

# Ultrasound Measurement of Liver Span in Jordanian Adults: A Preliminary Experience

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## Abstract

**Background and Objective:** One of the most frequent ultrasound requests by clinicians is evaluation of hepatic size. Clinical evaluation by percussion and palpation can be inaccurate, unreliable with significant inter-observer variation. Ultrasound remains a very important imaging modality when the liver is concerned because it is simple, practical and easy-to-use. Yet, ultrasound measurement of liver span didn't receive much attention, particularly in this region. The aims of this study were to establish a normal figure of liver span for adults in Jordan, to investigate relationships between liver span and several anthropometric factors including age, gender, weight, height, body mass index and body surface area and to standardize ultrasound measurement of liver span.

**Methods:** A prospective study was carried out at Jordan University Hospital between March 2007 and April 2008, on non-selected population sample of 242 male and 275 female adults with age range of 18-76 years. Statistical analyses including correlation, regression and 95% confidence intervals were performed on the data to test the statistical significance of the various relationships between liver span as represented by midclavicular line longitudinal diameter on one side, and several anthropometric factors including age, gender, weight, height, body mass index and body surface area.

**Results:** our results showed that all anthropometric variables contributed highly and significantly to the variation in female liver span. The same factors however, with the exception of body mass index, significantly contributed to the variation in male liver span, however to a much lesser extent than females. The best predictor of liver span was height in case of males, body surface area in case of females, and both height and body surface area when both genders are considered. The 95% liver span confidence intervals were 12.3-12.8, 11.9-12.3 and 12.2-12.5 for males, females, and both genders combined, respectively.

**Conclusion:** Height and body surface area were the best determinants of liver span in males and females, respectively.

**Keywords:** Midclavicular Line Longitudinal Diameter, Liver Span.

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## Introduction

One of the most frequent ultrasound requests by clinicians is the evaluation of hepatic size.<sup>1</sup> In the past, clinical liver span measurement remained the simplest and most applicable in the developing countries,<sup>2</sup> however, this clinical measurement by percussion and palpation can be inaccurate, unreliable with significant inter-observer variation. Also, palpability below right costal margin is not a good index of hepatic size, especially when there is upward enlargement or downward displacement of the liver.<sup>3</sup>

In addition, radiography or scintigraphy proved to be non-practical because of magnification and unnecessary radiation exposure.<sup>4, 5</sup> Ultrasound remains a very important imaging modality, most popular and wide spread when the liver is concerned because it is simple, quick, practical, accurate, easy-to-use, provides real time images and does not utilize ionizing radiation.<sup>6</sup> Yet, to answer the question of hepatomegaly, ultrasound measurement of liver span didn't receive much attention, particularly in this region; furthermore, no truly simple sonographic way of evaluating hepatomegaly has been agreed upon in this part of the world. Therefore, there is a need to follow an easy, quick, reproducible sonographic method for measuring liver span, specifically for determining presence or absence of hepatomegaly. To achieve this, we sought to determine normal liver span by the Midclavicular Line Longitudinal Diameter (MCLLD) as it is the most commonly applied measure of estimating liver size in routine diagnostic situations, and is proved to be the best measured diameter in differentiating between healthy and diseased livers.<sup>7</sup> Further, good correlation of liver size at midclavicular line between ultrasound and computed tomography was revealed earlier.<sup>8</sup>

The aims of this study were three fold. First, to establish a normal figure of liver span (as measured by MCLLD) for adults in Jordan. Second, to investigate relationships between liver span and several anthropometric factors including age, gender, weight, height, Body Mass Index (BMI) and Body Surface Area (BSA). Third, to standardize ultrasound measurement of

liver span using simple, quick, accurate and reproducible sonographic method.

## Subjects and Methods

A prospective study was carried out at Jordan University Hospital between March 2007 and April 2008, on non-selected population sample of 242 male and 275 female adults with the age range of 18-76 years. All subjects included in this survey were eligible for the study at the time when they were referred for various ultrasound exams unrelated to the measured organ. Included subjects have fulfilled the following criteria, after completing a short questionnaire and giving their informed consent:

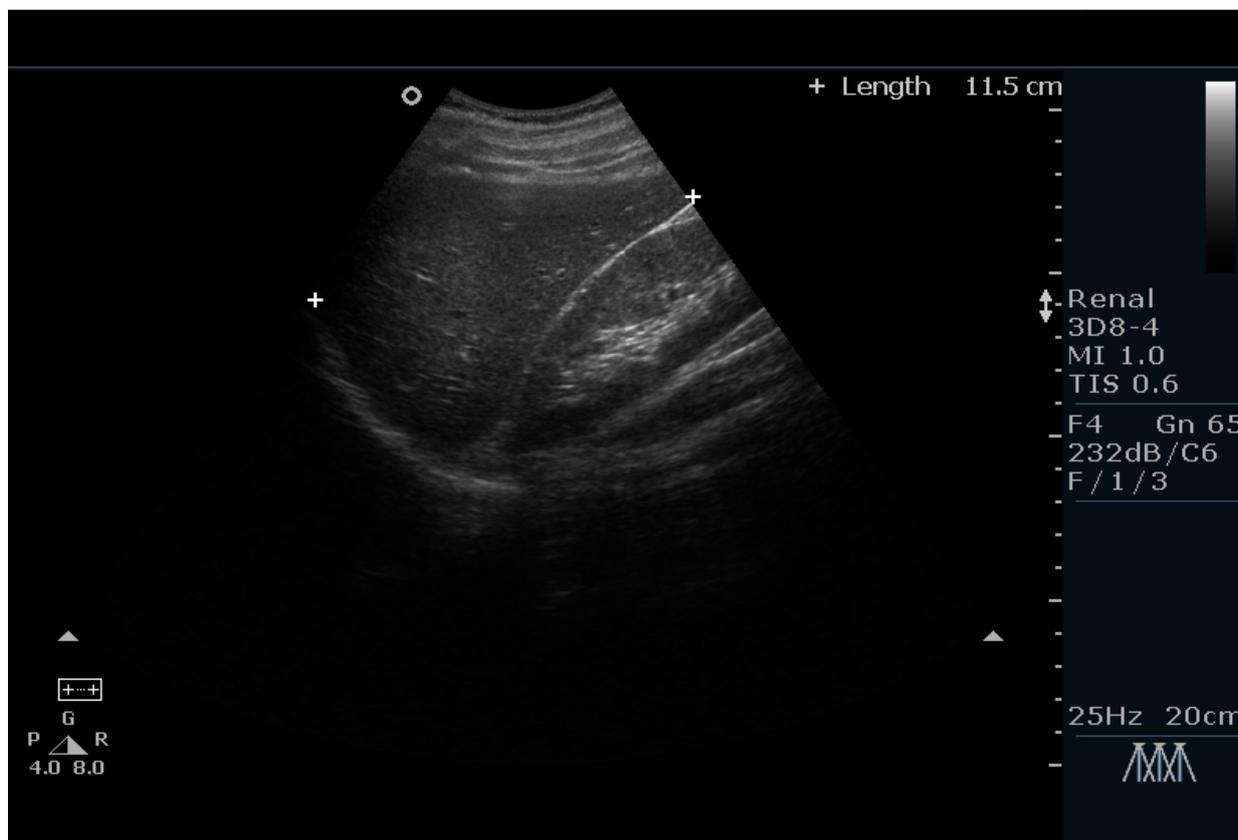
- 1- No history of hepatic, biliary, pancreatic disease or upper abdominal surgery.
- 2- No history of frequent alcohol consumption.
- 3- No history of Diabetes Mellitus.
- 4- No history of oncologic, haematologic or traumatic conditions.
- 5- Normal clinical exam of chest, abdomen and pelvis, particularly no clinical signs of liver disease.
- 6- All subjects with disorders known to affect the liver, particularly hepatitis B & C and congestive heart failure, were excluded.
- 7- Pregnant women were excluded.
- 8- Any subject with body weight more than 95 kg or less than 50 kg was excluded as she/he can have different orientation of the liver necessitating a report of further parameters for the determination of liver size.<sup>7</sup>

In addition, all subjects included have demonstrated normal homogenous echopattern of the liver without evidence of fatty change or focal hepatic abnormality. Demographic data including age, gender, height and weight were recorded for each subject; and Body Mass Index (BMI) and Body Surface Area (BSA) were calculated for each subject.

The study was conducted by six radiologists in a pair fashion where the Craniocaudal liver diameter at midclavicular line for each subject was measured independently by two radiologists and the average measurement was used.

All measurements were taken in supine position during deep inspiration to reduce masking by the lung, with the right hand under the head to raise the lower costal margin. Measurements were made from hepatic dome down to lower hepatic margin (Figure 1) using curvilinear probe (2-4 MHz) on a high resolution real time scanner (Philips HD 11). All measurements were recorded to the nearest millimeter.

Statistical analyses including correlation, regression and 95% confidence intervals were performed on the data to test the statistical significance of the various relationships between liver span as represented by MCLLD on one side, and several anthropometric factors including age, gender, weight, height, BMI and BSA.



**Figure (1):** Measurement of MCLLD from hepatic dome to lower hepatic margin.

## Results

The means and standard deviations of liver span along with the studied anthropometric variable are shown in Table (1). Males are nearly three years older than females, 41 compared to 38 years old, and this difference was significant as revealed by the univariate ANOVA (p-value = 0.013). Males are nearly seven kgs heavier than females, 75 compared to 68 kgs, and this difference was statistically significant (p-value = 0.000). However, females have larger weight variation than males as indicated by the larger

standard deviation. Males are nearly 11 cms taller than females, 172 compared to 161 cms, and this difference was statistically significant (p-value = 0.000). The BMI for females is significantly larger than the BMI for males (p-value = 0.012), 24.2 compared to 23.4. Similar to weight, females' BMI has larger variation compared to males as indicated by the larger standard deviation. The BSA for males is significantly larger than BSA for females (p-value = 0.000), 1.89 compared to 1.74. Again, similar to weight and BMI, females' BSA has larger variation compared to males.

**Table (1): Study Results by Gender.**

<b>Variable</b>	<b>Variable Mean and (Standard Deviation)</b>			<b>ANOVA P-Value</b>
	<b>Males (242 Subjects)</b>	<b>Females (275 Subjects)</b>	<b>Both (517 Subjects)</b>	
<b>Age (Years)</b>	41.1 (16.1)	37.8 (13.7)	39.3 (15.0)	0.013
<b>Weight (Kg)</b>	75.1 (11.3)	68.4 (16.1)	71.5 (14.4)	0.000
<b>Height (cm)</b>	172.2 (8.3)	161.0 (8.7)	166.2 (10.2)	0.000
<b>BMI</b>	23.4 (4.0)	24.2 (6.4)	23.8 (5.4)	0.012
<b>BSA</b>	1.89 (0.16)	1.74 (0.21)	1.81 (0.20)	0.000
<b>MCLLD</b>	12.6 (1.7)	12.1 (1.9)	12.3 (1.8)	0.005

Males liver span, as measures by the MCLLD, is significantly larger than that for females (p-value= 0.005), 12.6 compared to 12.1 cms. Thus, based on the aforementioned results, it is evident that male and female adults have significantly different characteristics in terms of age, weight, height, BMI and BSA. This fact has led to the conclusion that further analyses should be performed separately for both genders.

Statistical correlation analyses were performed between liver span, as measures by the MCLLD, on one side and anthropometric variables on the other for males, females and both genders combined. The results of these analyses are shown in Table (2). The correlation coefficient between liver span and age for male subjects was found to be negative, in the order of -0.12, and was statistically significant at the 0.05 level. For female subjects, liver span had a positive correlation coefficient with age, in the order of 0.15, and was statistically significant. That means age significantly contributed to the variation in liver span, however in opposing directions for males and females. While liver span increases with advanced age in the case of females, the opposite is true for males. Female weight had revealed a strong positive correlation with liver span, in the order of 0.49, and was statistically significant. Male weight, however, had much poorer positive correlation with liver span, in the order of 0.11, but still statistically significant. Height followed the same rhythm of weight as it significantly and positively correlated with liver span; with correlation coefficients of 0.29 and

0.19 for females and males, respectively. Female BMI had revealed a strong positive correlation with liver span, in the order of 0.45, and was statistically significant. Male BMI, on the other hand, had much poorer positive correlation with liver span, in the order of 0.08, and was not statistically significant. Female BSA had shown the strongest correlation with liver span, in the order of 0.51, and was statistically significant. Male BSA, on the other hand, had much poorer correlation with liver span, in the order of 0.11, but still statistically significant. Overall, it is clear from these correlation analyses that the studied anthropometric variables contributed highly and significantly to the variation in female liver span. The same factors however, with the exception of BMI, significantly contributed to the variation in male liver span, however to a much lesser extent than that of females.

To quantify the interdependence between liver span, as measured by the MCLLD, on one side, and the studied anthropometric variables on the other, regression analyses were performed. In the regression models, the dependent variable was the liver span represented by the MCLLD, while the independent variables were age, weight, height, BMI and BSA. Three separate regression models were developed for males, females and both combined. The stepwise regression procedure was used to develop the three models. Equations 1, 2 and 3 show the three developed models for males, females and both genders combined, respectively.

$$\text{Liver Span} = 6.168 + 0.037 \text{ Height} \quad (1)$$

$$\text{Liver Span} = 3.943 + 4.701 \text{ BSA} \quad (2)$$

$$\text{Liver Span} = 4.580 + 0.014 \text{ Height} + 3.003 \text{ BSA} \quad (3)$$

Where,

Liver Span: represented by MCLLD in cms,

Height: adult height in cms, and

BSA: body surface area in (kg x cm)<sup>0.5</sup>

Table (2): MCLLD Correlation with Study Factors by Gender.

Variable	Variable Coefficient of Correlation with MCLLD According to Gender		
	Males (242 Subjects)	Females (275 Subjects)	Both (517 Subjects)
Age (Years)	-0.12*	0.15*	0.04
Weight (Kg)	0.11*	0.49*	0.38*
Height (cm)	0.19*	0.29*	0.27*
BMI	0.08	0.45*	0.31*
BSA	0.11*	0.51*	0.38*

\* Significant correlation at 0.05 level.

Thus, the best predictor of liver span was height in case of males, BSA in case of females, and both height and BSA when both genders are combined. All three models were statistically significant at the 0.05 level. The adjusted R-square for model 1 (males) was 0.032 indicating that nearly only 3% of the variation in male liver span could be explained by male height. The adjusted R-square for model 2 (females) was 0.261 indicating that nearly 26% of variation in female liver span could be explained by female BSA. The adjusted R-square for model 3 (both males and females combined) was 0.187 indicating that nearly 19% of the variation in liver span, regardless of gender, could be explained by both height and BSA combined. Overall, it is clear that height and BSA are the best anthropometric variables in terms of explaining variation in liver span.

Ninety-five percent confidence intervals were constructed for liver span in males, females and both genders combined. The 95% confidence intervals were 12.3-12.8, 11.9-12.3 and 12.2-12.5 for males, females, and both genders combined, respectively.

## Discussion

Ultrasound is a cornerstone imaging method in the evaluation of the liver simply because it is easy to use, inexpensive, quick, provides real time images and doesn't require anesthesia or utilize ionizing radiation. Unfortunately, to the best of our knowledge, no published studies have examined liver diameter at MCL and its potential influence parameters in a large collective in this part of the world.

Longitudinal hepatic diameter at MCL is the most commonly applied and predominant clinical method of estimating liver size in routine diagnostic situations.<sup>9-11</sup> As well, it proved to be the best measured diameter in differentiating between healthy and diseased livers, had a better correlation with autopsy studies and BSA measurement, and was proved to be an easy practical method for routine use in this purpose.<sup>1, 6, 7</sup> Therefore, we chose to use only longitudinal hepatic diameter at MCL for liver size measurement in this study.

Niederau et al.<sup>9</sup> conducted a prospective study in Germany on a large group of adult healthy subjects; 840 men and 160 women. Results of our survey were in-line with Niederau et al.'s results in three main aspects.

First, studied diameter (MCLLD) showed a positive correlation mainly with BSA and height. Second, both studies showed larger diameters in men compared to women and this result had been confirmed by autopsy studies which found that men have larger gastrointestinal organs than women.<sup>12, 13</sup> Third, measured diameter decreased with age in Niederau et al's survey in line with our result of negative correlation between age and liver size in males; bearing in mind that the majority of Niederau et al.'s sample were men (840 males out of 1000). However, the mean liver size in our study was 12.3 cms compared to 10.5 cms in Niederau et al.'s study. This difference may be attributed to relatively high BMI values in our sample.

Our results are generally in agreement with previous surveys of liver size by clinical methods, autopsy and Ultrasound.<sup>2, 13-15</sup> Our results were in accord with Singh K et al. and Toukan et al. as both studies, similar to this study, have concluded that height is a major determinant of liver span. Even, height was the best determinant of liver span in Singh et al.'s survey, probably because the mean age of his population sample was only 17 years (clearly a young population sample where height is a major variable). Our survey results also agree with Toukan et al. in regard to greater liver size in males compared to females; and in agreement with other previous research results.<sup>12, 13</sup> However, when liver span was correlated with weight, we didn't agree with Toukan et al.'s; as we concluded a positive correlation in-line with other studies.<sup>2,9,15,16</sup>

Kratzer et al.<sup>17</sup> conducted a similar prospective study on a larger population to establish normal value for liver diameter at MCL and to determine the influence of sex, height, BMI and alcohol consumption on liver size. In their sample, the average measured liver diameter at MCL was 14.0 cms compared to 12.3 cms in our study. This difference may be attributed to the higher values of heights (171 cms compared to 166) and weights (77 kgs compared to 71 kgs) in their sample. Another explanatory factor is the fact that in their study they observed an increase in average liver diameter with higher frequency of

alcohol consumption, while in our study all subjects with history of frequent alcohol consumption were excluded. Kratzer et al also concluded that sonographic measurement of liver size at the MCL is a practical and easy method for routine use; in support of the adoption of this method in this study.

We could find only one published study that dealt with this subject in the Arab World, this came from Egypt by El Sharkawy et al.<sup>17</sup> They found that average right hepatic lobe diameter at MCL sagittal plane was 14.6 cms in a 77 adult subjects (out of 217 inclusive of children); larger than our figure of 12.3 cms. Possibly, this may be due to the fact that their study was conducted on a limited number and in a very limited geographic area (Kalama village in Nile delta) where Schistosomiasis and hepatitis are endemic diseases.

At the end, a very important aspect must be stressed is the fact that our average measured liver diameter seem close enough to 13 cm or less in line with the work of Gosink and Leymaster<sup>1</sup> who correlated liver data obtained at autopsy with anthropometric data to make the diagnosis of hepatomegaly. These findings were compared with sonographic measurements obtained from the same patients shortly before their death. They concluded that when ultrasound measured liver diameter was 13 cm or less, 93% of livers were considered of normal size, while when ultrasound measured liver diameter was 15.5 cm or greater, autopsy findings in connection with anthropometric data permitted diagnosis of hepatomegaly in 75% of studied cases.

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## قياس حجم الكبد بالتقنية فوق الصوتية عند البالغين الأردنيين: دراسة تقديرية

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### الملخص

**الهدف:** يُعدُّ تقدير حجم الكبد من أكثر طلبات الأطباء المألوفة في الدراسة فوق الصوتية؛ حيث إن تقديره من الناحية السريرية (بالقرع والجس) غير دقيق ولا يعتمد عليه، إضافة لاختلاف النتائج حسب الفاحص، لذلك تبقى الدراسة فوق الصوتية الإجراء الأهم بخصوص الكبد؛ فهو إجراء بسيط وعملي وسهل التطبيق، ولا يزال قياس الكبد لا يلاقي الاهتمام الكافي في منطقتنا. تهدف هذه الدراسة إلى وضع صورة قياسية لقياس الكبد لدى البالغين في الأردن، وبحث العلاقة بين قياس الكبد وعوامل متعددة أخرى، مثل: العمر، والجنس والوزن والطول ومؤشر كتلة الجسم ومساحة سطح الجسم؛ وذلك لوضع معايير موحدة لقياس الكبد.

**منهج الدراسة:** دراسة مستقبلية أجريت في مستشفى الجامعة الأردنية بين شهري آذار (مارس) لعام 2007 ونيسان (إبريل) لعام 2008 على عينة عشوائية من المراجعين، 242 منهم من البالغين الذكور و275 من البالغين الإناث، بمتوسط أعمار بين 18-76، وقد تم تطبيق التحاليل الإحصائية على البيانات للربط بين قياس الكبد، وعوامل متعددة مثل العلاقة بين القطر الطولي على مستوى الخط الناصف للترقوة من جهة والعمر والوزن ومتوسط كتلة الجسم ومساحة سطح الجسم من جهة أخرى.

**النتائج:** أظهرت نتائج الدراسة أن جميع العوامل المتغيرة تؤثر على نحو عالٍ ومهم في اختلاف قياس الكبد لدى الإناث، والعوامل ذاتها باستثناء مؤشر كتلة الجسم تؤثر في اختلاف قياس الكبد لدى الذكور، وإن يكن على نحو أقل من الإناث. وكان الطول يلعب الدور الأهم في التنبؤ بقياس الكبد لدى الذكور، في حين كان لمساحة سطح الجسم الدور الأهم في التنبؤ بقياس الكبد لدى الإناث، والعاملان سوية في حال الجمع بين حالات الذكور والإناث.

وكانت 95% من قيم قياس الكبد كالتالي:

للذكور 12,3 – 12,8

للإناث 11,9 – 12,3

لدى جمع الجنسين 12,2 – 12,5

**النتيجة:** يعد كل من الطول ومساحة سطح الجسم من أفضل العوامل المساعدة لتوقع قياس الكبد لدى الذكور ومساحة سطح الجسم لدى الإناث.

**الكلمات الدالة:** القطر الطولي على مستوى الخط الناصف للترقوة، قياس الكبد.