ORIGINAL RESEARCH PAPER

Radiology

MEASUREMENT OF SUBCUTANEOUS AND VISCERAL FAT BY ULTRASONOGRAPHY AND ITS CORRELATION WITH HEPATIC STEATOSIS IN BANGLADESHI POPULATION

KEY WORDS: Abdominal fat (subcutaneous & visceral), Steatosis, Ultrasonography.

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ABSTRACT

Objective: To find out the correlation between sonographic measurement of subcutaneous and visceral fat and grade of hepatic steatosis also evaluated by ultrasound.

Materials and Methods: In the period from June 2015 to July 2016,350 patients were evaluated. The subcutaneous and visceral fat thicknesses were measured with a curvilinear, 3-4 MHz transducer transversely placed 1 cm above the umbilicus. The distance between the internal aspect of the rectus abdominis muscle and the posterior aortic wall in the abdominal midline was considered for measurement of the visceral fat and distance between skin and anterior aspect of linea alba considered as subcutaneous fat. Increased liver echogenicity, blurring of vascular margins and increased acoustic attenuation were the parameters considered in the qualification of hepatic steatosis.

Result: Out of 350 patients, steatosis was found in 37% of study population. Significant statistical difference was observed in visceral fat between male & female with steatosis and without steatosis & also among age range.

Conclusion: USG can be used to measure the abdominal fat thickness routinely which correlates well with steatosis to differentiate normality from risk of steato hepatitis.

Introduction:

Obesity is a major public health problem and has increased among the population in developed and developing countries. It is a strong predictor of increased morbidity and mortality[1].Literature has consistently shown association of upper body obesity and chronic disease such as diabetes, hypertension, dyslipidemia, cardiovascular disease and metabolic alterations.[2,3]

Nonalcoholic fatty liver disease (NAFLD) covering a wide spectrum of liver lesions from benign steatosis to nonalcoholic steatohepatitis (NASH) with high risk for progression to cirrhosis and hepatocellular carcinoma. The reasons for differences in fat accumulation in the liver among persons who do not abuse alcohol is unknown .However ,adipose tissue releases adipokines , which may be an important factor that increases liver fat content . Exposure of the liver to free fatty acids due to dietary intake or release of free fatty acids from adipose tissue may be another important factor [4,5].Abdominal adipose tissue includes a subcutaneous fat depot ,and an intra-abdominal fat depot, which can be divided into intraperitoneal and retroperitoneal depots . The intraperitoneal fat depot (visceral fat) can be divided into mesenteric and omental depots [6].Subcutaneous fat differs from visceral fat in that venous drainage from subcutaneous fat is directed into the systemic circulation, whereas venous drainage from visceral fat is directed into the portal vein. The metabolic products thus reach the liver directly and exercise a first pass effect on liver metabolism. Visceral fat releases free fatty acids and adipokines and thereby exposes the liver to fat accumulation [7,8]. NAFLD can be diagnosed by imaging studies such as ultrasonography(USG),computed tomography (CT) and magnetic resonance imaging(MRI).Steatosis can be quantified by US as mild (grade 1), moderate (grade 2) and severe (grade 3), and such quantification is fairly correlated with CT,MRI and histopathological analysis.[9,10]According to some authors, US may present 89% sensitivity and 93% specificity in the identification of steatosis. On the other hand, other authors report sensitivity up to 94% and specificity up to 100%.[13]The classification of fatty liver by Saadeh et al.[10]

Grade 1(mild): diffuse increase in liver echogenicity, with normal visualization of intrahepatic vessels and of the diaphragm.

Grade 2(moderate): blurred visualization of intrahepatic vessels and of the diaphragm.

Grade 3(severe): intrahepatic vessels, diaphragm and the posterior region of the liver cannot be visualized.

USG is a relevant noninvasive tool for evaluating NAFLD and intend to demonstrate that the normal or grade I liver echogenicity rules out NAFLD and removes the necessity of liver biopsy. CT is considered as gold standard for evaluating intra-abdominal fat but actually it is highly expensive, lacks practicality, time consuming and exposes the patient to ionizing radiation. Criteria for evaluating visceral fat by MRI were also developed, but this method is subjected to artifacts and also its variation coefficient is also higher. Anthropometric measurements are most frequently utilized in the evaluation of body fat, but this method is incapable of differentiating visceral from subcutaneous fat. In contrast to the disadvantages of CT,MRI and anthropometric measurements, US has shown to be simple, low cost method without radiation risk, easily available and already proved reproducibility and reliability in the quantification of visceral fat.

Material and methods:

This cross sectional study was carried out in 350 patients attended the Radiology and Imaging department of BIRDEM for ultrasound of whole abdomen from June 2015 to July 2016.Chronic diseases such as alcoholism, cirrhosis, lymphoma ,renal failure ,history of bariatric surgery and endocrinopathies (Cushing syndrome ,hypothyroidism) were excluded from the study. All the patients were evaluated by experienced radiologist of the department. The scans were performed with a Hitachi Aloka F-37 machine with a curvilinear 3-4 MHz transducer, the utilization of a linear transducer for measuring subcutaneous fat was not considered necessary. The differences between measurements with curvilinear and linear transducers were non-significant, so the technique proposed by Radominski et al [14] was utilized. Measurements of subcutaneous and visceral fat thickness were performed with the patient in dorsal decubitus positioned, and the curvilinear 3-4MHz transducer placed cross-sectionally on the midline,1 cm above the umbilicus during the expiratory phase without pressure on the abdomen not to distort the measurement. Subcutaneous fat thickness correspond to the distance in centimeters between the skin and the anterior surface of linea alba. Visceral fat thickness correspond to the distance in centimeters between the posterior surface of linea alba and the plane of posterior aortic wall. Generally there is accumulation of extra peritoneal fat on the midline appear as a hypo echoic ellipsoid image included in visceral fat thickness. The aorta is located at left to midline, identifying this image, a horizontal line is drawn, passing through its posterior wall up to midline and distance from linea alba with this line is the visceral fat thickness.

Results:

In the present study, 350 patients in the age range between 15-90 years were evaluated. Out of that,230 were female(65.7%) and 120 were male(34.3%).About 62.8% were steatosis free & 37.2% presented with steatosis. Among 37.2%,23.4% presented with grade-I steatosis (57 were female & 25 were male),9.4% had grade-II steatosis (15 were female & 18 were male) and 4.3% had grade-III steatosis (8 were female & 7 were male). Comparison between male & female with steatosis & without steatosis showing that there was no significant statistical difference in case of subcutaneous fat but significant statistical difference presented in visceral fat in both groups.

Distribution according to age range of subcutaneous and visceral fat among steatosis free women showing up to 29years (48), 1.6±2.0cm & 3.6±2.3cm ,up to 59years(87) were 1.9±2.3cm & 4.9±2.0cm and >60years were 2.2±1.4 cm & 5.0±2.8 cm respectively. No statistical significant difference was seen among age range of subcutaneous fat (p=0.38) but statistical significant difference was present among age range of visceral fat (p<0.05).

Among steatosis free men, subcutaneous and visceral fat were up to 29years,1.42±1.0cm & 4.7±1.9cm, up to 59 years 2.53±1.5 cm 5.9±2.4cm and >60 years 1.98±2.0 & 5.0±2.2 cm. So, statistical significant difference was present among age range of subcutaneous fat (p value <0.05) and no statistical significant difference among age range of visceral fat(p=0.115).Following table 1 & 2 showing the distribution of subcutaneous and visceral fat according to grade of steatosis among women and men.

Table 1: distribution of subcutaneous and visceral fat according grade of steatosis among women

Female Individual	Subcutaneous fat (cm)	Visceral fat (cm)
Grade I steatosis (57)	2.2±1.7	5.8±3.0
Grade II steatosis (15)	3.0±1.9	8.5±2.9
Grade III steatosis (8)	2.5±1.4	9.4±2.5
P*	0.12	0.00029

*Variance Analysis (ANOVA), *post-hoc comparison-Tukey's Test*

Comments:

a. No statistical significant group difference among different grade of steatosis in subcutaneous fat thickness.
b. statistical significant increase in visceral fat thickness with the increase in the grade of steatosis (p <.05)

Table 2: distribution of subcutaneous and visceral fat according grade of steatosis among men

Male Individual	Subcutaneous fat (cm)	Visceral fat (cm)
Grade I steatosis (25)	2.4±1.9	7.0±2.7
Grade II steatosis (18)	2.7±2.0	8.9±3.0
Grade III steatosis (7)	3±1.8	9.5±3.8
P*	0.725	0.0527

*Variance Analysis (ANOVA), post-hoc comparison-Tukey's Test

Comments:

a. Subcutaneous fat thickness among the grades of steatosis did not present any statistical significant difference.
b. A progressive & statistically significant increase in visceral fat thickness with the increase in steatosis.

So, among patients with steatosis, visceral fat thickness is significantly increase proportional to the grade of steatosis both in men and women. On the other hand, subcutaneous fat thickness did not present any relevant alteration among the different grade of steatosis.

Discussion:

Obesity is not a homogeneous condition and the regional distribution of adipose tissue is important to understanding the relation of obesity to disturbances in glucose and lipid metabolism. Many prospective studies shows relation of excess fat in upper part of the body(central or male type) with increased mortality & risk for disorders such as diabetes, hyperlipidaemia, hypertension, atherosclerosis of coronary,crerbral & peripheral vessels more often than lower body(gluteo-femoral or female type) fat distribution. There are many methods for estimating body fat such as-BMI, skin fold thickness, waist circumference, WHR (waist-hip ratio), USG, CT& MRI. Undoubtedly, BMI is the most common method for estimating body fat but increased BMI does not show which body compartment is inadequate and cannot differentiate subcutaneous from visceral fat accumulation [1].Previous studies show, subscapular to tricipital skin fold ratio used as a marker of central distribution of fat [14] but they were more strongly correlated with subcutaneous abdominal fat & expose its limitation to identifying precisely intraabdominal deposition. Waist circumference &WHR is the most commonly used parameters to identify and quantify intraabdominal fat deposition but intra & inter examiner variability >3% may limit its usefulness. Waist circumference seems to quantify subcutaneous fat better than visceral fat [15]. This method is sensible but not specific for the identification of visceral obese subjects. The use of USG in the assessment of intra-abdominal fat, initially proposed by Armellini et al [15] was further confirmed by strong correlation with the CT determined visceral fat area. On the other hand, US & CT determined subcutaneous fat in the abdominal area shows weak correlation possibly because of accumulation of subcutaneous tissue in back. Also compression of probe distort the measurement of subcutaneous fat.US was expected to be the most specific method because it allows the individual visualization of subcutaneous as well as visceral fat, noninvasive,quick method with good reproducibility (interexaminer variation<1%) and lower cost than CT.[16]It is also a useful method for monitoring weight loss, variation in visceral fat & associated risks. It was shown that subcutaneous fat at abdominal level is lost in greater proportion than visceral fat after severe weight loss suggesting that visceral fat does not reflect nutritional status to the extent that subcutaneous fat does.[17]Published data also suggest that visceral fat increase less than subcutaneous fat with increased body weight. Studies also suggest a direct association between intra-abdominal fat and liver fat content but not between subcutaneous abdominal fat and liver fat content .Both subcutaneous and visceral fat increase with increasing weight in both sexes but while abdominal subcutaneous adipose tissue decrease after the age of 50 yr in obese men, it increases in women up to the age of 60-70yr, at which point it starts to decline.[18]

Roberto studied 365 patients which conclude that no statistical significant difference in subcutaneous fat thickness between male & female individuals, age groups & in relation to the presence or not of steatosis. However, among patients with steatosis, visceral fat thickening presented significant increase proportional to the grade of steatosis, both in men & women.[19]

Conclusion:

The present study demonstrate the correlation between steatosis and visceral fat thickness and this study also conclude that USG is the best alternative & initial method for assessment of visceral fat and identification of NAFLD. This result helps us to remove the necessity of liver biopsy in normal or grade-1 steatosis. It is suggested that the measurement of visceral fat thickness is included in routine ultrasonography studies,considering the practicality and efficaciousness of this method as a predictor of steatohepatitis and metabolic syndrome. It help us for giving accurate treatment and follow up by noninvasive low cost method. The limitation of the present study is related to the lack of correlation with serum parameters and histological analysis. Further prospective study is needed to identify the cut off values for defining visceral fat level related to hepatic steatosis.

References:

1. Calle EE, Thun MJ,Petrelli JM,Rodriguez C,Healyh CWJr.Body mass index and mortality in a prospective cohort of US adults.N Engl J Med.1999;341:1097-105.

2. Kaplan NM.The deadly quartet.Upper body obesity,glucose intolerance, hypertriglyceridemia, and hypertension.Arch Intern Med.1989;149:1514-20.
3. Timar O,Sestier F,Levy E.Metabolic syndrome X:a review.Can J Cardiol.2000; 16:779-89.
4. Yki-Jarvinen H. Fat in the liver and insulin resistence. Ann Med 2005;37:347-56.
5. Westerbacka J,Lammi K, Hakkinen AM,et al. Dietary fat content modifies liver fat in overweight nondiabetic subjects. J Clin Endocrinol Metab 2005;90:2804-9.
6. Frayn KN. Visceral fat and insulin resistence-causative or correlative? Br J Nutr 2000; 83(suppl 1):s71-7.
7. Engfeldt P,Arner P. Lipolysis in human adipocytes,effects of cell size,age and of regional differences.Horm Metab Res Suppl 1988;19:26-9.
8. Bjorntorp P."Portal" adipose tissue as a generator of risk factors for cardiovascular disease and diabetes.Arteriosclerosis 1990;10:493-6.
9. Nielsen S, Guo Z. Johnson CM, et al. Splanchnic lipolysis in human obesity. J clin Invest 2004;113:1582-8.x
9. Joy D, Thava VR, Scott BB. Diagnosis of fatty liver disease: is biopsy necessary?Eur J Gastroenterol Hepatol,2003;15:539-43.
10. Saadeh S,Younossi ZM,Remer EM,etal.The utility of radiological imaging in nonalcoholic fatty liver disease.Gastroenterology.2002;123:745-50.
11. Andrade JO,Andrade MHF,Andrade GF,et al.Quantification of liver echogenicity for ultrasonographic classification of nonalcoholic fatty liver disease. GED Gastroenterol Endosc Dig.2006;25:159-64.
12. Radominski RB, Vezozzo DP, Cerri GG, et al.Arq Bras Endocrinol Metabol.2000; 44:5-12.
13. Seidell JC, Cigolini M, Charzeswka J, Ellsinger BM et al.Fat distribution in European men: a comparision of antropometric measurements in relation to cardiovascular risk factors.Int J Obes Relat Metab Disord.1992: 16:17-22.
14. Bonora E, Micciolo R, Ghiatas AA, et al.Is it possible to derive a reliable estimate of human visceral and subcutaneous abdominal adipose tissue from simple anthropometric measurements? Metabolism.1995; 44:1617-25.
15. Armellini F, Zamboni M, Rigo L, et al. The contribution of sonography to the measurement of intra-abdominal fat.J Clin Ultrasound.1990;18:563-7.
16. Ribeiro-Filho,Fernando F, Alessandra N, et al.Methods of estimation of visceral fat: advantage of ultrasonography. Obes Res. 2003;11:1488-94.
17. Mayo-Smith W, Hayes CW, Biller BMK, et al.Body fat distribution measured with CT: correlations in healthy subjects, patients with anorexia nervosa and patients with Cushing's syndrome. Radiology 1989;170:515-18.
18. Zamboni M, Armellini F, Muller D, Sorkin J.et al.Methodological and clinical aspects of subcutaneous fat distribution.Progress in Obesity Research.1996;7:145-50.
19. Eifler V R. The role of ultrasonography in the measurement of subcutaneous and visceral fat and its correlation with hepatic steatosis. Radiol Bras.2013;46:1-9.