Radiological determination of spleen size

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A simple method for determining the size of the spleen would be of value in the study of both normal function and hypersplenism. In the past various radiological methods have been used. These include measurement of the long axis of the spleen (Bergstrand and Ekman, 1957), the width of the spleen 2 cm from the lower pole (Wyman, 1954; Brogdon and Crow, 1959), or the length and width (Rösch, 1965; Whitley, Maynard, and Rhyne, 1966). These are all dependent on a clear outline of the spleen but the spleen cannot always be seen even in good quality radiographs taken with measures to prevent scatter, particularly in the very thin subject. To delineate the outline further, some workers have used Siedlitz powders to distend the stomach and inflated the colon with air via a rectal tube (Zelman and Pickard, 1955; Zelman, 1958). Radioactive scanning of the spleen is also possible (Croll, Brady, Brodsky, and Stanton, 1965; Marsh, Lewis, and Szur, 1966) but this involves considerable radiation and is unsuitable for serial studies.

During measurements of splenic blood flow (Williams, Condon, Williams, Blendis, and Kreel, 1968) it became apparent that a relationship might exist between spleen weight and the area determined from an anteroposterior radiograph. This has been explored further in various groups of patients with normal sized spleens and in subjects with splenomegaly associated with portal hypertension or blood dyscrasia.

MATERIAL AND METHODS

Three control groups were examined. The first consisted of a necropsy series of 38 male and 20 female adults (aged 25 to 89 years). After removal the spleens were weighed, placed on radiographic films in a position approximating to that in life, and anteroposterior and lateral radiographs were taken. The areas in each plane, together with the maximum length, width, and thickness of the spleen at right angles, were then measured from the radiographs. The second group comprised 76 patients in whom the measurements were taken from the sinusoidal filling phase of a diagnostic coeliac arteriogram (Kreel

and Williams, 1964). In the third group, consisting of 75 patients having intravenous pyelography, the measurements were made from a radiograph taken within one minute of the injection of contrast medium. At this time there was sufficient dye in the spleen for its outline to be clearly visualized.

ABNORMAL SERIES In nine patients with cirrhosis, 11 with blood dyscrasias, and seven with tropical splenomegaly, the splenic area and other dimensions were recorded from the sinusoidal filling phase of a diagnostic coeliac arteriogram. In addition, size was assessed clinically by measuring the maximum length (in the longitudinal axis) of the spleen below the costal margin. The weight was subsequently obtained after splenectomy or at necropsy, care being taken to clamp the splenic artery and vein simultaneously before removal.

In two patients radiographs were also taken of the spleen after removal at splenectomy, both in the simulated position in life and when tilted 15°, 30°, and 45°, in the vertical axis.

RESULTS

The mean splenic weight in the necropsy series was 198 g (SD 61 g). When this was compared with the various measurements of spleen size, the closest correlation ($r = 0.88$, $P < 0.001$) was found with the anteroposterior area. The mean value for the latter was 75 cm² (SD 17 cm²) with very similar values in the coeliac arteriogram series (85 cm², SD 17 cm²) and in the pyelogram series (70 cm², SD 17 cm²), after allowing for magnification factors. In all cases in the latter two groups the splenic outline was clearly demonstrable (Fig. 1). In the necropsy series significant but less close correlations than for anteroposterior area were found between weight and lateral spleen area ($r = 0.74$), maximum length ($r = 0.7$), or width ($r = 0.69$), and maximum width times length at right angles ($r = 0.8$).

In the pyelogram series there was an extremely close correlation between spleen area and body surface area ($r = 0.98$, $P < 0.001$). The mean ratio of splenic area (cm²) to body surface area (M²) expressed as a percentage was 0.4. A similar correlation was

FIG. 1. Radiograph taken within one minute of injection of contrast medium for an intravenous pyelogram showing the clear outline of the spleen.

not possible in the other groups since the weight and height of the patients had not been recorded. Separating the patients according to sex or to age in decades failed to show statistically significant differences in the dimensions recorded although in general female and young adults tended to have smaller spleens.

FIG. 2. Relation between spleen area and weight in patients with splenomegaly. The continuous line represents the regression equation and the broken line the 95% confidence limits.

PATIENTS WITH SPLENOMEGALY As the spleen increased in size the anteroposterior area continued to show the closest correlation with weight although there was proportionally less increase in the area, particularly with spleens weighing more than 1,800 g. The relationship formed an exponential graph when plotted arithmetically which could be converted to a linear and highly significant plot by relating area to log₁₀ spleen weight (Fig. 2). Less close correlations were found between the weight and the spleen length determined radiologically ($r = 0.8$) or clinically ($r = 0.84$). The results of rotating the spleen in the vertical axis (Table I) indicated that no significant change in the measured anteroposterior area occurred until the spleen reached an angle of 45° from the simulated position in life.

TABLE I
THE CHANGE IN SPLENIC AREA WITH ROTATION OF THE SPLEEN

Position on Radiographic Plate	Spleen Area (cm ²)	
	Patient 1	Patient 2
Flat	350	298
15° from vertical axis	355	298
30° from vertical axis	344	285
45° from vertical axis	300	240

The findings in the necropsy series showed that the anteroposterior area of a normal sized spleen, as measured from the radiograph, was more closely correlated with its weight than any other single parameter. The range for normal spleen weight agreed with that of a previous series (Whitley *et al*, 1966) and the mean and range of values for spleen area in the necropsy group were similar to those obtained from the pyelogram and coeliac arteriogram series. Thus a similar close correlation probably exists between the area in normal subjects during life and splenic weight, a comparison which for obvious reasons is difficult to carry out. Although the spleen may shrink to some extent with increasing age (Houcke, Merlen, and Houcke, 1962) and after death, as well as at operation (McFadzean and Todd, 1967), our results suggest this shrinkage is less than previously reported. The very close correlation found between spleen area and body surface area in one control group also suggests that body surface area could be used to predict the weight of the spleen in normal subjects.

In clinical studies the length of the spleen palpable below the costal margin has often been used as an index of spleen size (Bowdler, 1967; McFadzean and

Todd, 1967; Richmond, Donaldson, Williams, Hamilton, and Hutt, 1967). However, this does not take into account the considerable proportion of the spleen deep to the rib cage and there is also a considerable degree of observer variation in palpation of the spleen (Blendis, Murray-Lyon, Williams, McNeilly, Shepherd, and Laws, 1969). Furthermore, the weight of the spleen increased exponentially in relation to size so that small errors in clinical measurement represent larger changes in weight. The figure relating anteroposterior area to $\log_{10}$ splenic weight should provide a simple and practical method for determining the weight of the spleen throughout the range encountered in clinical splenomegaly. The finding that considerable rotation of the spleen leaves the area relatively unchanged was reassuring. However, the splenic outline cannot always be clearly defined on a straight radiograph (Riemenschneider and Whalen, 1965) and additional procedures, such as an injection of contrast medium into a peripheral vein as in pyelography, may sometimes be necessary.

SUMMARY

The area of the spleen determined from an anteroposterior radiograph or during pyelography or coeliac arteriography in patients with diseases not affecting the liver or spleen gave a closer correlation with spleen weight than any other measurement of spleen size. In patients with splenomegaly due to cirrhosis or blood dyscrasia there was proportionally less increase in the area. However, highly significant linear correlations could be derived by relating area to $\log_{10}$ spleen weight, for both normal and abnormal groups, which may prove useful in the quantitation of splenic function.

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