RATE OF LOSS OF ^{51}Cr FROM THE SPLEEN

E. D. Williams, S. Ahuja, L. Szur, S. M. Lewis, and H. I. Glass

Hammersmith Hospital and Royal Postgraduate Medical School, London, England

The study of the sites of deposition of ^{51}Cr-labeled red cells by surface counting has been used to assess the role of the spleen in patients with hemolytic anemia (*1,2*). The measurement of accumulated radioactivity in the spleen is affected both by deposition of ^{51}Cr due to destroyed red cells and by the subsequent loss of ^{51}Cr from the organ. Although the deposition rate is the parameter of interest, external counting estimates only the net rate of accumulation of radioactivity and is therefore only of limited value. The rate of loss is an important factor but is usually not measured. The effect of various rates of loss on the interpretation of surface counting studies has been discussed by Belcher, et al (*3*) and by Spencer, et al (*4*).

The daily rate of loss of ^{51}Cr from the spleen has been estimated by several authors, in most cases by external counting over the spleen. Hughes Jones, et al (*1*), using data obtained from surface counting studies with incompatible red cells which were deposited in the spleen, estimated rates of 1.8, 2.4, and 3.1%/day in three patients. Jandl, et al (*2*), from urinary excretion measurements following the injection of antibody sensitized red cells which were largely destroyed in the spleen, found an average loss rate in four subjects of 4%/day while Johnson, et al (*5*) reported results obtained by external counting which gave a mean rate of 3%/day in eight patients. External counting over the spleen following the injection of labeled red cells damaged by heating gave values of 4.5%/day (*6*), 10%/day (*7*), and 7.9 and 9.5%/day (*8*). Aster, et al (*9*), in studies with ^{51}Cr-labeled platelets, found the average rate of loss to be 2.7%/day in five subjects. Spencer, et al (*4*) studied two dogs following administration of ^{51}Cr-labeled undamaged red cells. After 1 week the circulating blood was exchanged for unlabeled blood, and loss rates of 5.3 and 9.9%/day were found by external counting.

The present study was undertaken to establish with greater precision the range and variation in the rate of loss of ^{51}Cr from the spleen in a number of patients with hematological disorders. A quantitative scanning technique (*10*) was used to measure the radioactivity in the whole spleen with a correction for activity remaining in the blood.

METHOD

Fifteen patients were studied, including two hematologically normal subjects, six with lymphoproliferative, and five with myeloproliferative diseases. These patients were being investigated to assess the effectiveness of splenectomy in hypersplenism associated with splenomegaly. The patient's red cells (5 ml) were labeled with 200 μCi ^{51}Cr, damaged by heating at 49.5°C for 30 min, and reinjected. The splenic area was scanned 1 hr later using a dual 3-in. detector scanner with focusing collimators. The region which was scanned included the whole spleen and an area below it which was used to estimate the radioactivity in the surrounding tissue. A scanner speed of 30 cm/min was used. After completion of the scan, the scanner speed was measured by feeding fixed frequency pulses to the dot tapper and measuring the spacing of dots printed. Further scans were obtained on succeeding days over the same area, anatomical marks being transferred to each scan to aid subsequent alignment. The sensitivity and stability

Received Feb. 7, 1972; revision accepted Apr. 22, 1972.

For reprints contact: David Williams, Hammersmith Hospital, Dept. of Medical Physics, Du Cane Rd., Shepherds Bush, W12 OHS, London, England.

of the detectors was checked on each occasion by counting a ^{51}Cr standard in a fixed position midway between the detectors with the collimators removed.

Two rectangular regions were marked out on each dot scan. One region included the whole spleen and the other was used to estimate the contribution to the counting rate in the spleen area due to radioactivity in the surrounding tissue. Identical regions were used on each scan of the same patient. The dots in each region were counted and the net number of dots in the splenic region was obtained by subtracting the number of dots in the tissue region from those in the splenic region after correcting for the ratio of the areas of the splenic and tissue regions. The results for each scan were also corrected for variations in the sensitivity and speed of the scanner and for decay. The corrected number of dots on each scan was expressed as a percentage of the maximum measured uptake of ^{51}Cr in the spleen and the least-squares fit of these data to a monoexponential function was obtained. This permitted the rate of loss of ^{51}Cr from the spleen to be calculated and expressed as percent lost per day.

RESULTS

The mean rate of loss of activity per day in 15 patients (Table 1) was 6.1%/day (s.d., 3.2%/day; range, 3.0–14.3%/day). The error in an individual measurement has been estimated at ±16% of the measured loss rate.

In one case the measurement on the first day was not used because it was significantly below the second value. This was assumed to be due to incomplete clearance of the damaged cells into the spleen when the first scan was performed.

TABLE 1. RATE OF LOSS OF ^{51}Cr FROM THE SPLEEN MEASURED BY SCANNING

No.	Diagnosis	Loss of ^{51}Cr (%/day)	Hematocrit (%)	Maximum diameter of spleen on scan (cm)
1	Cerebral tumor	4.1	37	10
2	Thymoma	3.0	34	7
3	Polycythaemia vera	4.1	47	18
4	Polycythaemia vera	9.2	59	17
5	Polycythaemia vera	8.1	50	9
6	Myelosclerosis	3.5	36	16
7	Myelosclerosis	3.9	25	13
8	Thrombocythaemia	3.0	41	11
9	Hodgkin's disease	8.3	38	11
10	Hodgkin's disease	14.3	28	16
11	Hodgkin's disease	6.5	33	12
12	Lymphosarcoma	9.5	30	18
13	Chronic lymphocytic leukaemia	4.4	37	23
14	Reticulum cell sarcoma	5.3	40	9
15	Autoimmune hemolytic anemia	3.9	37	11

There appears to be no correlation between the measured loss rate and any of the following factors: the clinical diagnosis, the hematological data, or the size of the spleen.

DISCUSSION

Values for the rate of loss of ^{51}Cr from the spleen quoted in the literature range from 1.8 to 9.9%/day with a weighted mean of 3.9%/day and s.d. 3.4%/day. This mean value is not significantly different from our result. However, the range of values in individual reports is smaller although based on a small number of cases. It is possible that this variation between different series may be due to the differences in the techniques used. However, since these variations exist when an identical technique has been used on all patients, it seems likely that there is a true variation in the loss of ^{51}Cr from the spleen between individual subjects. This is confirmed by our own observations using a method which should be more accurate than those in which surface counting techniques were used. The dual-detector system has a response which is almost independent of the size and depth of the spleen in the patient (*10*). The use of a scanner makes it possible to include counts from the whole spleen and to exclude any from the liver. A correction is also made for radioactivity in other tissues.

The loss of ^{51}Cr from the spleen and its variation in individual subjects has a two-fold significance. First, it is of value in the assessment of surface counting results in hemolytic anemias and thus may, for example, explain the occasional lack of correlation between the surface counting findings and the results of splenectomy. Second, the rate of loss of ^{51}Cr is of considerable importance in techniques which aim at quantitating red cell destruction in the spleen.

The significance of a wide variation in loss rate in surface counting studies had been pointed out by Belcher, et al (*3*) and by Spencer, et al (*4*). For example, Belcher, et al indicated an increase in the maximum splenic radioactivity of 50% if the loss rate changed from 8 to 4%/day when the red cell destruction rate was 5%/day. A high rate of loss may therefore cause the result of an external counting study to fall within normal limits even though there is increased splenic destruction.

The quantitative estimation of splenic red cell destruction (*11*) requires that the rate of loss of ^{51}Cr from the spleen be known. The estimation of this rate for an individual subject is therefore important. The accuracy of the estimation of the rate of splenic

red cell destruction is affected by the accuracy of the correction made for the rate of loss of radioactivity from the spleen. For example, an error of 5%/day in the rate of splenic loss of ^{51}Cr results in a 20% relative error in the estimation of the rate of splenic destruction.

Although previous authors have used a variety of different techniques to ensure the uptake of ^{51}Cr-labeled red cells in the spleen, their data are consistent with those obtained by us using heat damaged cells. There is no clear evidence, therefore, that the rate of loss depends on the mechanism of deposition of ^{51}Cr-labeled cells in the spleen. It is possible that the loss of ^{51}Cr from the spleen is due to the breakdown of the globin part of hemoglobin to which the ^{51}Cr is attached. This process is not necessarily related to any action by the spleen.

It is concluded that the variations in the rate of loss of ^{51}Cr from the spleen are greater than previously thought. This finding suggests that in quantitative studies of the splenic destruction of red cells it is necessary to estimate the rate of loss of ^{51}Cr from the spleen in the individual subject. However, as this is not always possible, if a correction is being applied for the loss of radioactivity, we would recommend a correction of 6.1%/day.

SUMMARY

A technique is described for measuring the rate of loss of ^{51}Cr from the spleen by quantitative scanning. Results obtained from 15 patients are presented. The wide range of these values is noted, and their influence on external counting studies is discussed.

REFERENCES

1. HUGHES-JONES NC, SZUR L: Determination of the sites of red cell destruction using ^{51}Cr-labelled cells. *Brit J Haemat* 3: 320–331, 1957

2. JANDL JH, GREENBERG MS, YONEMOTO RH, et al: Clinical determination of the sites of red cell sequestration in haemolytic anaemias. *J Clin Invest* 35: 842–867, 1956

3. BELCHER EH, HUGHES JONES NC: The mathematical analysis of ^{51}Cr deposition in organs following the injection of ^{51}Cr-labelled red cells. *Clin Sci* 19: 657–663, 1960

4. SPENCER RP, ROCKOFF ML, SPECTOR H: Studies on quantitation of the ^{51}Cr-erythrocyte spleen-to-liver ratio. *J Nucl Med* 9: 51–57, 1968

5. JOHNSON PM, HERION JC, MOORING SL: Scintillation scanning of the normal human spleen utilizing sensitized radioactive erythrocytes. *Radiology* 74: 99–101, 1960

6. HARRIS IM, MCALISTER JM, PRANKHERD TAJ: The relationship of abnormal red cells to the normal spleen. *Clin Sci* 16: 223–230, 1957

7. WAGNER HN: Splenic scanning. *Northwest Med* 63: 767–771, 1964

8. WINKLEMAN JW, WAGNER HN, MCAFEE JG, et al: Visualization of the spleen in man by radioisotope scanning. *Radiology* 75: 465–466, 1960

9. ASTER RH, JANDL JH: Platelet sequestration in man. I. Methods. *J Clin Invest* 43: 843–855, 1964

10. WILLIAMS ED, GLASS HI, ARNOT RN, et al: A dual detector scanner for quantitative uptake and organ volume studies. In *Medical Radioisotope Scintigraphy,* vol 1, Vienna, IAEA, 1969, 665–683

11. SZUR L, GLASS HI, LEWIS SM, et al: Quantitative estimation of red cell uptake in the spleen using ^{81}Rb and ^{51}Cr-labelled red cells. *Brit J Radiol* 41: 819–825, 1968