise, 22/62 (35%) of the study subjects had high subcutaneous fat and high BMI with normal visceral fat levels which were more distributed among postmenopausal females which amounted to 17 (77%) cases. **Fig:3(a&b)**. Among the participants falling under this category,16/22 (72%) had normal lipid profile and the remaining 6/22(27%) had deranged lipid profile(Table-3). Derangement was evident only with TG levels,however proatherogenic lipoproteins (HDL & LDL) levels remained normal which explains the direct role of visceral fat in producing derangement of lipid levels especially proatherogenic lipoproteins.

In our study, significant rise in levels of proatherogenic lipoproteins were observed among subjects who had viscerally obesity. Similar pattern was reported by Delma J. Nieves.[26].

It is thus concluded from this study results that visceral obese subjects were indirectly at risk of developing coronary artery disease when compared with individuals who had subcutaneous obesity & general obesity.

Further research can throw light on the role of visceral obesity as a prominent risk factor in development of myocardial infarction / CAD in people who present with metabolic syndrome and other comorbidities.

CONCLUSIONS

It was noted that every study participant with increased visceral fat exhibited abnormal proatherogenic lipid profile, irrespective of body mass index and subcutaneous fat status. This elucidates that visceral obesity was an indirect risk factor for developing coronary artery disease. Individuals with subcutaneous obesity and normal visceral fat showed normal lipid levels and presented low risk for coronary artery disease.Computerized tomography remains an indispensable diagnostic tool for assessing visceral fat which is an indirect indicator of coronary artery disease. By using single section examination, the risk of radiation(0.5mSv) is very minimal than annual general population exposure limits(1mSv).

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