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● *Original Contribution*

NORMAL VALUES OF SPLEEN LENGTH AND VOLUME: AN ULTRASONOGRAPHIC STUDY IN CHILDREN

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Abstract—We aimed to determine normal ultrasonographic limits of spleen length and volume in healthy Caucasian neonates and children. A total of 458 healthy cases (age, 1 d to 15 y; sex, 241 males and 217 females) with normal body measurements were included. Spleen length and volume were obtained ultrasonographically. The two genders were comparable for the mean spleen length and volume. Lower and upper normal limits were tabulated according to age and sex groups. Significant correlations (Pearson $r > 0.80$; $p < 0.001$) were present between spleen length/volume and age, height and weight. Two equations were created to estimate spleen length and volume by age. Normal spleen lengths and volumes and their lower and upper limits were obtained ultrasonographically in a large sample of Caucasian pediatric patients. (E-mail: fouladi.daniel@yahoo.com) © **2016 World Federation for Ultrasound in Medicine & Biology.**

Key Words: **Spleen size, Spleen volume, Ultrasonography, Children.**

INTRODUCTION

Determination of spleen size is a pivotal step in the examination of neonates and children (Zhang and Lewis 1989). Clinical investigation comprising palpation and percussion is the conventional method of obtaining splenic size, but according to available data, it lacks accuracy and reliability in detecting splenomegaly (Dhingra et al. 2010). Only in 15%–17% of healthy neonates and 10% of normal children the spleen may be palpable (Mimouni et al. 1985). In many cases, the spleen has to be two to three times larger than its normal size before it is palpable (Kliegman et al., 2011).

Ultrasonography has been proposed as a non-invasive, accurate and reliable imaging modality in obtaining splenic dimensions (Rosenberg et al. 1991). Related studies, however, are either outdated (Dittrich et al. 1983) or insufficient, causing difficulty in defining splenomegaly in neonates and children (Konus et al. 1998).

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Various conditions such as infection with malaria, hematopoietic disorders, inflammation, storage diseases, neoplasms, reticuloendothelial proliferation and viral infections may affect spleen size (Ezeofor et al. 2014). Some of these conditions, such as malaria (Chauhan et al. 1996), typhoid fever, malnutrition and environmental issues (Eze et al. 2013), may be endemic to particular regions, leading to heterogeneity in normal spleen size range among studies from different areas. Besides this geographic discrepancy, racial variations in the splenic size have been demonstrated previously (Ehimwenma and Tagbo 2011; Ezeofor et al. 2014; Loftus and Metreweli 1998).

To the best of the authors' knowledge, this is the second study (Dittrich et al. 1983) in a Caucasian pediatric population that seeks to report normal values of ultrasonographically measured spleen length and the first one that examines spleen volume in this group.

MATERIALS AND METHODS

Study design and participants

A total of 458 healthy Caucasian neonates and children with an age range of 1 d (full-term neonate) to 15 y

were prospectively recruited from a teaching pediatric center between April 2012 and August 2014.

Weight and height of the enrolled cases were between the 5th and 95th percentiles of the relevant growth curves. Patients were excluded if they had any pathology that effected spleen size, shape or position.

This study was approved by the ethics committee of a local university and informed consent was obtained from parents or legal guardians.

Somatometric variables

Body height (length in neonates and infants), weight and body surface area (BSA) were recorded by a pediatrician. The BSA was calculated using the standard equation described by Du Bois and Du Bois (1989).

Ultrasonographic examination

A single skilled sonographer with over 10 y of experience (M.N.) performed online ultrasonographic measurements of the spleen with the subject lying in a right lateral decubitus position. No preparation was done nor was sedation used, and in neonates, the mother was asked to hold her baby in the instructed position and keep him/her calm during ultrasonographic examination.

A high-resolution real-time scanner (SonixOp; Ultrasonix, Richmond, British Columbia, Canada) was employed. We used a 5–12-MHz linear array transducer for neonates, a 4–7-MHz pediatric probe for infants and younger children and a 3.5-MHz convex transducer for the older children. On longitudinal sonographic images, maximum length (ML) and craniocaudal length (CCL) of the spleen were measured as the optically maximal distance at the hilum between the most superomedial and the most inferolateral points and from the uppermost splenic margin to the lowermost splenic margin, respectively (Fig. 1a). On transverse sonographic images maximum width (W) and thickness (T) of the spleen were measured as the greatest overall dimension and the shortest distance between the hilum and the outer convex splenic surface, respectively (Fig. 1b) (Yetter et al. 2003). The ML was designated as the spleen length (Megremis et al. 2004). Splenic volume was estimated using the equation (1) (Yetter et al. 2003):

$$\text{Spleen volume} = 0.524 \cdot W \cdot T \cdot (ML + CLL)/2 \quad (1)$$

All measurements were performed during quiet breathing or during breath holding in the older children. To minimize intra-observer variations, all measurements were obtained three times sequentially and the mean values were recorded. There were high intra-observer agreements for both liver length (intraclass correlation coefficient [ICC] of 0.84 with 95% confidence interval of 0.80–0.87) and volume (ICC of 0.81 with 95% confidence interval of 0.77–0.83).

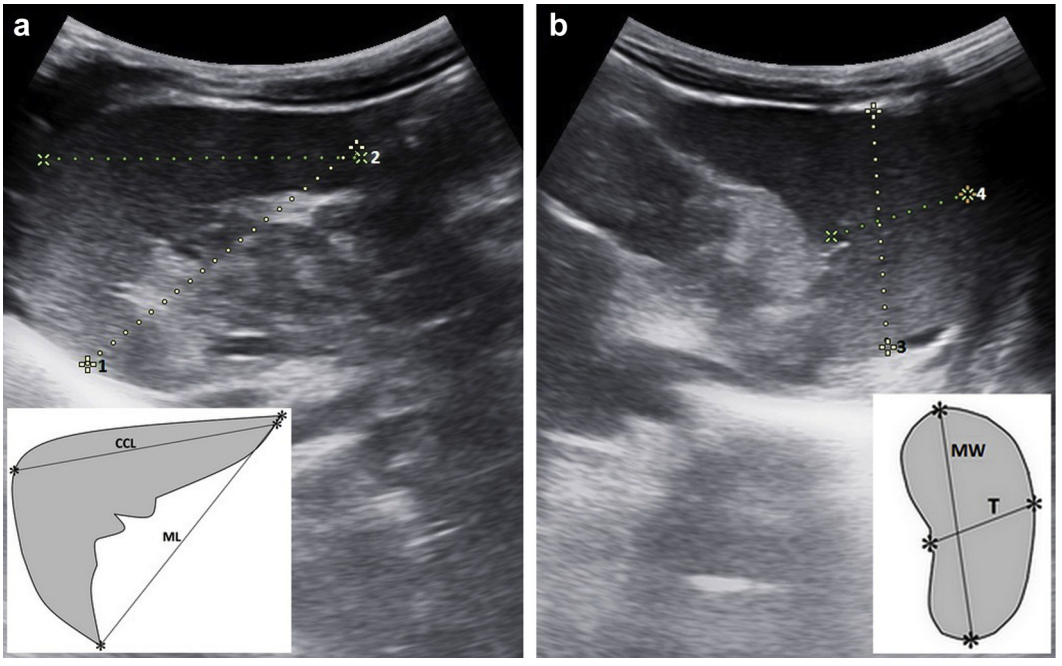

Fig. 1. Sample longitudinal sonographic image depicting ML (dotted line 1) and CCL (dotted line 2) of the spleen measured as the optically maximal distance at the hilum between the most superomedial and the most inferolateral points and from the uppermost splenic margin to the lowermost splenic margin, respectively (a); A sample transverse sonographic image depicting MW (dotted line 3) and T (dotted line 4) of the spleen measured as the greatest overall dimension and the shortest distance between the hilum and the outer convex splenic surface, respectively (b). ML = maximum length; CCL = craniocaudal length; MW = maximum width; T = thickness.