SONOGRAPHIC MEASUREMENT OF THE NORMAL LIVER MARGINAL ANGLES

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ABSTRACT

The liver marginal angles have been measured in 937 normal health check-up subjects by ultrasound. They were 57.7 % men and 42.3 % women. The aims of this study were to evaluate correlation between liver marginal angles and physical data, age, sex. The results show that the mean of weight, height, BMI and LIMA in male were larger than female. The average of LLMA, LIMA and RIMA were 41.6 ± 4.4, 39.3 ± 4.3 and 45.9 ± 8.6 degrees, respectively. There were negative correlation between age and sex, age and weight, age and height, while correlation between sex and weight, sex and height, sex and AP diameter were positive. Sex can predict the LIMA from the equation: LIMA = 38.17 + 2.09 (sex).....equation I. Physical data that were used to predict the RIMA were BMI and height from the equation: RIMA = 56.89 + 1.05 (BMI) - 20.27 (Ht). From the classification of obesity, mean BMI was 21.42 kg/m^2(body surface area) for men, 20.89 kg/m^2 for women. Among the normal health check-up subjects, the overweight group constitutes 7.3 % of the total cases.

LLMA = Left lateral marginal angle, transverse cut
LIMA = Left inferior marginal angle, sagittal cut
RIMA = Right inferior marginal angle, sagittal cut
BMI = Body mass index
(sex) in equation I means: male = 1, female = 0

INTRODUCTION

Measurements of liver in case of mild hepatomegaly based on percussion and palpation are inaccurate and unreliable in some obese patients,[1] while radiography or radionuclide studies expose the patient to gamma radiation.[2,3] Ultrasound has been found to be both accurate, reliable, without contraindication,[4] more sensitive than computed tomography[5] and without radiation hazard.[6] A measurement of liver marginal angles, called the angle sign is the one of sonographic criteria of hepatomegaly. The liver is enlarged when LLMA, LIMA and RIMA measure more than 45, 45 and 75 degrees,[7,8] respectively. However, despite the widespread of clinical uses, we still have no general accepted standards of liver marginal angles in normal Thai people. We therefore con-

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ducted a prospective study of a large group of healthy subjects to evaluate the physical data, to correlate liver marginal angles with sex, age, weight, height, BMI and AP diameter at xiphoid level.

MATERIALS AND METHODS

Subjects: One thousand consecutive health check-up volunteers were examined by ultrasound between september 1996 and october 1997. Sixty-three subjects were excluded because of (a) a history of hepatic, biliary, pancreatic disease, subjective abnormal ultrasound, clinical (n=38) or laboratory finding (n=17), (b) increase alcohol intake, defined as daily consumption, for at least three years, of more than 20 ml. of ethanol for women and more than 60 ml. of ethanol for men[9,10] (n=2), (c) abnormal chest radiographs(n=6). There were 541 men and 396 women, age between 17-75 years . Sex, age(years), weight(kg.), height(m.), AP diameter(cm.) at xiphoid level, medical history and results of the physical examination were recorded, along with hematocrit, white cell count, platelet, SGOT, SGPT, HBs-Ag and anti-HBs. BMI was calculated from the equation: $BMI = Wt/(Ht^2)$, for the classification of the obesity.[11] All subjects had normal radiographs.

Ultrasound examination: We employed a high resolution real time scanner with a 3.75 MHz transducer (Toshiba imager). Subjects were examined (a) supine to demonstrated LLMA and LIMA (b) with the right side elevated 10-15 degrees to show the RIMA. Transverse scans of the liver were obtained in the midline, 2-3 cm. below xiphoid process, the portal vein in left lobe is the reference landmark for measuring LLMA as shown in figure 1. LIMA were measured by sagittal scans in the midline, 2-3 cm. below xiphoid process, the abdominal aorta is the reference landmark as shown in figure 2. For the right side elevated 10-15 degrees, sagittal scans were obtained by placing the upper edge of transducer at the lower edge of right costal margin, RIMA were measured at the mid point of right kidney as shown in figure 3. All angles were measured during deep inspiration in order to minimize masking by the lung and eliminate morphological variation due to respiration.

(n = number of subjects who were excluded)

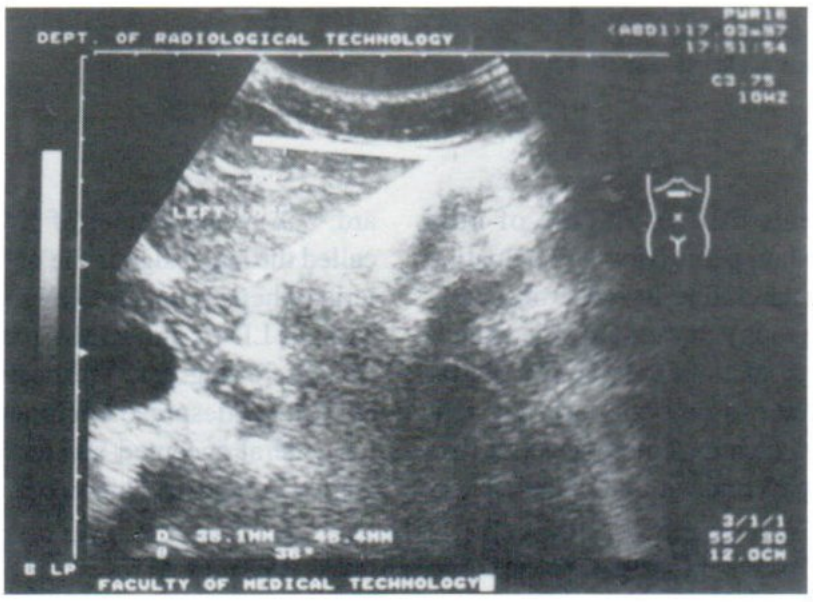

Fig. 1 Left lateral marginal angle, transverse cut

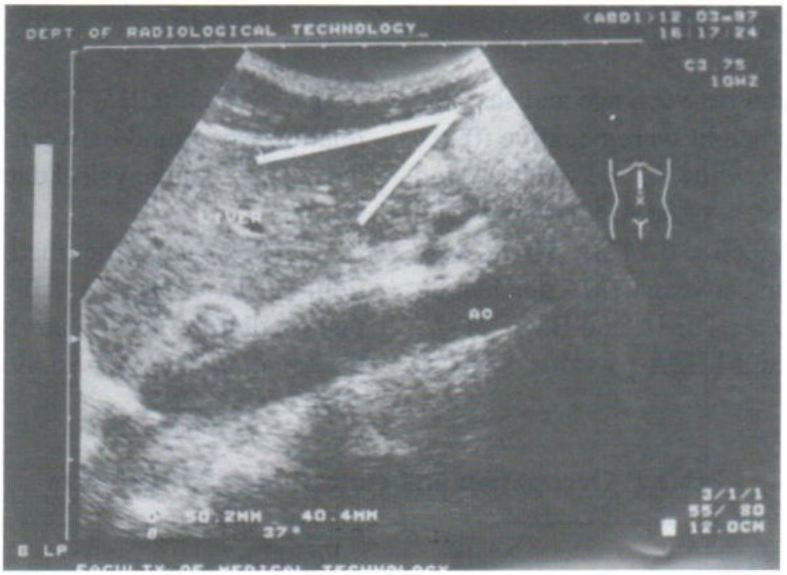

Fig. 2 Left inferior marginal angle, sagittal cut

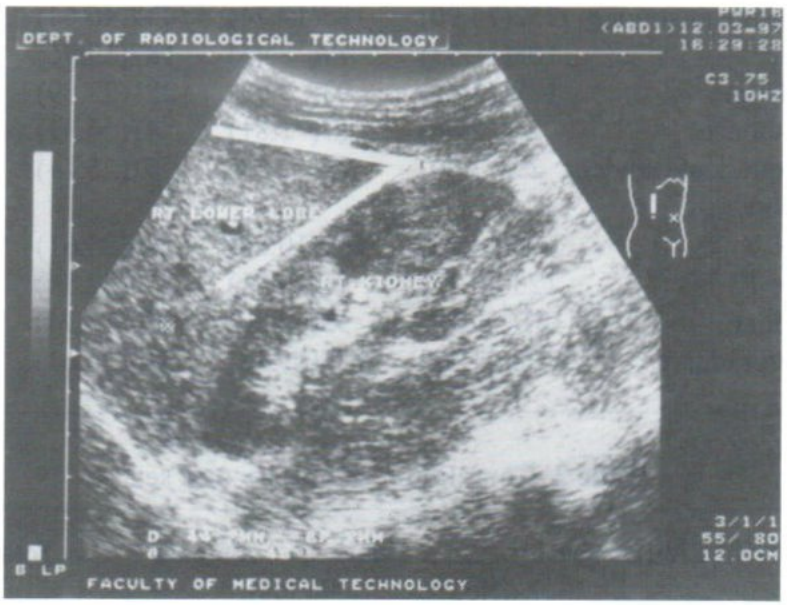

Fig. 3 Right inferior marginal angle, sagittal cut

Statistics: The data were analyzed by using a SPSS-PC program. Descriptive statistics and correlation for physical data, sex, age, BMI, LLMA, LIMA and RIMA were evaluated. Independent t-test was used to compare the mean of all parameters with sex. Multiple regression analysis was carried out for age, sex, physical data, BMI and all angles by stepwise regression method.

RESULTS

The occupation and education of 937 subjects are shown in table 1. Table 2 show the correlation of sex and the classification of obesity. Women was less obese than men (p-value = 0.042). Mean values, standard deviation and range are shown in table 3. The mean of physical data, age and all angles were compared with sex as shown in table 4. In male, mean of weight, height, BMI and LIMA were larger than female (p-value = <0.005,<0.005, 0.042 and 0.005). No significant difference was found between AP diameter, LLMA, RIMA and sex (p-value = 0.060, 0.772 and 0.110)

The correlation between age and sex, age and weight, age and height were negative ($r = -0.171, -0.168, -0.323$), while that between sex and weight, sex and height, sex and AP diameter were positive ($r = 0.472, 0.638, 0.142$). There were significant correlation between RIMA and height, RIMA and AP diameter, RIMA and BMI, RIMA and LLMA, RIMA and LIMA (p-value = 0.012, 0.013, <0.005, 0.015, 0.025). No significant correlation was found between LLMA and physical data, LIMA and physical data as shown in table 5.

Sex can predict the LIMA from the equation: LIMA = 38.17 + 2.09 (sex). Physical data that predict the RIMA are BMI and height from the equation: RIMA = 56.89 + 1.05 (BMI) - 20.27 (Ht).

Table 1 Occupation and education of 937 subjects

	Male No.(%)	Female No.(%)	Total No.(%)
Occupation			
Government service	252(26.90)	185(19.74)	437(46.64)
Farmer	108(11.53)	79(8.43)	187(19.96)
Employee	128(13.66)	93(9.93)	221(23.59)
Wife-house	24(2.56)	17(1.81)	41(4.37)
undergraduate student	29(3.09)	22(2.35)	51(5.44)
Education			
Grade 6	138(14.73)	102(10.88)	240(25.61)
Grade 12	123(13.13)	91(9.71)	214(22.84)
Diploma	81(8.64)	59(6.30)	140(14.94)
Undergraduate	198(21.13)	145(15.48)	343(36.61)

Table 2 Correlation of obesity and sex

BMI	Classification of obesity	Male No.(%)	Female No.(%)	Total
< 20	Underweight	158(29.1)	191(48.3)	349(37.2)
20-25	Normal	349(64.6)	171(43.1)	520(55.5)
25-30	Overweight	34(6.3)	34(8.6)	68(7.3)
Total		541(57.7)	396(42.3)	937(100.0)

χ^2 - test = 6.314 P-value = 0.042*

* significant at $\alpha = 0.05$

Table 3 Mean, standard deviation, range of clinical features and liver marginal angles

	Mean	SD	Range
Age (years)	34.77	13.39	17 - 75
Weight (kg.)	56.26	7.65	36 - 81
Height (m.)	1.63	0.08	1.39 - 1.80
AP diameter (cm.)	19.68	3.60	15.0 - 24.5
BMI (kg./m.^{2})	21.09	2.01	14.7 - 28.5
LLMA (degrees)	41.64	4.47	31 - 59
LIMA (degrees)	39.38	4.33	28 - 54
RIMA (degrees)	45.99	8.68	27 - 77

Table 4 Comparison of mean ± SD of clinical features and liver marginal angles in sex

	Male	Female	P-value
Age (years)	32.81±13.23	37.44±13.24	0.045*
Weight (kg.)	59.76± 7.82	51.51± 7.42	<0.005**
Height (m.)	1.68± 0.06	1.57± 0.07	<0.005**
AP diameter (cm.)	20.36± 7.05	18.75± 2.29	0.060
BMI (kg./m.^{2})	21.42± 1.68	20.89± 1.43	0.042*
LLMA (degrees)	41.73± 3.96	41.50± 5.11	0.772
LIMA (degrees)	40.27± 4.14	38.17± 4.32	0.005**
RIMA (degrees)	44.96± 8.31	47.30± 9.04	0.110

* significant at $\alpha = 0.05$

** significant at $\alpha = 0.01$

Table 5 Correlation between clinical features and liver marginal angles

		Age	Sex	Weight	Height	AP diameter	BMI	LLMA	LIMA	RIMA
Age	r	1.000	-0.171	-0.168	-0.323	0.016	0.071	-0.060	-0.129	0.014
	p	@	0.045*	0.049*	<0.005**	0.852	0.404	0.480	0.132	0.870
Sex	r	-0.171	1.000	0.472	0.638	0.142	0.059	0.026	0.239	-0.139
	p	0.045*	@	<0.005**	<0.005**	0.096	0.487	0.763	0.005**	0.105
Weight	r	-0.168	0.472	1.000	0.610	0.223	0.743	0.065	0.127	0.119
	p	0.049*	<0.005**	@	<0.005**	0.009**	<0.005**	0.448	0.138	0.164
Height	r	-0.323	0.638	0.610	1.000	0.009	-0.068	-0.027	0.146	-0.213
	p	<0.005**	<0.005**	<0.005**	@	0.914	0.428	0.752	0.088	0.012*
AP	r	0.016	0.142	0.223	0.009	1.000	0.270	0.049	0.108	0.211
diameter	p	0.852	0.096	0.009**	0.914	@	0.001**	0.569	0.208	0.013*
BMI	r	0.071	0.059	0.743	-0.068	0.270	1.000	0.090	0.040	0.329
	p	0.404	0.487	<0.005**	0.428	0.001**	@	0.295	0.636	<0.005**
LLMA	r	-0.060	0.026	0.065	-0.027	0.049	0.090	1.000	0.157	0.207
	p	0.480	0.763	0.448	0.752	0.569	0.295	@	0.067	0.015*
LIMA	r	-0.129	0.239	0.127	0.146	0.108	0.040	0.157	1.000	0.191
	p	0.132	0.005**	0.138	0.088	0.208	0.636	0.067	@	0.025*
RIMA	r	0.014	-0.139	0.119	-0.213	0.211	0.329	0.207	0.191	1.000
	p	0.870	0.105	0.164	0.012*	0.013*	<0.005**	0.015*	0.025*	@

@ coefficient cannot be computed
* significant at $\alpha = 0.05$
** significant at $\alpha = 0.01$

DISCUSSION

In the previous studies, liver size was measured in many diameters by clinical methods, autopsy, ultrasound, radiography and radionuclide studies.[1,2,6,12-19] Some of these authors noted positive correlation between liver size and height, liver size and sex,[1,18] while liver size has negative correlation with age.[20] In the last decade, ultrasonography has been routinely used for the study of abdominal structures.[21] It gives a quantitative and reproducible estimate of total liver span, which reflects the hepatic dullness at physical examination and of liver span below the rib margin.[22] The bedside examination of the liver does not provide any accurate information regarding the actual volume of the liver[15] and its angles. Unfortunately, a few authors studied the normal liver marginal angles and showed the upper limit of angles, no information about the correlation between the angles and physical data.

We attempted to measure the normal liver marginal angles by ultrasound and employed the physical data to predict the angles. It was found that the average of LLMA, LIMA and RIMA are 41.6 ± 4.4, 39.3 ± 4.3 and 45.9 ± 8.6 degrees. LIMA increases in male. RIMA increases with AP diameter and BMI but decreases with height. We can use the physical data to predict RIMA . Both left marginal angles correlated poorly with the physical data. We feel that it is not necessary to

routinely record the physical data for sonographic measurements.

From the physical data, age and sex, show that weight and height decreases with age, male is more obese than female. Mean BMI is 21.42 kg./m.^{2} for men, 20.89 kg./m.^{2} for women. From classification of obesity, 37.2 %, 55.5 % and 7.3 % of subjects is underweight, normal and overweight. It was indicated that the overweight subjects of the normal health check-up subjects increases the risk for medical complication such as hypertension, insulin resistance, hyperuricemia and dyslipoproteinemia.[11,23] The physical data is still worth for health check-up program.

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REFERENCES

1. Niederau C, Sonnenberg A, Muller JE, Erckenbrecht JF, et al. Sonographic Measurement of the Normal Liver, Spleen, Pancreas and Portal Vein. Radiology 1983; 149: 537-540.
2. Sullivan S, Krasner N, Williams R. The Clinical Estimation of Liver Size : a Comparison of Techniques and an Analysis of the Source of Error. Br med J 1976; 2: 1042-1043.
3. Peternal WW, Schaefer JW, Schiff L. Clinical Evaluation of Liver Size and Hepatic Scintiscan. Am J Dig Dis 1966; 11:346-350.
4. Wright R, Millward-Sadler GH, Albertti KGMM, Karran S. Liver and Biliary disease. 2nd ed. London: W.B. Saunders, 1985.
5. Leevy CM, Sherlock G, Tygstrup N. Disease of the Liver and Biliary Tract. 1st ed. New York: Rava Press, 1994.
6. Carr D, Duncan JG, Railton R, Smith CB. Liver volumn Determination by Ultasound : a Feasible Study. Br J. Radiol 1976; 49: 776-778.
7. Weill FS. Ultrasonography of Digestive Diseases. St Louis: The C.V. Mosby, 1978.
8. Swobodnik W, Herrmann M, Altwein JE, Basting RF. Atlas of Ultrasound Anatomy. 1st ed. New York: Thieme Medical Publishing, 1991.
9. Pequignot G, Chabert C, Eydoux H, Courcoul MA. Increase in the Risk of Cirrhosis as a Function of Alcohol Intake. J Stud Alcohol 1975; 35: 1059.
10. Niederau C, Sonnenberg A. Liver Size Evaluated by Ultrasound : ROC curves for Hepatitis and Alcoholism. Radiology 1984; 153: 503-505.
11. Smith LH, Plum F, Carpenter CCJ, Andreoli TE. Cecil Essentials of Medicine. 2nd ed. Philadelphia : W.B. Saunders, 1990.
12. Sapira JD, Williamson DL. How big is the Normal liver? Arch Intern Med 1979;139: 971-973.
13. Naftalis J, Leevy CM. Clinical Estimation of Liver Size. Am J Dig Dis 1963;8:236-243.
14. Pietri H, Boscaini M, Berthezene P, Durbec J P, et al. Hepatic Morphotypes: Their Statistical Individualization Using Ultrasonography. J ultrasound Med 1988;7: 189-196.
15. Zoli M, Magalotti D, Grimaldi M, Gueli C, et al. Physical Examination of the Liver: Is it still worth it ? Am J Gastroenterol 1995;9:1428-1432.
16. Chen CM, Wang JJ. Clinical and Sonographic Assessment of Liver Size in Normal Clinese Neonated. Acta Paediatrica 1993 ;82:345-347.

17. Holder LE, Strife J, Padikal TN, Perkins PJ, et al. Liver Size Determination in Pediatrics Using Sonographic and Scintigraphic Techniques. Radiology 1975;117: 349-353.
18. Deland FH, North WA. Relationship between Liver Size and Body Size. Radiology 1968; 91: 1195-1198.
19. Meidl EJ, Ende J. Evaluation of Liver Size by Physical Examination. J Gen Intern Med 1993;8:635-637.
20. DeLand FH. Normal Spleen Size. Radiology 1970;97:589-592.
21. Okuda K. Advances in Hepatobiliary Ultrasonography. Hepatology 1981;1:662-672.
22. Gosink BB, Leymaster CE. Ultrasonic Determination of Hepatomegaly. J Clin Ultrasound 1981;9:37-41.
23. Wyngaarden JB, Smith LH, Bennett JC. Cevil Textbook of Medicine. 19th ed. Philadelphia: W.B. Saunders, 1992.