ESTIMATION OF SPLEEN SIZE IN SICKLE CELL ANEMIA

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Clinical estimation of spleen size is possible only when the organ is grossly enlarged; for even the inferior tip of a spleen to be palpable on abdominal examination, some splenomegaly must be present (*1*). Normal or smaller-than-normal spleens are thus beyond the examiner's perception.

Roentgenography can sometimes reveal the soft-tissue outline of abdominal masses, and the grossly enlarged spleen can thus be visualized, but the normal or atrophic spleen effectively hides beside the stomach without being visualized on x-ray exam.

Radioisotope spleen scanning with heat-denatured red cells first gave one the opportunity to visualize the spleen parenchyma by external examination. The recent introduction of colloidal ^{99m}Tc-sulfur (*2*) has allowed improved, more rapid visualization of the spleen (and liver). With the availability of this radiopharmaceutical (kindly supplied to us as Colloscan by Abbott Laboratories) a possible solution to a clinical conundrum became apparent.

Children with sickle cell anemia have shown an apparent increase in susceptibility to pneumococcal infection (*3*). Because of findings of small, atrophic-appearing spleens in sickle cell anemia and the known association of pneumococcal infection with the post-splenectomy syndrome (*4*), a possible correlation between the primary disease, splenic atrophy and pneumococcal infection appeared to exist. The present study undertook to evaluate well children with sickle cell anemia for evidence of splenic atrophy.

MATERIALS AND METHODS

Children with established diagnoses of sickle cell anemia being followed in the Hematology Clinic of Columbus Children's Hospital were identified and their parents contacted. Contact was made with 12 children, of whom 11 were scheduled for visits for spleen scans and other tests. In addition, spleen scans were performed in 14 children without sickle cell disease but with suspected splenomegaly (palpable spleens) and eight children without sickle cell disease or suspected splenomegaly in whom spleen scans were incidental to clinically indicated liver scans.

After obtaining informed consent, ^{99m}Tc-sulfur colloid was injected intravenously in a dose of 0.05 mCi/kg. From ½ to 1½ hr later scans were made of liver and spleen from anterior and posterior aspects using an Ohio-Nuclear Model 54F scanner equipped with 5-in. crystal and 187-hole, fine-focus collimator. Scanning speed ranged from 200 to 350 cm/min.

Completed scans were evaluated by measuring dimensions of the area of splenic uptake as seen on posterior scan, adjusting for activity attributable to left lobe of liver as seen on anterior view. In some cases, left lateral views were also obtained, but the technique suggested by Spencer (*5*) did not prove feasible in small children because activity from liver was well within the isoresponse range of the 3-in. focus collimator on left lateral view, and the superimposed spleen, especially if small, was undetectable. However, the present technique has successfully shown 2 × 2-cm spleens on posterior view even when overlaid anteriorly by the left lobe of the liver. This is probably because the left lobe of the liver is relatively thin in A-P dimension, whereas edgewise its depth is much greater.

Three independent observers were asked to evaluate the scans for spleen dimensions: their measurements corresponded within 1 cm in every case. Where no spleen was visible, the size 1 × 1 cm was assigned since this represents minimum resolution of the collimator used.

After obtaining height and width of the spleen, the volume was calculated according to the formula suggested by the data of Whitley *et al* (*6*) as proposed by Spencer (*5*). Spencer proposed the formula $W = 0.7\ p^{3/2}$, where W equals spleen weight and p equals the product of length and width as measured on AP roentgenograms. The calculated spleen weight was then compared with age-specific normal spleen weights as tabulated by Copoletta and Wolbach (*7*), and a ratio of observed-to-expected was obtained for each child and averaged within

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each group. By this method, the group of children clinically normal with respect to spleen size did not correspond to expected weights for their spleens so the ratios were normalized to a value of 1.0 for the clinically normal children.

Subsequently, one of us (LDS) proposed the formula $W = \pi w^2 h/3$, where W equals spleen weight, w equals maximum width from posterior view and h equals height as seen on posterior scintillation scan (*8*). The data were recalculated with this formula and ratios were obtained as before, and were normalized and compared.

RESULTS

Representative scans from each study group are shown in Figs. 1–3. The normalized ratios of spleen size are shown in Table 1. The actual calculated weights ranged from 0.7 to 190 gm for children with sickle cell disease, 53–617 gm for "normal" children and 63–1,989 gm for children with suspected splenomegaly when calculated by Spencer's formula. By the proposed formula, these values are less (see Table 2) although the relative differences between groups in the normalized ratios remains, of course, unchanged. Sickle cell disease cases are listed in Table 3 with the dimensions of their spleen scans.

DISCUSSION

Differences in spleen size among the three groups studied are apparent and statistically significant. This significant difference remains even if the arbitrary 1 × 1-cm value for nonvisualized spleens is increased to 2 × 2 cm, a size shown to be visualizable by these techniques and equipment. The major problem concerns the poor visualization of the shrunken, presumed fibrotic spleens of the children with sickle cell disease. It is possible that a malfunctioning spleen might not localize ^{99m}Tc-sulfur colloid and hence not be visualized by the present technique, and the spleens from sicklers would thus be larger

TABLE 1. NORMALIZED RATIOS OF CALCULATED SPLEEN WEIGHT COMPARED WITH EXPECTED WEIGHT

Sickle cell disease (11)	0.13
Clinically normal (8)	1.0
Suspected splenomegaly (14)	2.1

TABLE 2. COMPARISON OF CALCULATED SPLEEN WEIGHTS

	Range of calculated weights (gm)	
Group	Spencer (5)	Samuels (8)
Sickle cell disease	0.7–190	1 –134
Clinically normal	53 –617	16.5–515
Suspected splenomegaly	63 –1,989	75 –1,570

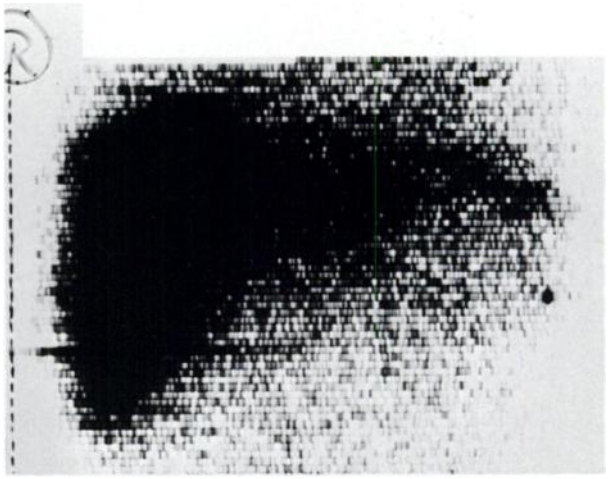

FIG. 1. Technetium-99m-sulfur colloid spleen-liver scan from posterior aspect of child with confirmed sickle cell anemia. Note small nubbin of visualized spleen with right lobe of liver well visualized. Calculated weight is about 34 gm, third largest spleen in series of sickle cell disease.

FIG. 2. Technetium-99m-sulfur colloid spleen-liver scans of child with resected Wilm's tumor, clinically without splenomegaly. Calculated weight of spleen is 142 gm. Top view is anterior; bottom is posterior.

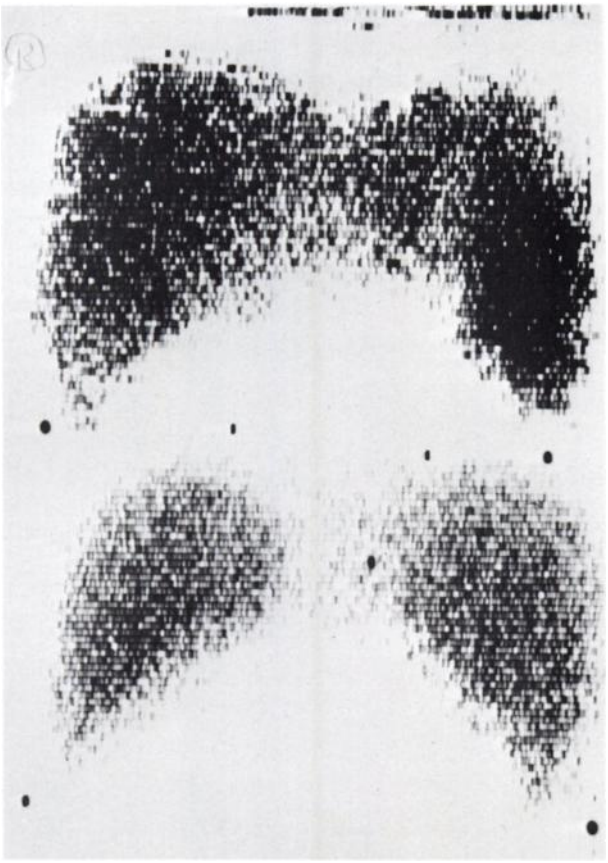

FIG. 3. Technetium-99m-sulfur colloid spleen-liver scan of child with acute leukemia and gross hepatosplenomegaly. Calculated spleen weight of 1,570 gm by Samuel's formula (8) compares favorably with the 1,620-gm size obtained at autopsy 3 weeks following scan. Top view is anterior; bottom is posterior.

than apparent on scan since the scan image represents the functional size of the spleen with respect to reticuloendothelial activity.

Further studies are needed with autopsy followup when feasible to substantiate these estimates of size. We have never used the ^{51}Cr-labeled "damaged" erythrocyte spleen scan in children because we have felt its disadvantages and risk in children outweigh its value. It does appear clear that at any age during the disease, shrunken spleens occur in sickle cell anemia. As shown by the last case in Table 3 (patient ED), significant changes in apparent size may occur in a single patient over the course of a few months: in this case the spleen was only a quarter of its size estimate based on scans 6 months previously. The clinical implications of these findings remain to be investigated.

TABLE 3. TABULATION OF CASES OF SICKLE CELL ANEMIA

Patient	Age	Electrophoretic pattern	Spleen size on scan	
			Width (cm)	Height (cm)
DW	2	—	1*	1*
PW	3	—	1*	1*
CW	3	—	1*	1*
JL	4½	—	1*	1*
RT	7	—	4	8
WH	7½	—	2	5½
LW	8	—	2½	5½
JB	8	SS	1*	1*
LB	8	SS	1½	2
DR	10	SS	1*	1*
ED	10†	SS	4	8
ED	10½†	SS	2½	5

Dash indicates electrophoresis was not done.
* Not visualized on scan; assigned size 1 × 1 cm.
† Same patient, rescanned after 6-month interval.

SUMMARY

Technetium-99m-sulfur colloid liver-spleen scans have been performed in a series of 11 children with sickle cell anemia and compared with series of children with clinically normal spleens and with palpable splenomegaly. Spleens of children with sickle cell disease are significantly smaller and half the time were not visualized at all. The implications of atrophy versus nonfunctioning of the splenic tissue are discussed.

ACKNOWLEDGMENT

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