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Original Research Article

Visceral obesity assessment in type 2 diabetes mellitus using a body shape index may be better as compared to body mass index

Suhas Maddodi*, S. K. Gautam

Department of Medicine, KPS Institute of Medicine, GSVM Medical College, Kanpur, Uttar Pradesh, India

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***Correspondence:**
Dr. Suhas Maddodi,
E-mail: Suhasmaddodi6@gmail.com

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ABSTRACT

Background: Body mass index (BMI) is being widely used to assess obesity and associated cardiovascular risk but found to be deficient of assessing visceral obesity for which ABSI was developed. Aim and objectives were to determine a body shape index (ABSI) as a better marker than BMI in assessing visceral obesity in type 2 diabetes mellitus (T2DM) patients.
Methods: The present cross-sectional study consisted total 150 patients over 40 year age, both male (90) and menopaused female (60). USG was used to measure the visceral obesity.
Results: The area under the ROC curve (AUROC) for BMI (kg/m²) predicting V/S fat ratio: >2.5 vs V/S fat ratio: <2.5 was 0.593 (95% CI: 0.5-0.685), thus demonstrating poor diagnostic performance compared to ABSI which was 0.815 (95% CI: 0.748-0.882), thus demonstrating good diagnostic performance.
Conclusions: ABSI was better in assessing visceral obesity compared to BMI so can be used along with other markers in assessing cardiovascular risk.

Keywords: Type 2 diabetes mellitus, Obesity, ABSI, BMI, Waist circumference, ABSI z score

INTRODUCTION

Diabetes is a group of metabolic disease characterised by chronic hyper glycemia and the prevalence of diabetes mellitus is increasing considerably in India. Uncontrolled T2DM can lead to cardiovascular disease, diabetic retinopathy, diabetic neuropathy, and diabetic nephropathy (WHO).

Etiological classification of diabetes: Type 1 diabetes (insulin deficiency), T2DM (insulin resistance), gestational diabetes mellitus (GDM) and specific type of diabetes (genetic defect in beta cell development, diseases of exocrine pancreas, endocrinopathies, drug induced, infections).

Overweight and obesity are the fifth leading cause of global death and are the prevalence is increasing day by day in India because of sedentary life style. It contributes to premature death.[1] Visceral obesity is associated more with cardiovascular risk than the gluteo-femoral adiposity.[2] So, visceral obesity is the deciding factor in cardiovascular risk of obese and diabetes patients.[3-6]

BMI and waist circumference (WC) are used to obesity and to assess cardiovascular risk but BMI has been found to be less effective in detecting visceral obesity and cardiovascular risk associated in previous studies. BMI cannot discriminate between muscle and fat, or identify fat location.

So Krakauer et al developed ABSI, which is based on waist circumference, BMI, and height in north American population. According to the authors, a high ABSI relates to a greater fraction of abdominal adipose tissue and appears to be a significant risk factor for premature death.[7]

$$\text{ABSI}=WC/BMI^{2/3}\ Height^{1/2}$$

ABSI can assess visceral obesity and cardiovascular risk associated so it can be incorporated into clinical guidelines in place of WC and together with BMI.

There is, however, limited research on the association of ABSI with established cardio-metabolic disease (CMD) risk factors. Very few studies have evaluated the joint contribution of BMI and ABSI to CMD risk factors. Very few studies have been done on ABSI in India.

METHOD

It's a cross sectional study conducted in KPS Institute of Medicine, GSVM Medical College Kanpur, India during December 2019 to October 2021 on 150 type 2 diabetes patients. The study was approved by ethical committee of GSVM Medical College Kanpur, India.

Inclusion criteria

Patients with age >40 years both male and female (post-menopausal age group) and T2DM were included in the study.

Exclusion criteria

Patients with the type 1 DM, pregnant female, history of smoking, alcohol and other drug abuse, patients taking steroids, immunosuppressive and anti-retroviral agents, familial dyslipidemia, diagnosed with intra-abdominal tumours, patients with chronic liver disease and kidney disease, hypothyroidism, Cushing syndrome, hypoproteinemia and congestive heart failure were excluded from the study.

Anthropometric and clinical assessment

After taking written and informed consent 150 type 2 diabetes patients, they are subjected to extensive history taking, anthropometric measurements (Weight, height and BMI), blood investigations (CBC, LFT, KFTS. electrolytes, HbA1C, HDL, LDL, triglycerides, thyroid profile) and USG abdomen to assess fat thickness

Table 1: BMI classification for Asian population.

BMI	Nutritional status
Below 18.5	Underweight
18.5-22.9	Normal weight
23.0-24.9	Pre-obesity (overweight)
25.0-29.9	Obesity class I
>30.0	Obesity class II

The WC was measured at the midpoint between the last rib and the top of the iliac crest with stretch-resistant tape. The BMI status (normal, overweight, and obese) of the participants were assigned based on WHO BMI cut off points for Asian population.

ABSI (m 11/6, kg 2/3) and its standard deviation score (SDS) were calculated using the following formula:

$$WC/BMI^{2/3}\ Height^{1/2}$$

WC in meter, height in meters

The ABSI is classified into risk classes by means of the ABSI-z value (z value) derived from the ABSI. The calculation is made according to the following formula:

$$\text{ABSI-Z}=SI - ABSI\ mean\ (sex, age)/ ABSI\ std\ (age, sex)$$

With the indices mean: average and std: standard deviation

Table 2: ABSI-Z risk groups.

ABSI-z value	Risk
Less than -0.868	Very low
Between -0.868 and -0.272	Low
Between -0.272 and +0.229	Average
Between +0.229 and +0.798	High
Greater than +0.798	Very high

Ultrasound abdomen for assessing visceral fat

Subcutaneous fat thickness and visceral fat thickness are measured by using a high-resolution ultrasound instrument Samsung RS 80 with multi frequency convex (3.5-5.0 MHz) and linear (7.5-10.0 MHz) transducers and the ratio is calculated (visceral fat / subcutaneous fat). The thickness of subcutaneous fat will be measured with a linear transducer at a frequency of 10.0 MHz. Patients are assessed in dorsal decubitus after 12 hr fasting. The transducer was positioned transversely at 1.0 cm above the umbilicus on the xiphoid-pubic line. The anatomical limits for the measurement of subcutaneous fat will be the skin and the external (superficial) fascia of the rectus abdominis muscle, and the thickness will be quantified in centimeters. The thickness of visceral fat will be measured with a convex transducer at a frequency of 4.0 MHz in the same way as subcutaneous fat measurement. The anatomical limits for the measurement of the visceral fat will be the internal (deep) fascia of the rectus abdominis muscle and the anterior wall of the aorta, during expiration, and the thickness will be quantified in centimeters.

Intra-examination variation coefficient was 1.2%. There is no cut off points to define visceral obesity based on ultra-sonograph in any literature. So, a ultra-sonograph determined visceral-to-subcutaneous fat ratio of 2.50 was established as a cut off value to define patients with abdominal visceral obesity (equivalent to visceral-fat area of >130 cm^2 by CT scan) as per study conducted by Ribeiro-Filho et al.[8]

CT or MRI is an optimal technique for the accurate assessment of intra-abdominal fat. However, they are

difficult to obtain in all patients considering the issues of availability, radiation exposure, and/or cost.

Statistical analysis

Statistical analysis will be done using statistical package for social survey (SPSS). The data obtained would be analyzed using Student's t test, Fisher exact test, chi squared test, non-parametric test (Wilcoxon Mann Whitney U test) and level of significance will be set at $p<0.05$.

RESULTS

The variable subcutaneous fat thickness (cm) was not normally distributed (Shapiro-Wilk test: $p\leq0.001$).

Table 3: Distribution of the participants in terms of subcutaneous fat thickness (cm), (n=150).

Subcutaneous fat thickness (cm)	
Mean (SD)	1.77 (0.52)
Median (IQR)	1.75 (1.4-2)
Range	1-3.2

Table 4: Distribution of the participants in terms of visceral fat thickness (cm), (n=150).

Visceral fat thickness (cm)	
Mean (SD)	5.36 (1.84)
Median (IQR)	5.25 (4-6.5)
Range	2.1-10

The variable visceral fat thickness (cm) was not normally distributed (Shapiro-Wilk Test: p=0.006).

Table 5: Distribution of the participants in terms of V/S fat ratio, (n=150).

V/S fat ratio	Frequency	Percent (%)	95% CI (%)
<2.5	51	34	26.6-42.2
>2.5	99	66	57.8-73.4

The 34% of the participants had V/S fat ratio:<2.5. 66.0% of the participants had V/S fat ratio: >2.5.

The mean (SD) of age (years) in the V/S fat ratio: <2.5 group was 54.69 (10.09) and >2.5 group was 57.06 (10.17). There was no significant difference between the groups in terms of age (years) (W=2203.500, p=0.203).

The mean (SD) of BMI (kg/m²) in the V/S fat ratio: <2.5 group was 24.62 (3.21) and >2.5 group was 25.92 (4.05). There was significant difference between the groups in terms of BMI (kg/m²) (W=2056.000, p=0.042). With the median BMI being highest in the V/S fat ratio: >2.5 group.

The 64.9% of the participants in the group [BMI: 18.5-22.9 Kg/m^2] had [V/S fat ratio: >2.5]. The 56.2% of the participants in the group [BMI: 23.0-24.9 kg/m^2] had [V/S fat ratio: >2.5]. 67.8% of the participants in the group [BMI: 25.0-29.9 kg/m^2] had [V/S fat ratio: >2.5]. The 72.2% of the participants in the group [BMI: 30.0-34.9 kg/m^2] had [V/S fat ratio: >2.5]. 100% of the participants in the group [BMI: 35.0-39.9 kg/m^2] had [V/S fat ratio: >2.5].

Table 6: Association between V/S fat ratio and parameters.

Parameters	V/S fat ratio		P value
	<2.5, (n=51)	**>2.5, (n=99)**	
Age (years)	54.69± 10.09	57.06± 10.17	0.203[1]
Gender			
Male	30 (58.8%)	60 (60.6%)	0.833[2]
Female	21 (41.2%)	39 (39.4%)	
Duration of diabetes (years)* **	7.06± 4.64	9.62± 5.10	0.001[1]
BMI (kg/m²)	24.6±3.21	25.92±4.05	0.042[1]
ABSI* **	0.08± 0.00	0.09± 0.00	<0.001[1]
ABSI Z-score* **	0.16± 0.41	1.15± 1.02	<0.001[1]
ABSI Z risk group* **			
Very low	0 (0.0%)	0 (0.0%)	<0.001[2]
Low	9 (17.6%)	1 (1.0%)	
Average	21 (41.2%)	8 (8.1%)	
High	18 (35.3%)	40 (40.4%)	
Very high	3 (5.9%)	50 (50.5%)	
HbA1c (%)* **	7.83± 1.61	9.63± 2.75	<0.001[1]

***Significant at p<0.05, 1: Wilcoxon-Mann-Whitney U test, 2: Chi-squared test.

The mean (SD) of ABSI in the V/S fat ratio: <2.5 group was 0.08 (0.00) and >2.5 group was 0.09 (0.00). There was a significant difference between the 2 groups in terms of ABSI (W=934.500, $p\leq0.001$), with the median ABSI being highest in the V/S fat ratio: >2.5 group.

There was a significant difference between the 2 groups in terms of ABSI Z-score (W=702.000, $p\leq0.001$), with the median ABSI Z-Score being highest in the V/S fat ratio: >2.5 group. The mean (SD) of ABSI Z-score in the V/S fat ratio: <2.5 group was 0.16 (0.41). The mean (SD) of ABSI Z-score in the V/S fat ratio: >2.5 group was 1.15 (1.02).

There was a significant difference between the various groups in terms of distribution of ABSI Z risk group ($\chi2=52.241$, $p\leq0.001$).

The 1% of the participants in the group [V/S fat ratio: >2.5] had [ABSI Z risk group: low]. The 8.1% of the participants in the group [V/S fat ratio: >2.5] had [ABSI Z risk group:

average]. 40.4% of the participants in the group [V/S fat ratio: >2.5] had [ABSI Z risk group: high]. 50.5% of the participants in the group [V/S fat ratio: >2.5] had [ABSI Z risk group: very high].

Table 7: Comparison of the diagnostic performance of various predictors in predicting V/S fat ratio: >2.5 vs V/S fat ratio: <2.5.

Predictors	AUROC	95% CI	P	Sn (%)	Sp (%)	PPV (%)	NPV (%)	DA (%)
BMI (kg/m²)	0.593	0.5-0.685	0.042	43	78	80	42	55
W/H ratio	0.758	0.673-0.843	<0.001	77	67	82	60	73
ABSI	0.815	0.748-0.882	<0.001	74	76	86	60	75
ABSI Z-score	0.861	0.802-0.92	<0.001	78	82	90	66	79

AUROC: Area under ROC curve; CI: Confidence interval; P: P value; Sn: Sensitivity; Sp: Specificity; PPV: Positive predictive value; NPV: Negative predictive value; DA: Diagnostic Accuracy.

The area under the ROC curve (AUROC) for BMI (kg/m²) predicting V/S fat ratio: >2.5 vs V/S fat ratio: <2.5 was 0.593 (95% CI: 0.5-0.685), thus demonstrating poor diagnostic performance. It was statistically significant (p=0.042). At a cut off of BMI (kg/m²) ≥27, it predicts V/S fat ratio: >2.5 with a sensitivity of 43%, and a specificity of 78%.

The area under the ROC curve (AUROC) for ABSI predicting V/S fat ratio: >2.5 vs V/S fat ratio: <2.5 was 0.815 (95% CI: 0.748-0.882), thus demonstrating good diagnostic performance. It was statistically significant (p≤0.001). At a cut off of ABSI ≥0.085, it predicts V/S fat ratio: >2.5 with a sensitivity of 74%, and a specificity of 76%.

The area under the ROC curve (AUROC) for ABSI Z score predicting V/S fat ratio: >2.5 vs V/S fat ratio: <2.5 was 0.861 (95% CI: 0.802-0.92), thus demonstrating good diagnostic performance. It was statistically significant (p≤0.001). At a cut off of ABSI Z-score ≥0.565, it predicts V/S fat ratio: >2.5 with a sensitivity of 78%, and a specificity of 82%.

DISCUSSION

V/F ratio

The 99 patients among 150 had V/S ratio >2.5.

The 60.6% of patients with V/S ratio >2.5 were male and 39.4% were females. There was no significant difference between the various groups in terms of distribution of gender ($\chi 2$=0.045, p=0.833).

The mean (SD) of BMI (kg/m²) was higher in the V/S fat ratio: <2.5 group {24.62 (3.21)} than in the V/S fat ratio: >2.5 group {25.92 (4.05)}.

The 64.9% of normal BMI, 56.2% of overweight, 67.8% of obesity 1, 82.2% of obesity 2, 100% of BMI >35 Kg/m² were having V/S ratio >2.5. There was significant difference between the groups in terms of BMI (kg/m²) (W=2056.000, p=0.042). with the median BMI being highest in the V/S fat ratio:>2.5 group.

The mean (SD) of ABSI was higher in the V/S fat ratio <2.5 group {0.08 (0.00)} than in the >2.5 group {0.09 (0.00)}. There was a significant difference between the 2 groups in terms of ABSI (W=934.500, p≤0.001), with the median ABSI being highest in the V/S fat ratio: >2.5 groups.

There was a significant difference between the 2 groups in terms of ABSI Z-score (W=702.000, p≤0.001), with the median ABSI Z-score being highest in the V/S fat ratio: >2.5 group. The mean (SD) of ABSI Z-score in the V/S fat ratio: <2.5 group was 0.16 (0.41) and >2.5 group was 1.15 (1.02).

The 1%, 8.1%, 40% and 50.5% of V/S ratio group were belong to ABSI low risk, average risk, high risk and very high-risk class respectively. There was a significant difference between the various groups in terms of distribution of ABSI Z risk group ($\chi 2$=52.241, p≤0.001).

Gažarová et al in his study found that visceral fat area 11.4% of participants were in the risk obese group and by ABSI mortality risk there were 22% of subjects with high risk (4.8% and 28.3% for men and women, respectively) and 19.1% with very high risk (11.1% and 22% for men and women, respectively). Our results were also similar to this.[9]

The area under the ROC curve (AUROC) for BMI (kg/m²) predicting V/S fat ratio: >2.5 vs V/S fat ratio: <2.5 was 0.593 (95% CI: 0.5-0.685), thus demonstrating poor diagnostic performance compared to ABSI which was 0.815 (95% CI: 0.748-0.882), thus demonstrating good diagnostic performance.

Gomez-Peralta et al in his study the AUROC of ABSI was 63.1% (95% CI 54.6-71.6%; p=0.003) and an ABSI value of 0.083 $m^{11/6}\ kg^{-2/3}$ was the optimal threshold in discriminating patients with sarcopenic obesity (sensitivity: 48%, specificity: 73%).[10] Compared to this study, in our study we found that sensitivity of ABSI is more (74%) in detecting visceral obesity.

Bertoli et al in his study found that the joint use of BMI and ABSI was also more strongly associated with VAT than BMI alone (BIC=22930 vs. 23479). We also found similar conclusion in our result.[11]

The V/F ratio is also significantly associated with HbA1c, medication statins, T/HDL ratio, ASCVD risk and complications like CAD, CVA, PAD.

Limitations

The only limitation in our study were sample size and we had used USG abdomen for assessing visceral obesity which is less sensitive compared to CT and MRI, but USG was cost effective and has no radiation exposure.

CONCLUSION

The 99 patients among 150 had increased visceral obesity (V/S ratio >2.5). Visceral obesity was found to be more in older age and male patients but it was not statistically significant. Visceral obesity was found to be more in obese group (BMI), high and very high-risk ABSI z score group. The area under the ROC curve (AUROC) for BMI (kg/m²) predicting V/S fat ratio was 0.593 (95% CI), thus demonstrating poor diagnostic performance. It was statistically significant (p=0.042) with a sensitivity of 43%, and a specificity of 78% (cut off of BMI≥27). The area under the ROC curve (AUROC) for ABSI predicting V/S fat ratio was 0.815 (95% CI), thus demonstrating good diagnostic performance with a sensitivity of 74%, and a specificity of 76% (cut off of ABSI≥0.085). It was statistically significant (p≤0.001). Thus, demonstrating ABSI can predict visceral fat better than BMI. Visceral obesity (V/S ratio) was significantly associated with duration of diabetes, HbA1c, T/HDL ratio, CAD, CVA, PAD, ASCVD risk. In our study we found that ABSI was more sensitive and specific than BMI in assessing visceral obesity which was similar to previous studies. We also found that cardiovascular risk also associated more with ABSI than BMI. ABSI and BMI are simple method for assessing cardiovascular risk and ABSI can be used along with other obesity markers to assess cardiovascular risks.

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