DIMENSIONS OF THE NORMAL ADULT SPLEEN SCAN AND PREDICTION OF SPLEEN WEIGHT

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In the clinical practice of nuclear medicine, it is useful to have normal values for organ sizes. Although considerable effort has been devoted to the diagnostic visualization of the spleen, limited information is available about normal spleen dimensions. The purpose of this report is to give the results of a study of spleen dimensions in normal adult man. In addition, a group of patients was studied to establish the relation between spleen size as seen by photoscanning and spleen weight determined after splenectomy or autopsy.

MATERIALS AND METHODS

Twenty-six normal subjects (10 females, 16 males), aged 20–38 years, were selected for the initial portion of the study.

In each volunteer the spleen was scanned in the posterior and left lateral position following intravenous administration of 2–4 mCi of ^{99m}Tc-sulfur colloid*. Photoscans were performed using a rectilinear photoscanner with a 3-in.-diam NaI(Tl) crystal and a focusing collimator with a 3-in. focal distance. No contrast enhancement was used, and an effort was made to select the high-energy portion of the ^{99m}Tc photopeak to minimize background scatter.

The dimensions of the photoscans were measured

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* Colloscan, from Abbott Laboratories, North Chicago, Ill.

TABLE 1. RELATIONSHIP OF PHOTOSCAN DIMENSIONS TO SPLEEN WEIGHT

Patient Number		Posterior view				Lateral view				Weight (gm)
		L (cm)	W (cm)	C (cm)	A (cm^2)	L (cm)	W (cm)	C (cm)	A (cm^2)	
1	Thrombocytopenia, SLE	9.2	7.2	26.0	50	10.0	9.0	29.0	67	60
2	Thrombocytopenia	11.0	6.2	28.0	51	9.4	5.2	24.0	38	100
3	Idiothrombo purpura	9.5	7.1	27.5	53.2	10.0	7.6	27.0	54.3	110
4	Hodgkins	—	—	—	—	10.0	6.0	27.0	50	160 a
5	Subphrenic abscess	11.3	7.0	30.0	59	11.8	6.1	30.5	55	180
6	Ruptured aorta	12.0	5.4	30.0	55	—	—	—	—	300
7	Renal failure	11.0	8.0	30.0	67	12.0	9.0	33.0	81	300
8	Chronic lympholeukemia	10.0	9.0	29.0	67	13.0	10.0	38	112	320
9	Trauma	12.6	5.2	35	69	14.8	8.8	40	96	340
10	SBE	16.5	6.5	45	111	19.0	12.0	51	174	480
11	Infectious mono	14.0	7.8	36	87	15.5	11.7	44	142	492
12	Lymphoma	13.0	12.5	37	100	10.0	9.2	50	180	582
13	Cirrhosis, hypersplenism	18.0	8.9	45	133	19.8	11.8	52	192	705
14	SBE	—	—	—	—	15.0	8.5	41.0	—	780
15	Cirrhosis, hypersplenism	20.0	6.8	47.0	114	—	—	—	—	860
16	Lymphosarcoma	21.0	11.0	51.0	196	—	—	—	—	1050 a
17	Lymphoma	25.0	9.8	53.0	172	—	—	—	—	1200 a

a = autopsied patients, L = length, W = width, C = circumference, A = area.

as follows: The scan was illuminated on a view box, and a line around the perimeter was transcribed onto tracing paper. The line was smoothed when necessary to eliminate any minor scalloping of the scan edge. Four measurements were made on each projection: maximum length (L), area (A) (planimeter), width (W), and circumference (C) (cartographer's wheel).

Seventeen additional patients (Table 1) underwent spleen photoscanning 24–72 hr before splenectomy (14 patients) or not less than 3 weeks before autopsy (3 patients). The spleen weights were obtained and compared with various scan dimensions.

RESULTS

Eight dimensions of the spleen in normal subjects are summarized in Table 2. The mean, range, and standard deviation are shown for each set of measurements. In the normal, the posterior and lateral projections have nearly the same dimensions. The area of the spleen is most variable, the standard deviation being almost one-third of the mean. The posterior circumference had the least variability, with only a 13.4% standard deviation. The upper limit of normal for the posterior length is taken to be 13.0 cm. The posterior lengths were plotted on probability paper and found to be approximately normal in distribution. Since 13.0 cm is 2 s.d. above the mean posterior length, approximately 95% of undiseased spleens would be expected to be smaller than 13.0 cm.

The normal spleen dimensions could not be correlated with body height, weight, or surface area.

In the operated or autopsied subjects a linear relationship with an r value greater than 0.94 was established with spleen weight and five of the eight scan dimensions. The linear equations for the prediction of spleen weight from scan dimensions are shown with their correlation coefficients in Table 3. Notice that spleen weight correlates well with area, circumference, and length in the posterior view and with area and circumference in the lateral view.

As an example, Fig. 1 shows spleen weight as a function of the posterior length. The mean posterior length of 10 cm predicts an average spleen weight of 172 gm. This weight falls within the normal range of autopsy spleens at Virginia Mason Hospital (150–200 gm).

DISCUSSION

The lateral area of the normal spleen scan was studied by Holzbach and associates in 1963 using ^{51}Cr-labeled damaged red blood cells (*1*). Holzbach's 23 normal spleen scans ranged from 35 to 85 cm^2 in lateral area, a distribution similar to that of 27–103 cm^2 obtained in our study.

Fischer and Wolf have proposed an "index" for spleen size which is the lateral scan area divided by body surface area. Normal values are given at 3.88–4.5 $\times$ 10^{-3} (*2*). The usefulness of this index is questionable since in our normal subjects body surface area does not correlate with the lateral area.

Samuels (*3*) derived the formula $V = \pi w^2 h/3$, or about w^2h, as an approximation of spleen volume. In this expression w and h equal posterior scan width and height, respectively. He applied this formula to two autopsy cases which showed approximate agreement. However, when we used this formula with our data, it failed to estimate the observed spleen weights.

Spencer (*4*) has proposed another method for predicting spleen weights using the lateral scan areas of Holzbach's data which included the weight of ten spleens obtained at autopsy or surgery. By considering the weight as a power function of the lateral scan area, he derived the formula: $W = 0.257A^{1.5}$ in which A and W equal lateral scan surface area and weight, respectively. The equation of this form which best fits our data is $W = 0.974A^{1.233}$. This equation yields a correlation coefficient of 0.897.

The posterior length would seem to be the most practical dimension for estimating weight when

TABLE 2. DIMENSION OF NORMAL SPLEEN ON PHOTOSCANNING

	Posterior view*				Lateral view†			
	L (cm)	W (cm)	C (cm)	A (cm^2)	L (cm)	W (cm)	C (cm)	A (cm^2)
Means	10.0	6.5	27.7	52.8	10.0	7.1	27.5	56.2
Range	7.7–12.9	4.8–9.4	22–34	36–91	7.7–12.8	4.2–10.4	21–37	27–103
s.d.	1.5	1.0	3.7	14.6	1.5	1.6	3.8	18.9
% s.d.	15	17.6	13.4	27.7	15	22	13.6	33.5

* 26 subjects.
† 21 subjects.
L = length, W = width, C = circumference, A = area.

TABLE 3. CORRELATION OF SPLEEN WEIGHT WITH SCAN DIMENSIONS

	Posterior view		Lateral view	
	Least squares best fit	Correlation coefficient	Least squares best fit	Correlation coefficient
Area	W = 7.38A − 202	0.947	W = 3.67A − 59	0.968
Circumference	W = 36.44C − 858	0.952	W = 20.9C − 450	0.960
Length	W = 70.25L − 530.84	0.960	—	0.800
Width	—	0.52	—	0.810

^{99m}Tc-colloid is used for spleen photoscanning. The posterior scan almost always shows the spleen distinctly separate from the liver, and the length is easily measured. In about 20% of cases, the spleen is not easily measured in the lateral projection because of underlying liver colloid. The linear correlation between posterior length and spleen weight is a good one, with a coefficient of correlation equal to 0.96.

Although correlation of spleen weight and scan dimensions is quite good in the normal and enlarged spleens, Fig. 1 indicates that with small spleens—less than 50 gm—one must assume a different relationship with posterior spleen length. This is evident because both length and weight must intersect the ordinate and abscissa at the zero coordinates. For this reason estimates of spleen weight smaller than 50 gm should not be attempted from these formulas. An exponential formula may approximate the data more closely at the lower end of the graph since the exponential curve does pass through the origin. Because there are only a few spleens of small size in our series, we were not able to evaluate this possibility definitely.

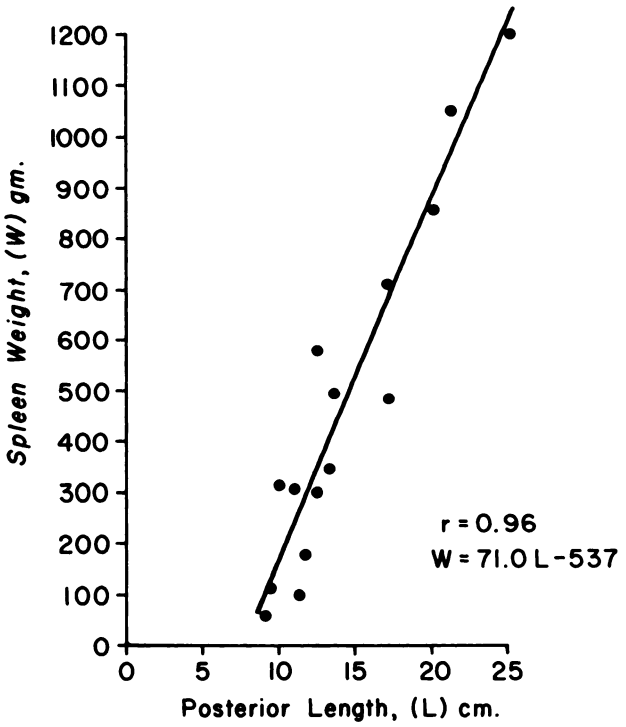

FIG. 1. Correlation of spleen weight at autopsy or splenectomy with posterior length in 15 patients. In normal range and above, relationship is linear with coefficient of correlation equal to 0.96. (See text for details.)

SUMMARY

To quantitate spleen scanning more adequately, a prospective study was performed to determine the dimensions of the normal spleen and to establish criteria for predicting the weight of enlarged spleens. Rectilinear spleen scans were obtained in 26 healthy adult volunteers. Normal values for mean plus and minus standard deviations of the posterior dimensions were 10 ± 1.5 cm, 6.5 ± 1.0 cm, 27.7 ± 3.7 cm, and 52 ± 14.6 cm^2 for length, width, circumference, and area, respectively. The lateral dimensions were 10 ± 1.5 cm, 7.1 ± 1.6 cm, 27.5 ± 3.8 cm, and 56.2 ± 18.9 cm^2 for length, width, circumference, and area, respectively.

A linear relationship was found between spleen weight and several of the scan dimensions. For example, posterior length is easily measured and may be used to estimate spleen weight by the equation W = 71.0L − 537 in which W is spleen weight in grams and L is the posterior length in centimeters. The correlation coefficient for this equation was 0.960. Spleen weight may also be predicted from spleen scan area and circumference.

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