



## Clinical and Ultrasonographic Assessment of Liver Span in Children

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### ABSTRACT

**Background:** *Hepatomegaly is an important clue to a variety of systemic pathological conditions. Palpable liver does not denote hepatomegaly. Measurement of liver span is more reliable than palpation just below costal margin. Ultrasonographic evaluation of liver size provides accurate measurement of liver size. This study was carried out to find the correlation of clinical and ultrasound measurement of liver size in various age groups and correlation of each with age, sex, height and weight.*

**Methods:** *600 children from newborn to 12 years of age were included in the study. Using a structured proforma, baseline data, clinical liver span and ultrasound measurement of liver were documented.*

**Results:** *The mean (SD) liver span by clinical method was 5.6 (0.426) in the newborn period and it closely correlated with ultrasound measurement of 5.7 (0.375). The correlation existed in all the age group and was found to be significant. Liver span had significant correlation with height ( $r=0.89$ ) and weight ( $r=0.86$ ). It also had significant correlation with age ( $r=0.90$ ). There was no significant correlation between sex and mean liver span. Multiple linear regression revealed that age, height and weight had significant influence on liver span with age being the most important factor.*

**Conclusion:** *Clinical estimates of liver span closely correlates with ultrasound measurements. Clinical methods should continue to be used for estimation of liver size.*

**Keywords:** *liver span, palpation, ultrasound.*

### Introduction

Liver is one of the principal organs of our body involved in over 500 physiological functions related to metabolism, digestion, immunity etc., which makes it an essential organ for sustaining life. Measurement of liver is particularly important when hepatic disease is suspected <sup>(1)</sup>. The clinical evaluation of liver size by assessing the liver span is more reliable index than palpation

just below the costal margin<sup>(2)</sup>. Ultrasonography is a non-invasive, safe, quick and accurate method for measurement of liver and other visceral organs<sup>(3)</sup>. This study was done to determine the clinical and ultrasound liver span measurements in various age groups, their correlation and correlation of each with age, sex, height and weight.

## Methods

We enrolled 600 children from newborn to 12 years, visiting the outpatient department of Institute of Child Health and Hospital for Children, Chennai, either for routine immunization or with minor dermatological ailments or accompanying their siblings. This prospective observational study was done over a period of one year from October 2006 to October 2007. Children with fever, any systemic illnesses like cardiovascular, respiratory, neurological and abdominal problems were excluded from the study. At each age group, 50 observations were taken (25 male and 25 female) and sampling was done using Stratified random sampling. Informed, written consent was obtained from accompanying caregivers/ parents of all children.

A structured proforma was used to document baseline data including the age, sex, weight and length/height of all the children. The age was recorded to the nearest completed month. An electronic weighing scale (with accuracy 5 g) and a wall-mounted stadiometer (1 mm markings)/ infantometer were used to measure the weight and height/length, as per standard methodology<sup>(4)</sup>. The midclavicular point was identified in each child and a vertical line was drawn from the midclavicular point to the midinguinal point and was defined as the midclavicular line (MCL). All clinical and sonographic measurements were recorded with reference to this line<sup>(5)</sup>.

All the enrolled children underwent sonographic examination with high-resolution real-time

scanner LOGIQ 500MD with 3.5MHz convex transducer on the same day of clinical examination. The longitudinal axis was measured after clear visualization of liver in mid-clavicular plane. Upper most edge under the dome of the diaphragm was defined as the upper margin whereas the lower most edge was defined as the lower margin and the distance between the two measured in mid-clavicular line<sup>(6)</sup>. All measured livers had a normal position and echo texture.

The mean clinical liver span, ultrasound liver span and their standard deviations (SD) were tabulated. Correlation between the clinical and ultrasound liver span measurements were studied using Pearson's correlation. Correlation of liver span with age was derived from Spearman's correlation. Mean and SD of liver span of both sexes were obtained individually and 'p' value calculated. Linear regression analysis was done to study the influence of age, sex, weight and height on the liver span. Statistical analysis was done using SPSS software.

## Results

600 children were enrolled in the study. The liver span was found to increase with age. The mean (SD) liver span by clinical method was 5.6 (0.426) in the newborn period and it closely correlated with ultrasound measurement of 5.7 (0.375). The correlation existed in all the age group and was found to be significant as shown in the table (1).

**Table (1).** Liver span by clinical method & ultrasound and its correlation

Age	Clinical Liver Span			Ultrasound liver span			Pearson's Correlation	'p' value
	Male	Female	Overall	Male	Female	Overall		
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)		
<b>Newborn month) (0-1)</b>	5.5 (0.479)	5.7 (0.354)	5.6 (0.429)	5.6 (0.389)	5.8 (0.339)	5.7 (0.375)	0.84	0.00
<b>Infancy months) (1-12)</b>	5.7 (0.52)	5.8 (0.54)	5.75 (0.527)	6.4 (0.713)	6.6 (0.770)	6.5 (0.742)	0.78	0.00
<b>1-2 years</b>	6.0 (0.433)	6.2 (0.433)	6.1 (0.440)	6.9 (0.742)	7.3 (0.686)	7.1 (0.703)	0.70	0.00
<b>2-3 years</b>	7.0 (0.479)	6.7 (0.456)	6.85 (0.487)	8.1 (0.773)	7.9 (0.657)	8 (0.717)	0.68	0.00
<b>3-4 years</b>	7.5 (0.5)	7.3 (0.577)	7.4 (0.544)	8.4 (0.334)	8.2 (0.526)	8.3 (0.564)	0.74	0.00

<b>4-5 years</b>	7.8 (0.52)	7.6 (0.515)	7.7 (0.515)	8.8 (0.43)	8.6 (0.383)	8.7 (0.370)	0.66	0.00
<b>5-6 years</b>	7.9 (0.577)	7.7 (0.433)	7.8 (0.505)	8.9 (0.594)	8.7 (0.483)	8.8 (0.545)	0.71	0.00
<b>6-7 years</b>	8.4 (0.599)	8.2 (0.52)	8.3 (0.535)	9.1 (0.539)	9.0 (0.583)	9.05 (0.558)	0.72	0.00
<b>7-8 years</b>	8.6 (0.595)	8.5 (0.612)	8.55 (0.600)	9.5 (0.550)	9.3 (0.789)	9.4 (0.680)	0.68	0.00
<b>8-9 years</b>	9.1 (0.595)	9.0 (0.736)	9.05 (0.753)	9.9 (0.563)	9.6 (0.524)	9.75 (0.560)	0.79	0.00
<b>9-10 years</b>	9.2 (0.52)	9.1 (0.661)	9.15 (0.625)	10.1 (0.597)	10.0 (0.575)	10.05 (0.583)	0.75	0.00
<b>10-12 years</b>	9.25 (0.765)	9.2 (0.677)	9.225 (0.598)	10.4 (0.526)	10.2 (0.787)	10.3 (0.670)	0.77	0.00

Liver span had significant correlation with height ( $r=0.89$ ) and weight ( $r=0.86$ ). It also had significant correlation with age ( $r=0.90$ ). There was no significant correlation between sex and mean liver span as shown in Table (2). Univariate regression analysis was done to analyze the influence of age, height and weight and all the

three had significant influence as shown in Table (3). Multiple linear regression was done to find the independent influence of age, height and weight (corrected for other factors) and all the factors had significant influence on liver span with age being the most important factor as shown in Table (4).

**Table (2).** Correlation of Liver span with Height, Weight, Age and Sex

Correlation with Height and Weight		
	Pearson Correlation	'p' value
Height	0.89	0.00
Weight	0.86	0.00
Correlation with Age		
	Spearman's Correlation	'p' value
Age	0.90	0.00
Correlation with Sex		
	Mean Liver Span (SD)	'p' value
Male	8.6 (1.5)	0.44
Female	8.5 (1.3)	

**Table (3).** Univariate Linear Regression Analysis

	Regression coefficient	95% confidence limits	'p' value
Age	0.36	0.35, 0.38	0.00
Height	0.048	0.046, 0.05	0.00
Weight	0.18	0.17, 0.19	0.00
Sex Male	0.089	-0.14, 0.32	0.44
Female	0.0		

**Table (4)** Multiple Linear Regression Analysis

	Regression coefficient	95% confidence limits	'p' value
Age	0.12	0.05, 0.19	0.00
Height	0.025	0.02, 0.03	0.00
Weight	0.031	0.01, 0.05	0.002

**Discussion**

Liver size gives us information about the diagnosis and course of gastro-intestinal and hematological diseases. Clinical liver span

findings contribute to the clinical diagnosis and management, especially in emergency settings as in management of shock. Enlargement of liver can be the earliest sign of incipient cardiac failure. To

determine whether liver is enlarged significantly, it is important to establish the expected size. The clinical assessment of liver size by percussion is a simple practical measure of assessing liver size.

The accurate assessment of liver size is an important part of the clinical examination. Sheila Sherlock states "Percussion is a valuable method of determining liver size"<sup>(7)</sup>. Clinical examination of the liver should include percussion and size of the organ expressed as the liver span in centimeters in the mid-clavicular line<sup>(8)</sup>.

Clinical liver span measurement by percussion is prone for inter-observer variation and there may be difference between clinical and ultrasound measurements. Further, palpation of liver in small children is different from the adults in that holding breath in inspiration needed for accurate palpation is rather difficult in children<sup>(9)</sup>. This study analyses the clinical measurement, ultrasound measurement, their correlation, significance of the difference and correlation with anthropometric parameters like age, sex, height and weight.

There was 0.1cm to 0.7cm difference between the observations in various age groups in present study and norms by Naveh and Berant<sup>(10)</sup>. Nelson states liver span ranges from 4.5 to 5cm at one week of age to approximately 7-8cm in boys and 6-6.5 cm in girls by 12 years of age<sup>(11)</sup>. Measurable liver span by percussion ranged from 3.5cm to 10.5cm and increased curvilinearly with increasing age( $p=0.00$ ). In a similar study by Lawson et al, measurable liver span ranged from 1.5cm to 10.5cm, and increased curvilinearly with increasing age. In this respect, the pattern of liver growth closely resembles that of body weight and height<sup>(9)</sup>.

Diagnostic imaging techniques are superior to clinical examination in determining liver size<sup>(12)</sup>. The sonographic measurement of the liver size at mid-clavicular line was shown to be an easy and practical method for routine use by Kratzer et al<sup>(13)</sup>. Sonography is routinely used to evaluate visceral organs in children because it offers numerous advantages<sup>(14)</sup>. There is no radiation, cost effective, portable, and non-invasive. It can

be repeated if needed. Further, the examination is real time, tri-dimensional and independent of organ function. However, plenty of research is required to establish normal and borderline values and to have uniform procedure for measuring liver size using ultrasound. The method used in this study is oriented to the method described by Rumack et al<sup>(6)</sup>.

The correlation between clinical and ultrasound measurement showed good correlation( $r= 0.91$ ). It also correlated well age-wise. In a study by Skrainka et al, estimation of liver span by direct percussion was as accurate as ultrasound. However, that by indirect percussion was inaccurate<sup>(15)</sup>. Chen CM et al showed that the liver span measured by clinical methods with percussion and percussion/ palpation methods correlated well with that measured by ultrasound<sup>(16)</sup>. In our study, there was a difference of up to 1.1cm in various age groups and ultrasound measurement was higher than clinical liver span measures.

There was a significant correlation between age and liver span by ultrasound ( $r = 0.90$ ,  $p = 0.00$ ) and as age increased, liver span increased. In the newborns, infancy and one year, liver span of girls were more than that of boys. From two years of age, the liver span was comparatively more in boys throughout up to 12 years of age. This holds true for both clinical and ultrasound measurements. The well-known phenomenon that the male gastro-intestinal organs are larger than the females has been documented in studies using diagnostic imaging. In autopsy studies, men had larger gastro intestinal organs than women<sup>(17)</sup>. In our study, this sex difference was not statistically significant ( $p = 0.44$ ). Similarly, in a study regarding factors affecting liver size in adults by Kratzer et al, their data showed, sex specificity was not clinically relevant<sup>(13)</sup>. Lawson et al in their study found that liver growth in children appeared to be sex specific and both age and sex were major influencing factors<sup>(9)</sup>. Liver span had good independent correlation with both height and body weight ( $r = 0.89$  and  $0.86$  respectively).

Castell et al estimated the limits of normal liver span in adult Americans, correlated with height and weight, and found that liver span was best-predicted using combination of height and weight. Height independent of sex was also an equally good predictor. A correlate between organ size and weight in anthropometric findings is supported by ultrasound studies and studies based on autopsy finding<sup>(18)</sup>. In a similar study by Safak et al, weight showed the strongest correlation to liver span<sup>(19)</sup>. Konus et al evaluated the normal liver size in 307 children by ultrasound and relationship of the dimensions with sex, age, height and weight. Longitudinal diameter showed the best correlation with age, weight, and height. Height showed the strongest correlation of the all<sup>(20)</sup>. On analysis with Univariate regression, age, height and weight exerted an influence on the liver span, whereas sex did not have significant influence in this study. Multiple linear regressions were done to find the independent influence of age, height and weight. All factors showed an influence on the liver span. Age was the most important factor influencing liver span.

### Conclusion

Clinical estimate of liver span strongly correlates with ultrasound measurement and remains a simple practical measurement of liver size. In addition to size, it provides other details like tenderness, liver edge, nodularity, consistency of surface etc. Bedside assessment of liver should continue to be used for estimation of liver sizes.

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