IRON METABOLISM IN PATIENTS ON REGULAR DIALYSIS TREATMENT

D. H. LAWSON, G. WILL, K. BODDY and A. L. LINTON

Renal Unit, Western Infirmary, Glasgow and Scottish Universities Research Reactor Centre, East Kilbride, United Kingdom

Abnormalities in iron metabolism are known to occur in patients undergoing regular dialysis therapy (R.D.T.).

However, there is division in the literature between those workers who have demonstrated iron overload in such patients (Eschbach *et al.*, 1967), and those who suggest that iron deficiency may arise (Shaldon, 1966). The present study was undertaken to clarify those views.

With the development of a shadow shield whole body monitor it has become possible to measure body retention of a tracer dose of Fe^{59}, making utilisation of iron and subsequent long-term iron turnover estimations possible in a single study.

METHODS

The Merlin Shadow Shield Whole Body Monitor of the Scottish Universities Research Reactor Centre in East Kilbride was used for this purpose.

This has an $11^1/_2'' \times 4''$ sodium iodide detector located in a central turret and surrounded by a shadow shield containing about 7 tons of lead (Boddy, 1967).

The patient lying supine and then prone on a motorised bed passes beneath the detector. Counting is started by a fixed microswitch and stopped by an adjustable switch according to the patient's height. The output signals are taken to a T.M.C. 400 channel pulse height analyser.

Patients studied were all counted in the monitor before administration of isotope and then after 1 μc $Fe^{59}Cl$ was given intravenously. Those studied included 4 patients with severe chronic renal failure on a Giovannetti dietary regime and 6 on R.D.T., using a twin-coil dialyser.

In order to estimate if any iron was lost into the dialysing fluid, samples of this were taken and also counted using the monitor.

It is theoretically possible that uptake of iron from the dialysing fluid may occur (Maher *et al.*, 1965), and if this did occur to any great extent iron overload may result. To exclude this possibility, selected patients were dialysed after iron had been added to the bath in a concentration of 120 μc $Fe^{59}Cl$ in 300 l fluid. The patients were then counted on the whole body monitor.

Finally, in order to estimate more accurately the amounts of blood lost in each coil at dialysis, 2 patients' red cells were labelled with Cr^{51} and the coils taken for counting after the end of dialysis.

All patients were dialysed twice weekly for 10 hours each dialysis, using a Kolff twin-coil machine.

RESULTS

Whole body counts: The findings of the long-term studies are summarised in Table I.

TABLE I
Daily iron losses

	Percentage loss of Fe^{59} per day	Mean
Normals	0.04–0.26	0.15
Renal failure not on dialysis	0.05–0.12	0.07
Renal failure on R.D.T.	0.40–1.46	0.70

It has previously been shown that the whole body iron turnover in normal adult males by this method is 0.04–0.26% of the administered dose of Fe^{59} per day with a mean value of 0.15% per day (Will and Boddy, 1967).

In the case of the 4 patients with chronic renal failure maintained on the Giovannetti diet all of whom had creatinine clearances less than 12 ml/min., the whole body iron turnover was at the lower end of the normal range, being 0.05–0.12% per day with a mean of 0.07% per day.

In the 6 patients with renal failure on R.D.T., however, the iron turnover was greatly increased at 0.40–1.46% per day with a mean of 0.70% per day. In other words, the mean iron turnover had increased ten-fold.

Two of the patients studied were under review, both before and after commencing R.D.T. The results in one of those patients are summarised in Figure 1.

This was a 44-year-old male patient with polycystic kidneys. His creatinine clearance was 5 ml/min. and unfortunately the period studied prior to commencing R.D.T. is short—16

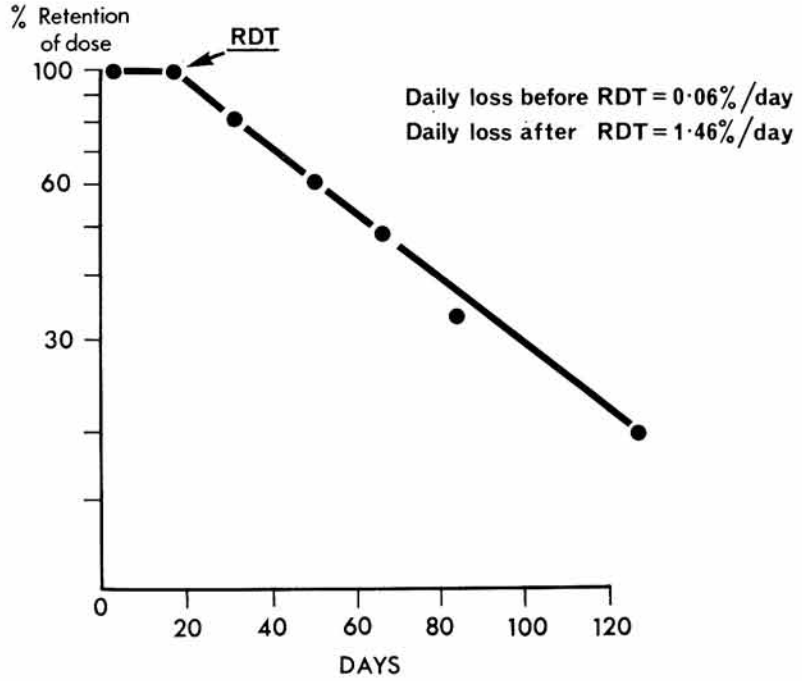

Fig. 1. Iron loss during dialysis (patient H.B.).

days—but during this time his daily iron loss was well within the normal range at 0.06% of administered dose per day. Immediately on starting R.D.T. this loss increased over twenty-fold to 1.46% per day—the highest loss in our series.

Iron loss: Loss of injected Fe^{59} from patient into dialysing fluid was low—0.12% of administered dose—so low in fact that it was at the limit of accuracy of our monitor and its significance is doubtful. It can, however, be said with accuracy that insignificant quantities of iron are lost by this route.

Iron gain: Uptake of labelled iron from the dialysing fluid was more readily detected and varied between 0.33% and 0.40% of the administered dose. It will be readily appreciated that the amount of iron thus absorbed will be dependent upon the iron concentration of the tap water. The water iron concentrations in various districts in Glasgow and in the main feeder reservoir are shown in Table II. The maximum permissible iron concentration in reservoir inlets in Britain is 300–500 μg Fe/l water. In concentrations above this level the water becomes totally unpalatable (Public Analyst, Glasgow Corporation, 1968).

TABLE II

Iron content of water

	μg Fe/l
Loch Katrine	2
Gorbals District	80
Average Glasgow	50
Maximum permissible in reservoir inlets	300–500

If a patient absorbs 0.33% of the iron in 300 l of dialysing fluid per dialysis, then even in a situation in which the iron concentration is as high as 500 μg Fe/l he will only absorb 1 mg of iron per week and certainly in Glasgow it will take 6 weeks of twice weekly dialyses to permit 1 mg of Fe to be absorbed.

From these findings it would appear that patients on R.D.T., using Kolff twin-coil kidneys, are losing iron at a fast rate and the most likely place for this to occur is at dialysis, both (*a*) in blood removed for investigations, and (*b*) in blood left in coil after dialysis.

Blood loss: As the maximum amount of blood removed from the patients under study in any one week for routine investigations is no more than 40 ml, this hardly explains the findings.

However, the blood loss in the coils was only inaccurately known. By washing the coils through with large quantities of saline and estimating the resultant haemoglobin concentration and 'packed-cell value' of the washings it was thought that 30–50 ml blood was lost at the end of dialysis when the patients were dialysed on chron-a-coils with a final wash through volume of 750 ml fluid. However, on studying the blood loss in the coils using the whole body monitor after the patients' red cells were labelled with Cr^{51} it was found that the blood loss varied between 68 and 140 ml, the average being 120 ml.

These results suggest that the patients' weekly blood losses are approximately 280 ml, a figure which largely explains the dramatically increased iron turnover revealed independently by the Fe^{59} studies. Supplies of the new Baxter ultra-flo coil became available in recent months and it appears that the blood loss per dialysis using this coil is much less than when using the chron-a-coil. Figures of 14–30 ml have been obtained using the Cr^{51} method of counting.

It has been stated that measurement of the serum iron and total iron binding capacity (T.I.B.C.) is a poor guide to the patients' iron status (Verroust *et al.*, 1967). However, in this case 5 out of the 6 patients were iron deficient by these measurements (Table III). The one patient, M.D., who was not deficient by these parameters was the only one being transfused regularly (see next page).

TABLE III

Serum iron and T.I.B.C. in R.D.T. patients

	μg/100 ml		
	Fe	TIBC	% saturation
K. O'B.	12	385	3.1
J. A.	44	368	12.0
D. McG.	48	549	8.7
H. B.	24	493	4.9
M. D.	70	268	26.0
J. McG.	43	561	7.6

Since July, 1967, we have adopted a policy of only transfusing patients on regular dialysis therapy should they become symptomatic (Verroust *et al.*, 1967). The blood requirements in the 6 patients being studied here are summarised in Table IV.

TABLE IV

Blood requirements in R.D.T.

	Units per month	
	Before*	After*
K. O'B.	—	0.5
J. A.	—	0
D. McG.	1.3	0.1
H. B.	—	0.1
M. D.	1.0	1.0
J. McG.	1.2	0.2

* Before and after decision to transfuse only when symptomatic.

It can be seen that patient M.D. is the only one to continue to require significant amounts of blood—this because of the development of angina of effort at P.C.V. values below 22%. This patient is the one patient in our series whose serum iron level is approaching normal (Table III).

Thus, despite the high figures obtained for blood loss we have been able to adopt a policy of non-transfusion in all patients unless symptoms persevere.

CONCLUSIONS

Iron deficiency may arise in patients being dialysed twice weekly on Kolff twin-coil machines, especially if the coil used is a chron-a-coil. This is due to blood loss in the coil at the end of dialysis and is less marked in patients who are transfused regularly.

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