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Original Article

The nomograms of sonographic measurements of the liver, spleen, and kidney in preterm and term neonates

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Abstract

Aim: To determine the reference values of normal ranges for liver, spleen and kidney dimensions for the preterm and term neonates

Material and Methods: In this retrospective study, spleen, liver and kidney dimensions were evaluated in 222 healthy newborns with a gestation age of over 24 weeks at neonatal intensive care unit with sonography within the first week of life. Relationships of all dimensions with sex, gestational age, height and weight were statically analysed.

Results: No statistically significant differences were found between the two sexes in any dimensions of the liver, spleen and kidney ($p>0.05$) . Gestational age, weight, and height were positively correlated with organ size ($p<0.01$). Weight showed the best correlation of the measurements. Significant differences were observed between organ sizes in preterm and term infants ($p=0.02$)

Conclusions: The reference values of spleen, liver and renal lengths and diagrams from this study may be useful in the sonographic evaluation of the preterm and term infants

Keywords: Kidney dimension; liver dimension; nomogram; preterm and term neonates; spleen dimension; ultrasonography

INTRODUCTION

Publications discussing the lengths of the liver and spleen in infants of normal size, weight, and gestational age according to appropriate histograms during the neonatal period are limited (1-5). Knowing the size of the liver and spleen in preterm and term infants will permit the evaluation of the development of these organs in infants. It will assist physical examination, which is more difficult in the neonatal period than other periods. Sonography is the preferred screening method for the evaluation of organ size during the neonatal period. The main reason for this preference is that sonography does not contain ionizing radiation; it can be easily performed at the bedside, and it is inexpensive (6,7).

In this study, we aimed to determine whether sonography is an appropriate method to evaluate whether the size of the liver and spleen, weight, and gestational age are acceptable according to the developmental percentile and whether these measurements could contribute to the creation of a nomogram.

MATERIAL and METHODS

A retrospective analysis was performed by reviewing the reports of infants who were evaluated in the neonatal clinic and neonatal intensive care unit between May 2018 and November 2019. Procedures performed with ultrasound evaluation in the first seven days of life were included in the study. The evaluations of infants with congenital abnormalities, metabolic diseases, congenital infections, or significant growth retardation were excluded from the study. Those younger than 38 gestational weeks were accepted as preterm (1).

In addition, the laboratory values of infants were retrospectively evaluated, and those with abnormal values were excluded. Gestational age was evaluated based on notes in the system.

Patients were divided into four groups according to gestational week: Group 1, 24- 31; Group 2, 32-35; Group 3, 36-37; and Group 4, 38-41.

The reports of a single pediatric radiologist during the ultrasound procedure were evaluated. Craniocaudal size and the liver midclavicular line were measured during ultrasound. The spleen size was likewise evaluated over the midclavicular line. Measurements before and after the procedure were evaluated using Hitachi Hi-Vision Airus (Steinhausen, Germany) and MyLab 60 (Esaote Biomedica, Genoa, Italy) with a 5 MHz probe.

MedCalc Statistical Software version 19.1 (MedCalc Software bv, Ostend, Belgium; https://www.medcalc.org;

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2019). Post-hoc multiple comparisons were made with one-way ANOVA and Scheffe's method. The Pearson coefficient was accepted for correlation. P values of less than 0.05 were accepted as statistically significant.

RESULTS

The records of 290 infants were retrospectively examined, and a total of 222 infants were included in the study. The remaining 68 infants were excluded from the study because their retrospective data could not be obtained from the patient notes. In our study, 100 of 222 patients were preterm infants (45%), and the remaining 122 patients were term infants (55%). The mean gestational age was 38.2 ± 3.2 weeks (24-40.3 weeks), and the average birth weight was 2600 ± 916 g (815-4200 g). No significant difference was found between the organ sizes between sexes (p>0.05)(Tables 1-8). Significant differences were observed between organ sizes in preterm and term infants (p=0.02). Gestational age, weight, and height were positively correlated with organ size (p<0.01). Weight showed the best correlation of the measurements. (r=0.52, p=0,02) (Figure 1).

Table 1. Liver craniocaudal length according to gestational age based on the last menstrual period

Gestational Age	N	Minimum	Maximum	Mean	Median	SD	RSD	5 - 95 P
24-31 weeks	36	2.550	5.950	4.124	4.000	0.9530	0.2311	2.725 to 5.870
32-35 weeks	34	3.400	6.450	5.359	5.600	0.8561	0.1598	3.620 to 6.390
36-37 weeks	30	3.700	6.700	5.037	5.050	0.8323	0.1653	3.800 to 6.500
38-41 weeks	122	3.600	7.900	5.871	5.850	0.9597	0.1635	4.360 to 7.540

Table 2. Spleen craniocaudal length according to gestational age based on the last menstrual period

Gestational Age	N	Minimum	Maximum	Mean	Median	SD	RSD	5 - 95 P
24-31 weeks	36	1.900	3.700	2.731	2.700	0.4180	0.1531	2.030 to 3.570
32-35 weeks	34	1.800	4.200	2.838	2.750	0.6401	0.2255	1.900 to 3.960
36-37 weeks	30	2.400	4.600	3.540	3.550	0.6636	0.1875	2.400 to 4.500
38-41 weeks	122	2.500	5.100	4.180	4.200	0.4870	0.1165	3.420 to 4.840

Table 3. Spleen width according to gestational age based on the last menstrual period

Gestational Age	N	Minimum	Maximum	Mean	Median	SD	RSD	5 - 95 P
24-31 weeks	36	0.900	2.000	1.425	1.400	0.2912	0.2043	1.000 to 1.900
32-35 weeks	34	1.000	2.400	1.726	1.750	0.3856	0.2233	1.100 to 2.300
36-37 weeks	30	1.100	2.600	1.873	1.950	0.3463	0.1849	1.200 to 2.400
38-41 weeks	122	1.000	2.800	1.839	1.800	0.3938	0.2142	1.200 to 2.500

Table 4. Left kidney length according to gestational age based on the last menstrual period

Gestational Age	N	Minimum	Maximum	Mean	Median	SD	RSD	5 - 95 P
24-31 weeks	36	2.300	4.200	3.144	3.100	0.5474	0.1741	2.400 to 4.070
32-35 weeks	34	2.300	4.400	3.479	3.500	0.5014	0.1441	2.480 to 4.280
36-37 weeks	30	3.300	4.900	4.097	4.050	0.4552	0.1111	3.500 to 4.900
38-41 weeks	122	2.700	6.300	4.638	4.600	0.7350	0.1585	3.600 to 5.800

Table 5. Left kidney width according to gestational age based on the last menstrual period

Gestational Age	N	Minimum	Maximum	Mean	Median	SD	RSD	5 - 95 P
24-31 weeks	36	1.100	2.600	1.836	1.900	0.3697	0.2013	1.230 to 2.470
32-35 weeks	34	1.100	2.600	1.847	1.900	0.3653	0.1978	1.220 to 2.380
36-37 weeks	30	1.100	2.500	1.833	1.900	0.3781	0.2063	1.200 to 2.400
38-41 weeks	122	1.100	2.600	1.869	1.900	0.3675	0.1966	1.260 to 2.500

Table 6. Left kidney parenchymal thickness according to gestational age based on the last menstrual period

Gestational Age	N	Minimum	Maximum	Mean	Median	SD	RSD	5 - 95 P
24-31 weeks	36	4.000	7.000	5.389	5.000	0.9936	0.1844	4.000 to 7.000
32-35 weeks	34	4.000	7.000	5.176	5.000	0.7576	0.1464	4.000 to 6.000
36-37 weeks	30	5.000	7.000	5.833	6.000	0.7466	0.1280	5.000 to 7.000
38-41 weeks	122	4.000	8.000	6.000	6.000	0.9959	0.1660	5.000 to 8.000

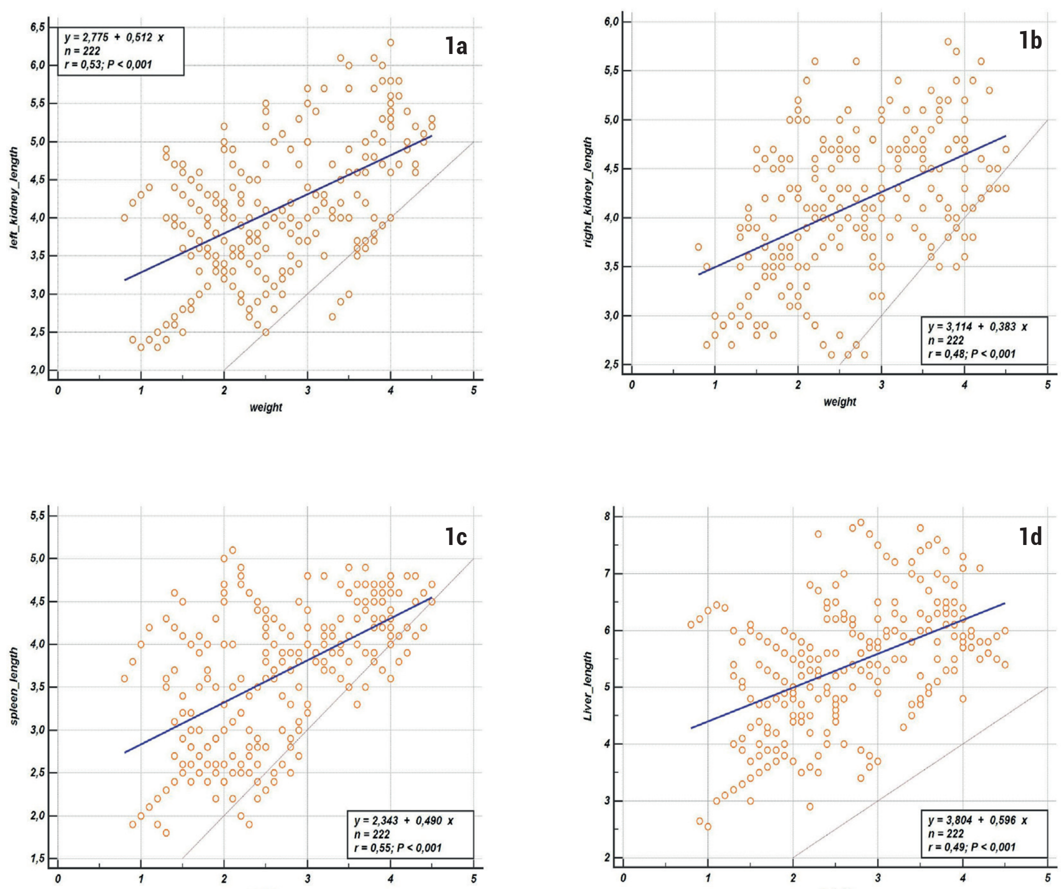

Figure 1. 1a shows the scatter diagram of left kidney length and weight, 1b shows the scatter diagram of right kidney length and weight, 1c shows the scatter diagram of spleen length (craniocaudal) and weight, 1d shows the scatter diagram of liver length (craniocaudal) and weight

Table 7. Right kidney length according to gestational age based on the last menstrual period								
Gestational Age	N	Minimum	Maximum	Mean	Median	SD	RSD	5 - 95 P
24-31 weeks	36	2.600	4.300	3.386	3.350	0.5632	0.1663	2.600 to 4.270
32-35 weeks	34	2.700	4.900	3.747	3.800	0.5287	0.1411	2.900 to 4.680
36-37 weeks	30	2.800	4.700	3.997	4.050	0.5810	0.1454	2.900 to 4.700
38-41 weeks	122	2.800	5.800	4.504	4.600	0.6010	0.1334	3.500 to 5.400

Table 8. Correlations of weight, length and gestational age with the dimensions of spleen, liver and kidney			
	Weight	Length	Gestational age
Spleen length	0.55	0.245	0.372
Spleen width	0.14	0.498	0.284
Liver length	0.49	0.412	0.359
Left kidney width	0.397	0.356	0.248
Right kidney width	0.206	0.330	0.221
Left kidney length	0.53	0.445	0.374
Right kidney length	0.48	0.386	0.237
Left renal parencyhmal thickness	0.22	0.160	0.350
Right renal parencyhmal thickness	0.28	0.162	0.282
Correlation is significant at the 0.01 level (2-tailed)			

DISCUSSION

There are limited published studies on the sizes of the liver, kidney, and spleen of preterm and term neonates. Unfortunately, the number of patients in these reports is insufficient to assess the normal range of the organ sizes (1-4). The neonatal period, the determination of the upper and lower limits of normal size, and the last menstrual period cause confusion due to incorrectly calculated dates. This confusion is why term and preterm neonate cohorts are necessary for further studies. In addition, following the development of preterm infants will be useful to identify infiltrative, immunological, metabolic, and congenital cases that are difficult to recognize in the neonatal period. The assessment of organ size with sonography is preferable because it is inexpensive and accessible and does not contain ionizing radiation.

Literature comparing the body size of preterm and term neonates includes a study by Soyupak et al, who reviewed 154 term and 99 preterm infants, Kahramaner et al, who included 384 neonates in their study, and Megremis et al, who studied 96 neonates and infants .(1,3,5). In our study, 222 preterm and term neonates were examined on the basis of gestational week. Of these infants, 45% were premature, and 55% were term infants.

In our study, no difference was found in the liver, spleen, and kidney examinations between male and female patients. This finding is similar to those of other studies in the literature. Soyupak, Konus, and Kahramaner found similar results for the liver and spleen, while Kahramaner found different results for kidney sizes between male and female infants.(1,2,4) In addition, the liver and spleen were significantly smaller in female preterm infants than in male preterm infants. However, no difference was found between organ sizes in premature infants in our study.

Statistically significant results were obtained in almost all parameters in correlations with body weight, gestational age, and height; the strongest correlation was found between the long axis of both kidneys and splenic length and body weight. These results were the base to compare with other measurements, especially body weight, and gestational age demonstrated a stronger correlation with body. While this finding was supported by Rosenberg and Soyupak's studies, Dittrich and Konus reported that body length provided the best correlation (1-2,8). In our study, a positive correlation was found between gestational age, body length, and weight and organ dimensions, and this finding is supported by other studies.

The long axis and dimensions of the organs in our study were smaller than those of the studies by Soyupak et al.(1) In the studies by Kahramaner et al, no comparison could be made because the body length was used as the base measurement (4). Konus et al followed infants to 3 months of age, which was longer than in our study (2).

One of the limitations of our study was that all measurements were performed by a single person. Inter-observer correlation by two or more radiologists would provide more meaningful and accurate results. Another limitation is the lack of longitudinal measurements. Only one measurement was made for each patient, and the patients were not evaluated by serial measurements.

CONCLUSION

In our study, the determination of nomogram values for the liver, spleen, and kidneys of term and preterm infants that we present will contribute to the data from other studies in the literature. Our study is one of the rare studies in the literature evaluating fetal abdominal solid organs.

Competing interests: The authors declare that they have no competing interest.
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