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Image Evaluation and Association Analysis of the Cardiovascular Disease of the Degree of Pancreatic Steatosis in Ultrasonography

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Increasing fat tissue of obese people, increases the rate of cardiovascular disease, diabetes, metabolic syndromes and dyslipidemia. An increase in the focal tissue of pancreas is a known risk factor of these diseases. Although there exists sufficient research on the diagnosis and treatment of pancreatic cancer, studies have been done on fatty pancreas.

In this study, based on ultrasound imaging and using a texture characteristic of GLCM, fatty pancreas was divided into three categories: mild, moderate and severe. We compared and analyzed the three groups was by Pancreatic ultrasonography and body characteristics, serological tests, pressure and the degree of arteriosclerosis, against normal control group. The following parameters of control and test groups were measured: WC (waist circumference),BMI (body mass index), TC (total cholesterol), TG (triglyceride), HDL-C (High-density lipoprotein cholesterol) and LDL-C (Low-density lipoprotein cholesterol), SBP (systolic blood pressure), BST (Blood Sugar Test) and aortic PWV (pulse wave velocity). We observed the values correspondingly increasing fat deposition. However, ABI (Ankle Brachial pressure index) stenosis and HDL-C levels decreased with increasing fat deposit ($p < 0.05$); a drop in these parameters are known to be harmful to the human body. The difference in texture characteristics between normal control group and pancreatic fatty group (mild, moderate, and severe) was statistically confirmed. Ultrasound imaging of pancreatic steatosis categorized the disease as mild, moderate and severe based on the characteristic texture. In conclusion, we observed on increase in metabolic syndrome, dyslipidemia, and arteriosclerosis, proportional to the degree of pancreatic fat deposition. The escalation of these diseases was confirmed and was directly related with predictors of cardiovascular diseases.

Keywords: Pancreatic steatosis, Pancreas ultrasonography, Cardiovascular disease, GLCM algorithm

1. INTRODUCTION

Recent improvements in scientific technology, medical techniques and equipment has boosted an increase in a variety of services related to personal well-being, as well as a rise in people completing early health screening. In advanced countries, early health screening contributes to decreasing mortality due to cardiovascular disease, hypertension, and diabetes. However, we have seen an increase in the domestic death rate. This is mainly due to increasing blood lipids levels and obesity in the population due to a deteriorating life style, such as diet and lack of exercise [1]. Apart from an increase in fat tissue, which is a known risk factor for cardiovascular, cerebrovascular disease, hypertension and dyslipide many cases of appear obesity are progressing

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to systemic metabolic dysbolism [2]. Ectopic fat tissue deposited on internal organs, liver, muscle, heart and pancreas differs from the fat tissue which is stored in subcutaneous fat cells. Deposition of ectopic fat is known to cause abdominal obesity, insulin resistance and diabetes mellitus. A correlation has been reported between hypertension and hyperlipidemia [3]. In particular, the increase in obesity and prevalence of metabolic syndrome, dyslipidemia and atherosclerosis are known risk factors for cardiovascular disease. A previous study has reported the strong association between fatty liver disease and metabolic relevance is high previous study [4]. Non-alcoholic fatty liver was also shown to predict the occurrence of cardiovascular disease, such as dyslipidemia, abdominal obesity, and metabolic syndrome [5]. An increase of fat deposition in pancreas as well as liver appeared as an HE abnormality in several clinical index values. In another study, pancreatic steatosis is a very relevant, such as insulin resistance, visceral fat, TG, and high ALT (Alanine Transaminase), these figures are known risk factors for metabolic syndrome. In addition, liver being an early marker of insulin resistance the severity of fat deposition is a likely marker for the disease [6,7].

In this study, the more severity of pancreatic steatosis examines the change in metabolic syndrome, dyslipidemia, atherosclerosis changes. In diagnostic ultrasound imaging of the pancreas steatosis was classified as mild, moderate, and severe, depanding on the extent of fat deposits. Physical properties and serological differences, using the results of calculating the degree of arteriosclerosis inspection metabolic syndrome, dyslipidemia, incidence of atherosclerosis to investigate the risk of cardiovascular disease. As an indicator of metabolic syndrome using waist circumference, HDL-cholesterol, TG, BST, SBP were compared using, at least as dyslipidemia indicator of TC, HDL-cholesterol, LDL-cholesterol, TG, etc. was, how to diagnose atherosclerosis ankle brachial blood pressure was used for PWV & ABI and arterial elasticity. Metabolic syndrome, dyslipidemia, atherosclerosis are known important risk factor for cardiovascular disease.

Figure 1 shows a complete flow chart of the study.

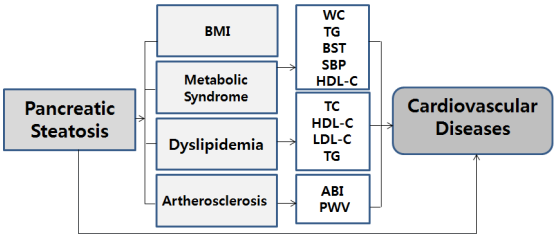

Fig. 1. The association between pancreatic steatosis and cardiovascular disease.

2. EXPERIMENT

Age and BMI were measured as physical characteristics of the pancreatic fat group, along with WC, HDL-C, TG, BST, and SBP as indicators of metabolic syndrome. In addition, we measured the TC, HDL-C, LDL-C, and TG as indicators of the dyslipidemia, ABI and PWV was measured as an indicator of arteriosclerosis. Each indicator of degree of pancreatic fat depositio and metabolic syndrome, dyslipidemia, and atherosclerosis had relevancet to cardiovascular disease.

2.1 Analysis of ultrasound image of pancreatic steatosis

The extent of pancreatic fat deposition was to accurately classify and quantify the value of a pixel in an ultrasound image. Using the histogram equalization and the filter range for the noise reduction effect to improve the contrast of the image as preprocessing method of an ultrasound image we increased the recognition rate classification. GLCM algorithm was applied to highlight the texture characteristics of the image [8]. A characteristic parameters of GLCM algorithm, namely Autocorrelation, Sum of squares, and Sum average, were extracted for Sum of variance of the dispersion, expresseing it as a value of the texture features [9].

2.2 Diagnosis of pancreatic steatosis

Increase in TG and free fatty acid is known to cause fat deposition in the liver, heart, muscles, and pancreas. Fat was considered as 'steatosis' when there were disorderly fat deposits[10]. In the ultrasound diagnosis of pancreatic steatosis based on the spleen, we diagnosed two cases: one case the greater echogenic pancreas than the spleen parenchyma, where the other was similar to retro-peritoneum fat echo or the brighter image[11].

In this paper, depending on the texture characteristics the pancreas was classified as mild, moderate, and severe. Figure 2 shows an ultrasound image to classify normal and pancreatic steatosis in three steps.

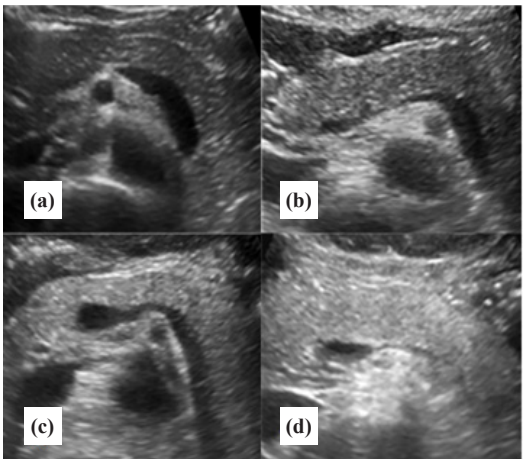

Fig. 2. (a) normal pancreas, (b) mild, (c) moderate, and (d) severe, pancreatic steatosis grade ultrasonography.

2.3 Metabolic syndrome & dyslipidemia, arteriosclerosis evalution

Metabolic syndrome refers to a complex of symptoms of various illnesses, resulting in functional collapse and failure to produce insulin. Metabolic syndrome is diagnosed based on the following parameter: WC > 90 cm, BST > 100 mg/dL, blood pressure more than 130/85 mmHg, TG 150 mg / dL, HDL-C <40 mg/dL. It is also diagnosed on the type of diabetes treatment received. If at least three of these five parameters are positive the disease is classified as metabolic syndrome [12,13].

Dyslipidemia refers to the total blood cholesterol, LDL-C, TG or an increased state of HDL-C reducing state. Diagnosis of dyslipidemia is considered as per the following criteria: TC < 200 mg/dL, LDL-C < 130 mg/dL, HDL-C > 60 mg/dL,and TG < 150 mg/dL are the normal range. Dyslipidemia dignosed when at least one parameter falls outside the normal range, and when the measure is 2-fold greater. This means higher LDL-C levels increases the risk of heart attack and stroke where as higher levels of HDL-C, high may be an indicator of a reduce the risk. Thus dyslipidemia may be an important risk in identifying cardiovas-

cular diseases [14].

The reduced elasticity of the arteries fall it can cause disturb the vasoconstriction, and in more severe situations it causes occlusion [15].

Angina occurs when heart blood vessels the coronary arteries become severely clogged, which could further lead to a heart attack, and myocardial infarction caused by blood clots. Risk factors for atherosclerosis include LDL-C, HDL-C, and high blood pressure. To evaluate the degree of arteriosclerosis we performed PWV and ABI. Blood vessel elasticity is studied by aortic PWV, whereas ABI can evaluate the degree of angiostenosis or occlusion by calculating both humerus and ankle pressure [16,17]. Thus, the risk of cardiovascular diseases can be evaluated by the conditions of these vessels [18,19].

2.4 Subject

Between September 2015 and March 2016, we performed a retrospective study at the Busan W hospital health examination center. Analyzing the results of abdomen ultrasonography, 240 patients with pancreatic steatosis were enrolled, and 80 patients formed the normal control group. Patients suffering from any pancreatic diseases, malignant tumors or chronic disease, having a history of any brain diseases, myocardial infarction, hypertension, or undergoing any diabetes treatment, were excluded from the study. Normal control group and experimental pancreatic steatosis was measured by physical characteristics including BMI and WC; BST measured TC, TG, HDL-C, LDL-C and BST. And it measured the systolic and diastolic blood pressure and arteriosclerosis diagnostic device (Vasera VS -1,000, Japan). The ankle brachial blood pressure and aortic pulse wave velocity represents conditions of non-stenosis, and can be used as indicators that the arteries are not artherosclerosed. The data were analyzed measuring the difference between the average test level of pancreatic steatosis, through statistical methods utilizing SPSS Statistics 22; we examined the rate at which the disease occurs in the chi-square test for linear to linear. We evaluated the metabolic syndrome as compared to the normal control group, which is the risk of disease variable for cardiovascular, dyslipidemia and atherosclerosis, using ultrasonography and the clinical result characteristics of the fatty pancreas group. . By applying the GLCM algorithm to the diagnostic ultrasound images, the pancreas steatosis degree was calculated according to the rate at which fatty deposits are classified as mild, moderate, and severe. The ultrasound equipment used for experimental GE LOGIQ P9 (USA) and image reading was done by a person specialized in radiology, and verified by internal medicine.

3. RESULTS AND DISCUSSION

According to the degree of fatty deposits in the pancreas, the incidence of cardiovascular disease was classified, as shown in Table 1. Steatosis was classified as normal, mild, moderate and severe based, on the texture analysis of ultrasound diagnosed with pancreatic steatosis GLCM by applying the MATLAB algorithms. Autocorrelation, sum of squares, sum of average, and sum variance exhibited the four parameters for normal, mild, and moderate, and severe pixel value divided by a mean value and a standard deviation.

Table 1. Analysis of GLCM algorithm in the pancreatic steatosis grade.

	Pancreas		Steatosis (M±SD)	
	Normal	Mild	Moderate	Severe
Autocorrelation	9.6±2.2	13.7±1.9	19.9±3.2	30.4±5.1
Sum squares	37.8±7.7	49.5±8.3	79.3±13.9	120.6±21
Sum average	5.9±0.8	6.8±0.5	9.1±0.	10.8±0.9
Sum variance	27.3±6.6	45.6±43.2	56.7±10.6	92.1±18.1

$p < 0.05$, Unit: pixel

Table 2. Clinical and laboratory characteristics of normal and pancreatic steatosis grade.

	Pancreas		Steatosis (M±SD)	
	Normal	Mild	Moderate	Severe
Age (years)	38±11	44±11	50±12	51±12
BMI (kg/m^2)	21.9±3	22±2	26.7±2	29.8±3
WC (cm)	85.9±5.7	86.1±3.6	95.3±7.6	99.4±7.6
TC (mg/dl)	165.7±21	185.7±15	211±18	220±25
HDL-C (mg/dl)	64.9±7.5	46.8±5.8	39.8±6.2	38.9±6.2
LDL-C (mg/dl)	96.4±17.1	114.7±11	140.2±22	148±21.5
TG (mg/dl)	76.7±29	117.5±27	170.5±37	250±56
SBP (mmHg)	119.3±14	130.3±10	139.3±25	150±24.8
BST (mg/dl)	84.1±7.8	96.5±12.2	102.1±9.3	117.2±23
ABI (Index)	1.13±0.1	1.16±0.1	0.98±0.1	0.89±0.2
Rt PWV (cm/s)	1,150±12	1,292±23	1,538±33	1,704±19
Lt PWV (cm/s)	1,205±12	1,297±23	1,535±46	1,731±18

Body characteristics : Age, BMI (Body mass index),
Metabolic syndrome & Dyslipodernia Parameter :
WC(Waist circumference), TC (Total cholesterol), HDL-C (High-density lipoportein cholesterol), LDL-C (Low-density lipoprotein cholesterol), TG (Ttriglyceride), SBP (Systolic blood pressure), BST (Blood sugar test),
Arthrosclerosis Parameter : ABI (Ankle brachial pressure index), PWV(Pulse wave velocity),
* $p < 0.05$

Texture characteristic value of each image pixel increase as the degree of fat deposits. In normal controls and pancreatic fatty groups, the average differencebetween the groups with respect to age, WC, BMI, TC, LDL-Cl, SBP, BST, and aortic PWV increases as the pancreatic fat deposition gets higher. Lower ABI is non-toxic, and lower levels of HDL- cholesterol indicated more pancreatic fat in the blood vessels ($p < 0.001$).

As the average difference between normal and mild to mod-

Table 3. Frequency analysis of abnormal values in the clinical and laboratory of study groups.

	Pancreas			Steatosis Grade	
	Normal	Mild	Moderate	Severe	Total case
BMI	8 (14%)	32 (34%)	66 (73%)	79 (99%)	190 (59.%)
WC	3 (3.8%)	10 (12.5%)	50 (62.5%)	52 (65%)	115 (35.9%)
TC	2 (2.5%)	26 (32.5%)	51 (63.7%)	74 (92.5%)	153 (47.8%)
HDL	5 (6.3%)	23 (28.7%)	54 (67.5%)	61 (76.3%)	143 (44.7%)
LDL	3 (3.8%)	22 (27.5%)	62 (77.5%)	65 (81.3%)	152 (47.5%)
TG	1 (1.3%)	10 (12.5%)	51 (63.7%)	77 (96.3%)	139 (43.4%)
SBP	11 (13.8%)	16 (20%)	34 (42.5%)	38 (47.5%)	99 (30.9%)
BST	6 (7.5%)	21 (26.3%)	48 (60%)	61 (76.3%)	136 (42.5%)
ABI	4 (24.3%)	5 (15.5%)	37 (38.1%)	41 (51.2%)	97 (30.3%)
PWV (R)	2 (2.5%)	9 (11.3%)	21 (26.3%)	25 (28.7%)	57 (17.8%)
PWV (L)	2 (2.5%)	9 (11.3%)	22 (27.5%)	28 (35.0%)	61 (19.1%)

Body characteristics : Age, BMI (Body mass index),
Metabolic syndrome & Dyslipodernia Parameter :
WC (Waist circumference), TC (Total cholesterol), HDL-C (High-density lipoportein cholesterol), LDL-C (Low-density lipoprotein chol1esterol), TG (Ttriglyceride), SBP (Systolic blood pressure), BST (Blood sugar test),
Arthrosclerosis Parameter : ABI (Ankle brachial pressure index), PWV (Pulse wave velocity).

Table 4. Frequency analysis components of Fatty Pancreas.

	Pancreas	Steatosis grade		
	Normal	Mild	Moderate	Severe
Metabolic-syndrome	2 (2.5%)	6 (2.5%)	48 (60%)	66 (82.5%)
Dyslipodemia	4 (5.0%)	20 (25%)	67 (84%)	77 (96.3%)
Artherosclerosis	5 (6.3%)	13 (16.3%)	30 (37.5%)	57 (71.3%)

erate steatosis increases, severe pancreatic steatosis was confirmed, with statistically significant differences, as shown in Table 2 test results were confirmed statistically significant differences remain in the group of four categories.

Table 3 shows the ratio of occurrence of disease in the chi-square test for linear to linear. Mild, moderate, and severe pancreatic steatosis increases the BMI, WC, TC, HDL-C, LDL-C, TG, SBP, BST, aortic PWV and ankle to brachial blood pressure ratio.

Table 4 shows predominance of the risk factors, namely metabolic syndrome, dyslipidemia, and atherosclerosis, and compares them in the pancreatic fatty groups (mild, moderate and severe) to the control group. It is observed that as the severity of the pancreatic fatty group increases, there is an increased incidence of metabolic syndrome, dyslipidemia, and atherosclerosis.

4. CONCLUSIONS

Cancer was announced as the No.1 cause of death in the domestic population. However, the recent years have seen an increase in cardiovascular and cerebrovascular diseases [20].

These diseases are accompanied by increasing medical costs and low quality of life; therefore, more research is required in these areas. We predict that the main reason for increasing cardiovascular and cerebrovascular diseases of atherosclerosis and metabolic syndrome, is due to the increasing aging population. Dyslipidemia is the main cause of cardiovascular diseases, and it is increased in the cases due to overweight teenagers and young adults in their twenties. Thus, the focus needs to be on early and preventive treatment. Recent statistics show the death rate due to atherosclerosis cardiovascular diseases has increased rapidly, from 10 to 27 people, 100,000 [21]. Metabolic syndrome is an important risk factor. Compared to normal population, it is four times higher in patients having cardiovascular diseases [22]. Based on the degree of fat deposits of livertests need to be undertakento check for diseases involved,such as metabolic syndrome and dyslipidemia, after which we can proceed to manageby preventive medicine. Compared to studies on fatty livers, there is less for fatty. In patients undergoing health screening, there have been cases of patients having fatty liver along with fat deposits in the pancreas, or fattypancreas without any indications of a fatty liver.

Until recently,when fat tissue deposits are diagnosed on the liver, a risk factor is detected and through serological examination is done. However, this diagnostic has a poorscenario for detecting fat deposit of pancreas in absence of fatty liver. Abdomen ultrasonography should be the primary examination, since the method is simple, and it is convenient tounearth various diseases on real time.

In this study, we analyzed the pancreatic ultrasonography image so that we can quantize normal and fat infiltration degree with a computer program. Through the computer image analysis, we overcame the limitation of naked eye examination, and discovered the means for a clinical diagnosis of pancreatic steatosis. The feature of GLCM algorithm is extracted 4 things: autocorrelation, sum of squares, sum average and sum of variance by using the parameters, and it also expressed the feature of image texture to numerical value by using these parameters. The algorithm analysis also reveals the fat infiltration in pancreas; increase makes it lighter and coarser, with an irregular expansion of the margin [23]. Depending on the degree of pancreatic echogenicity, the degree of pancreatic steatosis can be classified as mild, moderate, and severe. These fatty deposits in the pancreas can be the basis of risk factors and diagnosis of the metabolic syndrome [24] and insulin resistance early markers in various research studies, and the relevance of cardiovascular disease related to pancreatic steatosis as evaluated is progressing [25]. WC, TG, BST, SBP, HDL- cholesterol were the risk factors for metabolic syndrome, and in the dyslipidemia HDL-cholesterol and TC, LDL-cholesterol, TG are known to increase in the pancreatic fat group. In case of ABI stiffness in the aorta PWV that identifies the status of ankle blood pressure and blood ratio, it was found that an increase in fat deposition decreases the elasticity of blood vessels, stenosis and occlusion, but there is no increase in the brachial artery.

Occlusion of blood vessels in the pancreatic fat group check the stenosis was reported, and occlusion and stenosis of the blood vessels leads to cardiovascular disease. There is also a study of metabolic syndrome and dyslipidemia as the factors that increase the risk of cardiovascular diseases.

In conclusion, the results of this study show that the metabolic syndrome, dyslipidemia, and atherosclerosis were significantly higher in the experimental group with pancreatic steatosis. These are important risk factors in cardiovascular disease when viewed in conjunction with an increase in incidence of pancreatic steatosis. This study has revealed useful data which can be used in pancreatic steatosis diagnosed as early markers of cardiovascular disease.

In addition, the study considers the importance of diagnosing and managing the evaluation of ultrasound preventive medicine, to identify mild, moderate, and severe steatosis in the pancreas and liver. The active research for future human visceral fat deposition will be complemented by this study, as early markers for various diseases such as cardiovascular disease to bring the fatty deposits in the organs.

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