Correlation between clinical evaluation of liver size versus ultrasonography evaluation according to body mass index (BMI) and biotypes

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ABSTRACT

Background: Body weight may influence liver size. **Aim:** To determine the correlation between clinical and ultrasound evaluation of the liver size according to body mass index (BMI). **Material and Methods:** A cross-sectional study of 81 subjects aged 25 ± 6 years (43 females). Two percussion measurements were taken and ultrasonography was performed on the same site demarcated by percussion. **Results:** Mean BMI was 23 ± 4 kg/m². Nineteen individuals (23.5%) had a BMI ≥ 25 kg/m². There was a significant difference between the values of liver size obtained by clinical and ultrasound methods. The correlation coefficient between the liver size obtained by clinical and ultrasound methods was 0.419 ($p < 0.01$). No significant differences in liver size were observed, between subjects with a BMI below or over 25 kg/m². In all subjects, regardless of BMI, there was a statistically significant difference between the mean sizes obtained by both methods. The correlation coefficients between both methods in subjects with a BMI ≤ 25 Kg/m² and their counterparts with higher BMI were 0.47 and 0.03, respectively. **Conclusions:** There are significant differences in liver size obtained by clinical examination and ultrasound. Only in subjects with BMI ≤ 25 kg/m², the correlation between the two techniques is significant.

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Key words: Liver; Physical examination; Ultrasonography.

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Comparación de la medición del tamaño del hígado por ultrasonografía y mediante examen físico

Introducción: El peso corporal puede tener influencia sobre el tamaño del hígado. **Objetivo:** Determinar el tamaño del hígado mediante examen físico y ultrasonido en sujetos con distinto índice de masa corporal (IMC). **Material y Métodos:** Estudio transversal de 81 individuos de 25 ± 6 años (43 mujeres). Se tomaron dos medidas del hígado por percusión y la ultrasonografía se efectuó en el mismo sitio marcado por la percusión. **Resultados:** El IMC promedio de los individuos fue de 23 ± 4 kg/m². Diecinueve sujetos (23,5%) tenían un IMC ≤ 25 kg/m². Se observaron diferencias significativas entre las mediciones obtenidas por examen físico y ultrasonografía en todos los sujetos, no importando el valor de IMC. No se observaron diferencias

en el tamaño del hígado entre sujetos con un IMC menor o mayor a 25 kg/m². Los coeficientes de correlación entre los dos métodos en sujetos con un IMC $\leq$ 25 kg/m² y aquellos con valores más altos fueron 0,47 y 0,03, respectivamente. Conclusiones: Las mediciones clínicas y ultrasonográficas del tamaño del hígado difieren significativamente. Sólo en sujetos con un IMC $\leq$ 25 kg/m², ambas mediciones tienen una correlación significativa.

The liver is the largest gland in the human body and is found in the intra-abdominal cavity. It weighs around 1500g and has higher density among male individuals. Its function is to filter and store blood, metabolize carbohydrates, proteins, hormones and strange chemicals; to form bile, store vitamins and iron; and to produce clotting factors¹⁻⁵.

The liver has two anatomical parts, the right lobe and left lobe, separated by an imaginary line that runs from the gallbladder fossa into the inferior vena cava^{1,3}.

During a clinical interview, a number of liver-related disorder complaints may be reported by a patient; pain is the main complaint, usually located in the abdominal right upper quadrant or epigastrium^{6,7}.

Following the clinical interview, patients will undergo physical examination, when inspection, percussion, palpation and auscultation of the liver can be made⁶. Physical examination addresses the liver in a projection surface that covers almost the entire chest wall^{6,8}. After inspection, percussion is performed with the aim of determining the liver upper boarder and, when possible, the lower boarder, estimating liver size⁶. Normal liver volume is proportional to body size. The normal adult liver spans 10 to 12 cm for men and 8 to 10 cm for women⁷. Generally, it can vary between 6 and 12 cm in all subjects when percussion is performed in the midclavicular line⁹.

Percussion should start gently in the midclavicular line just inferior to the second rib, starting from the pulmonary clear sound until dullness liver, which occurs approximately in the fifth intercostal space and corresponds to the diaphragm muscle on the liver dome. The patient should be positioned supine and the examiner always on his right⁹. In women, the breast should be gently moved upwards so as not to compromise the percussion. The last dullness points found on percussion in the imaginary line from midclavicular

to craniocaudal direction will determine the liver lower boarder^{10,11}. The path joining the two points, the onset of liver dullness being the first and the limit point of dullness at the lower edge the second, is the supposedly the real liver size⁶.

The liver volume can be measured by various techniques such as radiography, scintigraphy, computed tomography, magnetic resonance and ultrasonography^{12,13}. Ultrasonography is the first imaging method to assess hepatic affections, which has a number of key advantages, such as low cost, rapid implementation, risk-free, non-invasive, no use of ionizing radiation or sedation that facilitates technical performance, especially when it comes to children^{12,13}.

In the literature, there are no studies comparing liver measurement with biotype of participants determined by Charpy's angle, but there are reports that body weight influences liver size. Kratzter and colleagues¹⁴ also found a correlation between body mass index and liver measurement, and discovered that the higher the individual's BMI, the larger the liver size. Niederau and colleagues¹⁵ also found that besides the surface of body mass, body weight influences liver size. Konus and colleagues¹⁶ found a correlation ($r = 0.80$) between body weight and liver dimensions. They discovered that height is the best parameter for correlation with longitudinal liver size in the midclavicular line in children ($r = 0.85$), and concluded that the greater the child's height, the larger the longitudinal extent of the liver. Altunkaynak and Altunkaynak¹⁷ recently concluded that excessive weight is a determining factor for hepatomegaly, especially in females. The determination of the accuracy of physical examination techniques is highly desirable, since the changes found on physical examination will determine further investigation exams. This study was carried out to determine the correlation between clinical assessment of liver measurement versus ultrasonographic evaluation according to BMI and different biotypes.

Patients and Methods

A cross-sectional study was conducted between August 2008 and April 2009, at the Nossa Senhora da Conceição Hospital Diagnostic Center in Tubarão, State of Santa Catarina, Brazil. The target population consisted of number of patients that would undergo abdominal ultrasound examination. The study sample consisted of 81 male and female patients, selected according to their medical appointment scheduling. The study included those over eighteen years of age. All patients were informed about the research project and signed a free consent form, in addition to being registered in an inclusion form. Exclusion criteria included patients with chest deformities, ascites, those who had undergone right pneumonectomy, patients with Chilaiditi's syndrome detected through ultrasonography (transposition of a loop of large intestine between the diaphragm and the liver), and any other condition that could affect the physical examination or ultrasonography, as well as those who did not agree to participate in the study. Individuals excluded from the study were replaced by randomly selected patients to fill the total sample size.

All participants underwent two procedures at the same occasion, the physical examination and abdominal ultrasound examination. First, hepatic percussion was performed towards the midclavicular line, where the hepatic dullness beginning and ending points were marked. The path between these points was measured in centimeters. Two percussion measurements were taken; the average between them determined the patient's liver measurement by clinical method. At this point the examiner evaluated the patient's body type through the Charpy's angle (formed by the intersection of the lower ribs) classification and collected anthropometric data (body weight in grams and height in centimeters) to calculate the BMI of each participant. Then, ultrasonography was performed on the site marked by percussion, determining the patient's ultrasonic measurement of liver size. All participants were evaluated by an observer with knowledge and training in clinical method and by a physician expert trained in ultrasound technique.

A database was created and statistical analysis was performed using SPSS 16.0 software. The variables were summarized as percentage or ave-

rage as indicated. Correlation between hepatic measurements undertaken by clinical examination and those obtained by ultrasound method were calculated using Pearson's correlation coefficient. The research project was approved by the Human Research Ethics Committee of Unisul, under the code number 08.501.4.01.III.

Results

Eighty-one subjects, all Caucasians, were consecutively evaluated. Forty-three (53.1%) were females and 38 (46.9%) were males. Mean age was 25 years ($SD \pm 6$), with age ranging between 19 and 54 years. Mean height was 170 cm ($SD \pm 9$), with height ranging between 152 and 188 centimeters. Mean weight was 65,560 grams ($SD \pm 13,554$), with weight ranging between 43,000 and 103,000 grams. Mean BMI was 23 kg/m² ($SD \pm 4$), ranging between 17 and 38 kg/m². When using BMI of 25 kg/m² as a cutoff point, 19 subjects (23.5%) reached values higher than or equal to 25, while 62 subjects (76.5%) had values lower than 25. Biotype distribution according to Charpy's angle was 13 (16%) brevilinear, 31 (38.3%) normoliner, and 37 (45.7%) longiliner individuals.

There was a statistically significant difference between the values of liver size obtained by clinical examination and ultrasound method, demonstrating a tendency towards underestimation of liver size by clinical evaluation, as shown in Table 1.

There was no statistically significant difference of liver measurement obtained by percussion, when stratified by gender ($p = 0.861$). Similarly, there was no statistically significant difference of liver measurement obtained by ultrasonography when stratified by gender ($p = 0.389$). The results are shown in Table 2.

Pearson's correlation coefficient between liver size obtained by clinical examination and ultrasound method was 0.419 ($p < 0.01$), which is considered a good correlation. There was no statistically significant difference of liver measurement obtained by percussion, when stratified by BMI cutoff point ($p = 0.576$). Similarly, no statistically significant difference of liver measurement obtained by ultrasonography when stratified by BMI cutoff point ($p = 0.905$). The results are shown in Table 3.

The values of liver measurement obtained by

Table 1. Results of liver measurement in centimeters through clinical examination and ultrasound method

Values	Clinical Examination	Ultrasound Method
Average	8.8	11.6
Standard Deviation	1.7	2.6
Minimum	5.3	6
Maximum	15	16.5

p = 0.000

Table 2. Values of liver measurement in centimeters through clinical examination and ultrasound method stratified by gender

Gender	n (%)	Ultrasonography Mean (± DP)	Percussion Mean (± DP)
Female	43 (53.1)	11.9 (± 2.5)	8.7 (± 1.8)
Male	38 (46.9)	11.4 (± 2.7)	8.8 (± 1.7)
p		0.389	0.861

Table 3. Values of liver measurement in centimeters through clinical examination and ultrasound method stratified by BMI

BMI (kg/m ²)	n (%)	Ultrasonography Mean (± DP)	Percussion Mean (± DP)
≥ 25	19 (23.5)	11.6 (± 2.9)	8.6 (± 1.5)
< 25	62 (76.5)	11.7 (± 2.6)	8.8 (± 1.8)
p		0.905	0.576

Table 4. Values of liver measurement in centimeters through clinical examination and ultrasound method according to the biotype

Biotype	n (%)	Ultrasonography Mean (±DP)	Percussion Mean (±DP)
Brevilinear	13(16)	12.5 (± 2.4)	8.2 (± 0.8)
Longilinear	37(45.7)	12.3 (± 1.6)	8.9 (± 1.5)
Normolinear	31(38.3)	10.5 (± 3.2)	8.7 (± 2.2)
p		0.005	0.470

clinical examination and ultrasound method according to the biotype are shown in Table 4.

Pearson's correlation coefficients between BMI and liver measurement obtained by percussion and by ultrasonography were -0.092 and 0.01, respectively, which is not statistically significant. When assessing individuals with BMI greater than or equal to 25, there was a statistically significant difference between the mean values obtained by both methods (p = 0.001). In this group of individuals the correlation between the two methods showed a Pearson's correlation coefficient of 0.035, which is not statistically significant.

In the group of individuals with BMI less than 25, there was a statistically significant difference between the mean values obtained by both methods (p = 0.000), but in this group the correlation between the two methods showed a Pearson's correlation coefficient of 0.473, with statistical significance (p < 0.01).

Discussion and Conclusion

In this study, there was a good correlation between liver size obtained by clinical examination and ultrasound method (r = 0.419). Castell and colleagues¹¹ also obtained a good correlation (r = 0.77) between percussion and liver measurement obtained by image in their study of 116 healthy adults, but they did not mention which imaging standard was used for comparison. Sapira and colleagues¹⁸ found a Pearson's correlation coefficient of 0.64 in a study of 96 healthy subjects, when comparing the values obtained by percussion with ultrasound measurement. Rajnish and colleagues¹⁹ studied the accuracy of palpation and percussion compared to ultrasonography in a sample of 180 patients and concluded that the

clinical method alone is not sufficiently able to confirm or exclude the presence of hepatomegaly.

In this study, mean liver measurement obtained by clinical examination on the midclavicular line underestimated the mean value obtained by ultrasonography, which is also described in the literature by Sullivan and colleagues²⁰ in studies with adult patients. In another study of 21 children, the same result was not found, i.e., mean clinical liver measurement by percussion and auscultation overestimated mean ultrasonic measurement²¹.

It is known that several factors can interfere with liver measurement, such as weight, height, age, gender, percussion technique, site of percussion, phase of respiration, anatomical abnormalities, obesity, large-volume ascites, cirrhosis, tumors, hepatomegaly, personal habits and patient's position during the examination^{11,13,14,18,22-25}.

In a review, Meidel and Ende²² reported that the percentage of palpable liver in healthy subjects is 28%. Rajnish and colleagues¹⁹ found a good correlation between the three examiners (82% to 84%) in determining palpable liver in 36 patients with increased liver by ultrasonography, and concluded that 20% of patients had palpable livers. Sullivan and colleagues²⁰ concluded that clinical evaluation of liver can be difficult due to the hepatic shape, position and axis. Even the percussion angle of the examiner's fingers may interfere with liver measurement, as well as the force applied during the percussion^{26,27}. Rosenfield and colleagues²⁸ studied the correlation between scintigraphy and palpation in 100 adult patients and concluded that palpation can be changed with the patient in orthostatic or supine position. Jackson and colleagues²⁴ also concluded that the patient's position interferes with liver measurement. In a study among observers, Naylor and colleagues²⁹ concluded that there are clinical limitations to accurately determine the midclavicular line. All these factors may lead to an inaccurate identification of the liver borders, thus interfering greatly with the results.

In this study, mean liver size measured by clinical method was 8.8 ± 1.7 cm on the midclavicular line. Castell and colleagues¹¹ found a very close value in adults. The mean value was 9.75 ± 2 cm when using light percussion only.

The final mean value of ultrasound-measured liver size was 11.6 ± 2.6 cm. In a study of 915 healthy participants, Niederau and colleagues¹⁵ also found similar values; the mean value was

10.5 ± 1.5 on the midclavicular line. In a random sample of 2,080 participants including healthy and ill adults, Kratzer and colleagues¹⁴ found an ultrasonic mean value of 14 ± 1.7 cm on the midclavicular line.

This study found no significant differences in liver measurement by clinical examination and ultrasound method between male and female individuals ($p > 0.05$). This is not true in the literature. In a study of 915 healthy adults, Niederau and colleagues¹⁵ found a significant difference between genders, but they did not specify the measurement values. In a study of 116 adults, Castell¹¹ concluded that gender is a determining factor for liver size. They discovered that men have larger liver size than women and they even proposed a formula for correcting liver measurement by clinical percussion for each gender. In a sample of 2,080 adults, Kratzer and colleagues¹⁴ found a significant difference for ultrasound liver measurement between male and female individuals. Mean value for men was 14.5 ± 1.6 cm and 13.5 ± 1.7 cm for women. In a study of 307 children aged between 5 days and 16 years, Konus and colleagues¹⁶, however, found no significant size difference in hepatic lobes.

Mean ultrasound-measured liver size in longilinear, normolinear and brevilinear individuals was 12.3 ± 1.6 cm, 10.5 ± 3.2 cm and 12.5 ± 2.4 cm, respectively, the difference being statistically significant ($p = 0.005$). The difference in clinical liver measurement according to the biotype was not statistically significant ($p = 0.470$). These results suggest that there is no relationship between liver volume and body size. In the literature, there are no studies comparing liver measurement with the biotype of participants determined by Charpy's angle, however, there are reports that body weight influences liver size.

Pearson's correlation coefficients between BMI and liver measurement obtained by percussion and by ultrasound were -0.092 and 0.01, respectively, which did not show statistical significance. Assessing individuals with BMI greater than or equal to 25, there was a statistically significant difference between the mean values obtained by both methods ($p = 0.001$). In this group of individuals, the correlation between the two methods showed a Pearson's correlation coefficient of 0.035, not statistically significant. In the group of individuals with BMI less than 25, there was a statistically significant difference between the mean values

obtained by both methods ($p = 0.000$), but in this group the correlation between the two methods showed a Pearson's correlation coefficient of 0.473, with statistical significance ($p < 0.01$).

Kratzer and colleagues¹⁴ found a correlation between body mass index and liver measurement, and discovered that the higher the body mass index of the subject, the greater the liver measurement. Niederau and colleagues¹⁵ observed that body weight as well as body mass index influence liver size. Konus and colleagues¹⁶ found a correlation coefficient of 0.80 between child's weight and liver size. They found that height is the best parameter for the correlation with longitudinal liver size in the midclavicular line in children ($r = 0.85$), and concluded that the greater the child's height, the greater the longitudinal extent of the liver. Altunkaynak and colleagues¹⁷ recently concluded that excessive body weight is a determining factor for hepatomegaly, especially in females.

The results of this study show that liver measurement obtained by clinical examination correlates well with ultrasound method, but underestimates the actual liver size in adults, which can be demonstrated by the statistically significant difference between the final mean value obtained by clinical observation and that obtained by ultrasound method. In subjects with BMI greater than 25, the correlation between the two techniques was not good and it can be inferred that clinical method is less accurate for this group of patients.

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