Visceral Fat is Better Related To Liver Function and Lipid Metabolism Than Body Mass Index and Waist Circumference: A Cross-Sectional Study

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Abstract

Objective: The role of visceral fat area (VFA) in the metabolism of lipid and liver function was not known. To compare and evaluate the correlation of VFA, waist circumference (WC) and Body mass index (BMI) measured by Bioelectrical impedance (BIA) in terms of lipid metabolism and liver function. Receiver operating characteristic curve (ROC curve), optimum cut-off points and odds ratio (OR) for liver function and lipid metabolism variables were recommended.

Methods: A cross-sectional study was conducted on the subjects with the diagnose of obesity, including normal, overweight and obesity groups Direct Segmental Multi-Frequency Biolectrical Impedance technology was used to analysze body composition and biochemical indicators were tested. Participants were divided into normal and unnormal groups by lipid and liver indicators, cut off value of VFA and related variables was calculated by ROC analysis and multiple logistic regression analysis were conducted.

Results: Ninety-five participants were enrolled in this study, fifty-seven (60%) were male, and the average age was thirty-four years old. Compared with normal group, high density lipoprotein (HDL) and low density lipoprotien (LDL) disorder groups have a higher VFA (normal HDL group 87.3cm^2< unnormal HDL group 115.8cm^2; normal LDL group 90.5cm^2< unnormal LDL group 109.0cm^2, p<0.05). VFA was higher in the lactate dehydrogenase (LDH) disorder group than in the normal, and the difference was significant (144.6cm^2>96.2cm^2, p=0.016). BMI, WC and VFA values was manifested positively correlated to glutamic oxaloacetic transaminase (AST) and alanine aminotransferase (ALT), respectively. Area under the curve (AUC) of VFA was over than 0.7 revealed great ability of related to lipid HDL metabolism (p=0.004). VFA (AUC= 0.701, 95% CI 0.577-0.826, p =0.004) provides a better diagnostic accuracy to distinguish between HDL disorder and normal groups. The optimal cut-off value for VFA was 80.2cm^2 with 81.3% sensitivity and 56.8% specificity. For LDH disorder, a cut-off value of VFA 125.3 cm^2 shows a sensitivity of 83.3% and specificity of 78.9% (AUC=0.792, 95% CI 0.595-0.989, p=0.019). The risk of lipid metabolism disorder and liver dysfunction were explored, and Multivariate analysis showed that VFA>80.2cm^2 (OR=2.81, p=0.034) was a significantly risk factor related to HDL disorder and VFA>125.3cm^2 (OR=18.75, P=0.01) was the risk factor for LDH disorder. While, WC and BMI wasn't in the regression equation.

Conclusion: VFA was more reliable and related to the lipid metabolism and liver function. VFA could be used as an independent indicator for the evaluation of the risk lipid metabolism disorder and liver dysfunction.

Introduction

Obesity is one of common public health burden globally. According to the World Health Organization data 2021, adults aged 18 years and over with 13% were obesity, and obesity has nearly tripled since 1975 worldwide[1]. The latest report on nutrition and chronic diseases shows that the incidence of overweight and obesity in Chinese adults is 34.3% and 16.4%, respectively. Obesity has become one of the most

prominent problems in China (2020). Chronic noncommunicable diseases were associated with obesity such as cardiovascular diseases, diabetes, metabolic syndrome and hypertension[2]. In oldest-old adults, visceral fat area was the best discriminator for obesity associated with mobility disability[3]. Bertin revealed that obesity and Crohn's disease share common features with the development of mesenteric fat that may be involved in gut inflammation[4]. Jung revealed that visceral fat mass measured using DXA is an indicator of diabetes or prediabetes[5]. Visceral abdominal and perivascular fat depots assessed as ultrasound indexes are associated with complications of hypertension[6].

The measurements of obesity were mostly conducted by body mass index (BMI). According to world health organization (WHO) criteria, BMI ≥ 30kg/m^2 or waist circumference (male ≥ 102cm, female ≥ 88cm) would be diagnosed obesity. In addition, the critical value of body fat content or other obesity indexes are also useful indicators for measuring obesity[7]. The measurements of fats were conducted by Skinfold thickness, magnetic resonance imaging (MRI), dual energy X-ray (DXA), computed tomography (CT) and bioelectrical impedance (BIA) commonly. Bioelectrical impedance technology as a non-invasive detection technology, which has been widely used in the diagnose of diseases, such as obesity, sarcopenia obesity, diabetes, cardiovascular disease risk prediction, nutritional risk of surgical patients and protein calorie malnutrition of renal dialysis patients[8, 9]. Based on the electrical conductivity of human tissue, the bioelectrical impedance of human body can be measured at different frequencies through weak current; the content of human body components can be obtained by further calculating the bioelectrical impedance mode and phase angle[10]. Research has been showed, percentage body fat classified more obesity than BMI and FMI from the 50–59 groups[11].

Prevent research has been revealed with the increasing of fat, the response of target tissue to insulin would be reduced and then insulin resistance appears, which in turn promotes the occurrence of metabolic syndrome and obesity[12, 13]. Bouchi's study revealed with the decrease of abdominal fat could improve hyperglycemia and chronic inflammation in type 2 diabetes (T2D)[14]. In Kim's study, high fat was significantly associated with the prevalence of metabolic syndrome (incidence rate ratios, IRR: 2.30)[15]. In Badawi's BMI and latent tuberculosis study, there was a particularly apparent in the increased levels of triglycerides, cholesterol, fasting glucose, and glycosylated hemoglobin (HbA1C) levels in the Latent Tuberculosis Infection (LTBI) group and overweight subgroups[16]. Marit et al found the visceral fat was better related to the glucose metabolism than BMI[17]. Previous study on the influence of visceral Obesity on vascular structure and function in obese subjects has been identified visceral fat deposit would be increased risk of atherosclerosis and liver disease[18]. In the study of association between visceral abdominal fat accumulation and severity of liver fibrosis, Soldevila et al found 65% and 54% of patients had AST and ALT concentrations above normal values and VFA was a credible variable for the prediction of cirrhosis[19]. Darvishi indicated raised AST level was the independent risk factors for the Vit-D insufficiency in beta-thalassemia patients[20]. One study illustrated that leptin enhances hypothalamic lactate dehydrogenase A (LDHA) dependent glucose sensing to lower glucose production in high-fat-fed rodents in vivo[21].

Studies have been revealed that BMI, WC and visceral fat (VF) were related to the glucose metabolism, lipid metabolism and liver function. While, the comparison of BMI, WC and VFA by BIA on the lipid metabolism and liver functions were not compared by previous study, and variables ROC curve and optimum cut-off points were not recommended. Our research was to compare and evaluate the correlation of VFA, WC and BMI measured by BIA to lipid metabolism and liver function. Besides, ROC curve, optimum cut-off points and OR value for liver function and lipid metabolism disorder variables were recommended.

Methods And Materials

A cross-sectional study was conducted on the patients with the diagnose of obesity. Data were collected between Jan 2019 and June 2020 in Laian People's Hospital, Anhui Province, China. This study was secondary research based on diagnose and management of obesity and data were recruited by regular physical examination. Criteria and categories for obesity were reference to the diagnosis criteria of World Health Organization (WHO). 95 participants were enrolled in this study, including normal, overweight and obesity subjects. Besides, all the participants were signed Informed consent.

Data collection

Direct Segmental Multi-Frequency Biolectrical Impedance technology was used to analysze body composition (InBody® model 770). All the recruited participants would be finished body composition analysis with four couple of electrode holders placed on the ankles and forefingers of the hands, and at least 8 hours or overnight fasting with light clothes on the body. Weight, VFA, WC, BMI were obtained by this instrument. Height was measured by height meter (InBody® model BSM 170), and BMI were calculated.

Biochemical data

Biochemical variables related to liver profile and lipid metabolism serum triglyceride (TG), total cholesterol (TC), HDL, LDL, total bilirubin (TB), AST, Glutamyltranspeptidase (GGT), ALT, LDH and alkaline phosphatase (ALP) were determined by Absorption spectrometry automatic biochemical analyzer (LX20; Beckman, Brea, CA,USA), and we conduct a further analyze based on these medical testing data(serum biomarkers must be tested during the process the diagnose of obesity and regular medical physical examination). Serum lipid metabolism disorder diagnosis: total cholesterol >200 mg/dL, HDL-cholesterol < 40 mg/dL in men and <50 mg/dL in women; LDL-cholesterol>100mg/dL; and serum triglycerides >150 mg/dL[22].

Statistical Analyses

Normal distribution data were presented as Mean±SD, and numeric variables were presented by median and interquartile distance. Student's t test or Fisher's exact test was used to analyze the difference between groups; univariable regression was used between body composition, biochemical variables with

BMI, WC and VFA. ROC and AUC, cut-off values were calculated. With the ROC optimum cut-off values, Chi square analysis was conducted, OR and 95% confidence interval (95% CI) ware calculated. p value < 0.05 was considered to be statistically significant.

Results

Ninety-five participants were enrolled in this study, fifty-seven (60%) were male, and the average age was thirty-four years old. Participants demographical and body composition parameters are shown in Table 1.

Table 1
Participants demographic characteristics

Variables	Mean ± SD/Median (percentage/IQR)
Body composition indicators	
Men	57(60%)
Age	34.3 ± 15.12
Height(cm)	168.1 ± 7.76
Weight(kg)	74.6 ± 17.29
Body mass index (kg/m2)	26.3 ± 5.13
Waist circumference (cm)	87.9 ± 14.64
Visceral fat area(cm2)	96.7 ± 48.98
Liver function indicators	
TB	12.4(8.9)
LDH	191.0(79.5)
ALT	24.0(30.0)
AST	23.5(17.3)
ALP	78.0(29.0)
GGT	25.0(34.0)
Lipid metabolism indicators	
TG	4.8 ± 1.23
TC	1.5(1.1)
HDL	1.3 ± 0.99
LDL	3.0 ± 0.91

The difference of obesity indicators BMI, WC and VFA were analyzed between lipid metabolism variables TG, TC, HDL and LDL normal and unnormal groups. According to medical diagnosis results of TG and TC, there is no significant difference in the comparison of BMI, WC and VFA between normal and unnormal groups. While in HDL and LDL normal groups, VFA were lower than unnormal groups and significant statistics were obtained ($P < 0.05$). HDL and LDL disorder group with a higher VFA, while there are no significant differences in BMI, WC between normal and unnormal groups for serum HDL and LDL levels. This may indicate VFA has a better predicational ability in the diagnosis of lipid metabolism than BMI and WC (Table 2).

Table 2
Comparison of obesity variables between lipid metabolism indicators

Variables	Normal	Unnormal	p value
TG			
BMI	27.2 ± 4.59	27.4 ± 4.80	0.872
WC	90.1 ± 14.54	90.2 ± 14.24	0.973
VFA	103.5 ± 53.59	102.5 ± 41.34	0.937
TC			
BMI	27.2 ± 4.34	26.7 ± 4.57	0.648
WC	88.8 ± 14.88	89.0 ± 12.78	0.953
VFA	103.6 ± 50.82	89.9 ± 39.51	0.212
HDL			
BMI	26.9 ± 4.92	28.0 ± 3.54	0.298
WC	87.6 ± 15.35	93.0 ± 11.17	0.104
VFA	87.3 ± 47.99*	115.8 ± 40.49*	0.010*
LDL			
BMI	26.5 ± 4.37	27.8 ± 4.32	0.223
WC	87.0 ± 14.15	91.8 ± 12.23	0.138
VFA	90.5 ± 50.05*	109.0 ± 40.34*	0.049*
Note: Mean ± SD.			
* Compared with lipid metabolism disorder group, $p < 0.05$ means statistical significance.			

The difference of BMI, WC and VFA were analyzed between liver function variables TB, AST, GGT, ALT, LDH and ALP comparison groups, respectively. According to biochemical testing results, VFA was higher in the LDH disorder group than in the normal, and the difference was significant($144.6cm^2 > 96.2cm^2$, $p = 0.016$). BMI, WC and VFA were manifested positively correlated to ALT and AST. (Table 3).

Table 3
Comparison of obesity variables between liver function indicators

Variables	Normal	Unnormal	p value
TB			
BMI	26.4 ± 5.23	25.6 ± 4.91	0.485
WC	88.6 ± 14.49	85.1 ± 15.35	0.329
VFA	100.6 ± 50.40	81.9 ± 41.93	0.118
LDH			
BMI	26.7 ± 4.94	25.5 ± 6.65	0.353
WC	89.2 ± 14.27	85.5 ± 17.17	0.361
VFA	96.2 ± 45.05*	144.6 ± 50.13*	0.016
ALT			
BMI	25.7 ± 4.27*	29.8 ± 6.08*	0.037
WC	85.6 ± 12.60*	98.5 ± 13.43*	0.006
VFA	88.4 ± 42.45*	38.8 ± 43.03*	0.003
AST			
BMI	26.7 ± 3.97*	32.1 ± 6.05*	0.003
WC	88.2 ± 13.04*	104.1 ± 13.70*	0.006
VFA	95.5 ± 43.67*	142.1 ± 53.75*	0.017
ALP			
BMI	26.3 ± 5.13	-	-
WC	87.9 ± 14.64	-	-
VFA	96.7 ± 48.98	-	-
GGT			
BMI	25.9 ± 5.01	27.5 ± 5.40	0.178
WC	86.4 ± 14.52	92.1 ± 14.46	0.100
VFA	94.5 ± 50.65	103.2 ± 44.03	0.456
Note: Mean ± SD.			
*Compared with liver dysfunction group, $p < 0.05$ means statistical significance.			

The variables BMI, WC and VFA ROC curve were drawn. AUC, the premium cutoff points, sensitivity, and specificity were calculated. VFA presented a distinguished difference in HDL and LDL disorder groups (Fig. 1). The AUC and premium cutoff points for VFA, BMI and WC were showed in Table 4. AUC of VFA was over than 0.7 revealed great ability of related to lipid HDL metabolism ($p = 0.004$). Based on the ROC cutoff points, chi-square test was conducted between HDL and LDL groups, OR (odds ratio) and 95% CI (95% confidence interval) were calculated. Figures 1 and 2 showed the ROC curves with the value of diagnostic accuracy of lipid metabolism and liver function in the identification of disorder. The curve reveals that VFA (AUC = 0.701, 95% CI 0.577–0.826, $p = 0.004$) provides a better diagnostic accuracy to distinguish between HDL disorder and normal groups. The optimal cut-off value for VFA was 80.2cm^2 with 81.3% sensitivity and 56.8% specificity. For LDH disorder, a cut-off value of VFA 125.3 cm^2 shows a sensitivity of 83.3% and specificity of 78.9% (AUC = 0.792, 95% CI 0.595–0.989, $p = 0.019$). In AST and ALT indicators groups, BMI, WC and VFA were also showed good prompting ability of disorder with significant values (Table 4).

Table 4
AUC of VFA, BMI, WC and premium cutoff points from indicator's ROC

Variables	Area	P value	95%CI	Sensitivity	Specificity
HDL					
BMI < 25.7kg/m^2	0.610	0.118	0.495–0.759	81.3	45.9
WC < 79.7cm	0.627	0.070	0.475–0.744	93.8	35.1
VFA < 80.2cm^2	0.701	0.004	0.577–0.826	81.3	56.8
LDL					
BMI < 25.7kg/m^2	0.602	0.135	0.471–0.732	72.7	46.3
WC < 80.3cm	0.593	0.171	0.464–0.723	84.8	34.1
VFA < 78.6cm^2	0.629	0.058	0.500-0.758	78.8	53.7
LDH					
BMI < 34.3kg/m^2	0.678	0.153	0.423–0.934	50.0	93.0
WC < 93.2cm	0.709	0.094	0.496–0.922	83.3	66.7
VFA < 125.3cm^2	0.792	0.019	0.595–0.989	83.3	78.9
AST					
BMI < 32.2kg/m^2	0.747	0.046	0.500-0.995	66.7	93.7
WC < 108.5cm	0.806	0.014	0.587-1.000	66.7	93.7
VFA < 121.3cm^2	0.745	0.049	0.521–0.968	66.7	78.1
ALT					
BMI < 26.5kg/m^2	0.782	0.001	0.665–0.899	85.7	63.2
WC < 95.3cm	0.806	0.000	0.671–0.941	78.6	80.7
VFA < 130.2cm^2	0.742	0.005	0.593–0.892	57.1	87.7

A multivariate analysis was performed to calculate the risk of lipid metabolism disorder and liver dysfunction using the obtained cut-off values (Table 4). The results showed that VFA > 80.2cm^2 (OR = 2.81, p = 0.034), VFA > 125.3cm^2 (OR = 18.75, P = 0.01) and WC > 95.3cm (OR = 6.55, p = 0.023) were significantly related to HDL disorder, LDH disorder and ALT disorder, respectively (Table 5).

Table 5
BMI, WC and VFA as variables to predict lipid metabolism disorder and liver disfunction logistic regression analysis

Category	B	P value	OR	95%CI
HDL disorder				
VFA < 80.2cm^2	1.03	0.034	2.81	1.08–7.30
LDH disorder				
VFA < 125.3cm^2	2.93	0.01	18.75	2.00-176.03
AST disorder				
BMI < 32.2kg/m^2	1.00	0.513	2.72	0.14–54.36
WC < 108.5cm	1.00	0.513	2.72	0.14–54.36
VFA < 121.3cm^2	0.10	0.890	1.11	0.26–4.71
ALT disorder				
BMI < 26.5kg/m^2	-1.21	0.195	0.30	0.05–1.86
WC < 95.3cm	1.88	0.023	6.55	1.29–33.25
VFA < 130.2cm^2	1.35	0.097	3.86	0.78–19.06

Discussion

In the present study, our results indicate VFA was better related to the lipid metabolism;especially serum HDL, LDL levels and liver function variables such as LDH, AST and ALT. In the diagnosis of obesity, the measurements of VFA as a simple, noninvasive and harmless method by BIA was credible. It reveals that VFA was strongly related to the HDL and LDL metabolism than BMI and WC, this may indicate VFA was an independent risk factor for lipid metabolism disorder in the diagnosis of obesity. HDL is a normal biomarker in the metabolism of serum lipid and related to cardiovascular diseases[23]. In the research of abdominal adipose tissue and serum HDL-cholesterol, Despres suggested body fat topography and serum HDL was positively associated[24]. Bora has been found people with central obesity had significantly greater odds of developing decreased serum HDL level[25], and similar results was showed in Canterin's study (Obese subjects have lower aerum HDL cholesterol level)[26]. Rodriguez et al conducted

one study on the association of hepcidin with triglyceride-rich lipoprotein dyslipoproteinemia, small dense LDL and insulin resistance in adolescents, and results showed major changes in adolescents with obesity[27]. All these studies suggested VFA was strongly related to lipid metabolism, especially with HDL and similar results were obtained in our study. More than previous studies, our research has been suggested the ROC curve and optimum cut-off point for VFA in the risk prompting of lipid metabolism disorder (80.2cm^2, OR = 2.81).

LDH represents a suitable criterion for the identification of type of energy production, and any changes in isoenzyme pattern probably indicate an alteration of the tissue metabolism[28]. LDH was present in adipose tissues of rat, and their distribution was significantly altered by metabolic stress[29]. For this study, compared with normal group, VFA was larger in LDH disorder group; the premium cut-off and sensitivity plus specificity was 125.3cm^2 and 162.2%, respectively. By multiple logistic regression analysis, VFA was an independent risk factor for LDH disorder (OR = 18.75). This may indicate that VFA deposit is the risk factor for LDH disorder and fatty liver. Besides LDH, there is a consensus that liver function enzymes, such as AST and ALT, are biomarkers that reflect liver function[30]. Serum AST and ALT concentrations increased with body weight gain, ALT < 2 times upper limits of normal had a negative predictive value of 95% for ruling out significant inflammatory activity among patients without liver fibrosis[31]. Metabolic disturbances as insulin resistance, dyslipidemia and hyperglycemia are closely related to elevated serum ALT level; a cut-off point of AST/ALT ratio < 1 has been defined for hepatic steatosis assessment in obese patients[32]. In Pirimoglu's study, a strong correlation between liver fat fraction values and AST and ALT levels in children who are overweight and obese were found[33]. In our study, the AST and ALT disorder groups showed a higher VFA and the premium cut-off points of VFA were 108.5cm^2 and 130.2cm^2, respectively.

Conclusion

VFA was more reliable and related to the lipid metabolism and liver function. VFA could be used as an independent indicator for the evaluation of the risk lipid metabolism disorder and liver dysfunction in the normal physical examination and obesity diagnosis.

Declarations

Ethical and Consent:

Ethical Review: Except outpatient necessary diagnosis testing, this study does not involve any additional human testing. Ethical approval was waived.

Informed Consent: Written informed consent was obtained from all study participants.

Consent for publication:

All presentations of case reports have consent for publication.

Availability of data and materials:

The datasets during and/or analysed during the current study available from the corresponding author on reasonable request.

Competing interest:

the authors declared that we do not have any commercial or associative interest that represents a conflict of interest in connection with the work submitted.

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Figures

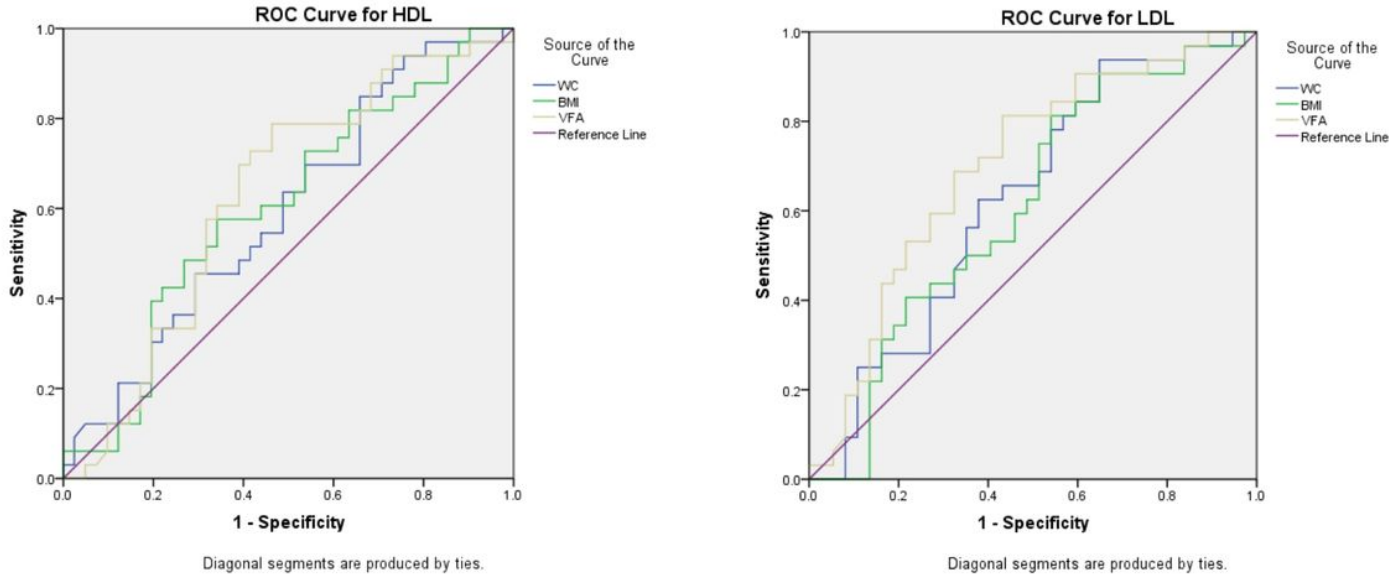

Figure 1

ROC curve of BMI, WC and VFA predicational ability for HDL and LDL indicators

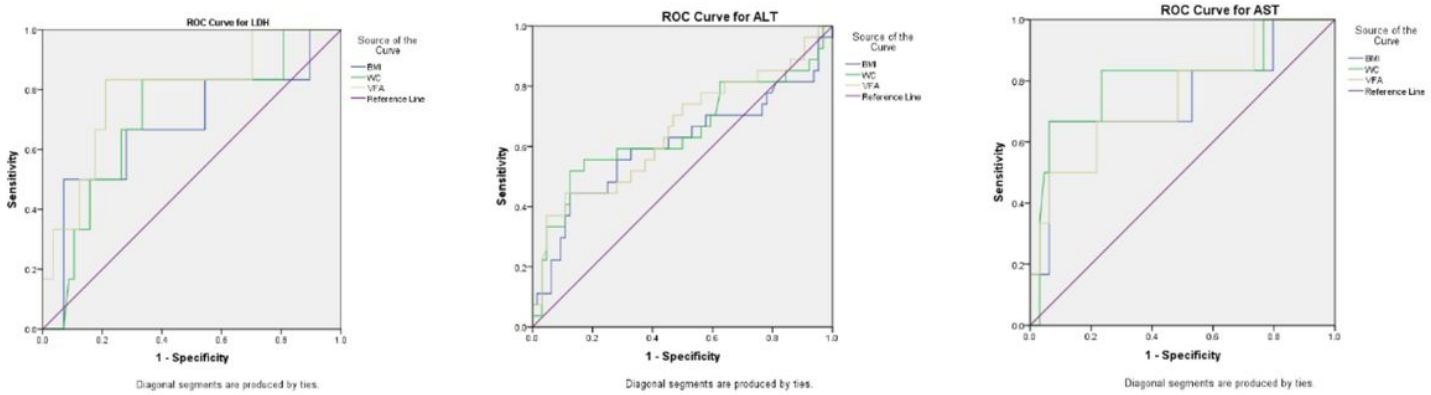

Figure 2

ROC curve of BMI, WC and VFA predicational ability for LDH, ALT and AST indicators