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Absorption of fatty acid-iron from the intestine II. Absorp-tion of iron after repeated oral administrations of fatty acid-iron and intravenous injection of collol-dal fatty acid-iron

Toshio Amano*

*Okayama University,

Absorption of fatty acid-iron from the intestine II. Absorp-tion of iron after repeated oral administrations of fatty acid-iron and intravenous injection of collol-dal fatty acid-iron*

Toshio Amano

Abstract

1. In an attempt to see how fatty acid iron will be absorbed from the intestine, a single administration of fatty acid iron was given and when histological observations were done with lapse of time, it was found that the iron compound was first split into iron and fatty acid and each of them was then absorbed by the intestines by a different mechanism as described in the first report. The present experiment further confirmed these findings. 2. Following the first experiment, another attempt was made to determine how iron was absorbed in the animals given successive oral administration under various conditions or a single intravenous injection of colloidal fatty acid iron, and it was demonstrated that under a certain condition the presence of fat in the feed accelerates the iron absorption from the intestine but its mechanism remains unclarified.

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ABSORPTION OF FATTY ACID-IRON FROM THE INTESTINE

II. ABSORPTION OF IRON AFTER REPEATED ORAL ADMINISTRATIONS OF FATTY ACID-IRON AND INTRAVENOUS INJECTION OF COLLOIDAL FATTY ACID-IRON

Toshio AMANO

Department of Pathology, Okayama University Medical School
(Director: Prof. Satimaru Seno)

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Previously in the histological observations[1] on iron absorption after a single oral administration of fatty acid iron it has been found that the fatty acid iron is split into iron and fatty acid and each is absorbed from the intestine by separate mechanisms. In the present experiments the oral administration of fatty acid iron was carried out for 9 consecutive days, and also intravenous injection of colloidal fatty acid iron was attempted, and the results of their histological observations are described in the present paper.

MATERIALS AND METHODS

As for the test animals just as in the previous report 25 hybrid male rats weighing about 150 g were divided into two groups. That is, one group was consisted of 20 animals given successive oral administration of fatty acid iron and the other was of 5 animals given intravenous injection of colloidal fatty acid iron. By sacrificing the animals at a certain interval the sections of the intestines, liver and spleen were prepared, and stained with Berlin blue for histological observation to see the iron absorption.

The 20 animals in the first groups were further subdivided into four subgroups of 5 animals each. The first subgroup of 5 animals were given 1 ml of the fatty acid iron (containing 25 mg Fe) with an equal volume of corn oil for each animal/day into the stomach the same as in the previous report for 9 consecutive days. Throughout the experiment these animals were kept relatively in a fasting state by giving water only. The second subgroup was given the same amount of the iron compound in the exactly the same manner as in the first subgroup but was fed on the standard Oriental solid feed (MNF) along with water. The five animals belonging to the third subgroup were kept in a relatively fasting state just as in the first subgroup by giving 1 ml (25 mg Fe) of 2.5 % aqueous solution of Eisenzucker (iron-sugar)[2] prepared according to German pharmaceuti-

cal method into the stomach at a time/animal/day for 9 consecutive days. The fourth subgroup of 5 animals was fed on the solid feed with water without the administration of the iron compound for nine days as the control. These animals in each subgroup were sacrificed on the tenth day, and their intestines, liver, and spleen were fixed in neutral formalin and the sections stained with hematoxylin-eosin or Berlin blue were used for the observations of the absorption of iron.

The five animals belonging to the second group were given a single injection of 0.5 ml of 10 % colloidal fatty acid iron into the vein of the tail and sacrificed 5 hours later for the histological observation of iron distribution in their liver and spleen tissues.

The colloidal fatty acid iron employed in the second group was prepared in the following manner: to 5 ml water two drops of Tween 80 was added, and to this mixture the fatty acid iron-ether solution (containing 0.5 ml of fatty acid iron) was mixed, and an emulsion was prepared in a blender (at 15,000 r. p. m. for 20 min) and by heating this emulsion ether was evaporated. The colloid so prepared contained granules of less than 3 μ. As this colloid was unstable, it was used as soon as possible (within 30 min).

RESULTS

The first group: In the first subgroup that was given the fatty acid iron while being kept in a relatively fasting state, their body weight decreased in a straight line and the liver and spleen were markedly atrophied and the weight of their liver and spleen was decreased to less than half that of the second and fourth subgroups. As the result of Berlin blue staining, quite marked deposition of iron could be recognized in the liver and spleen. In the liver, the iron desposits were detected in the parenchymal cells around the portal blood vessels in the periphery of lobules. In the liver parenchymal cells in the center of lobules no marked iron deposition could be seen. In Kupffer cells only a minimal amount of iron could be detected in those cells around the lobules where the iron deposits were observable. Thus macroscopically, the picture of lobules was clearly stained by iron. Iron in the parenchymal cells appeared diffusely in the entire cytoplasm and there could be demonstrated fine granular iron particles agglomerated in the periphery of the cells along the bile capillary. Kupffer cells at the site of iron deposit had phagocytized only a very small amount of microgranular iron. In the liver sections stained with H-E the parenchymal cells were generally atrophied but no fibrotic or cirrhotic changes could be detected.

In the spleen, quite dense deposits of granular iron could be observed in splenic pulp, in the periphery of follicles as well as within the follicles, but especially markedly in the area surrounding the follicles.

In the second subgroup fed on freely with solid feed, in a striking contrast

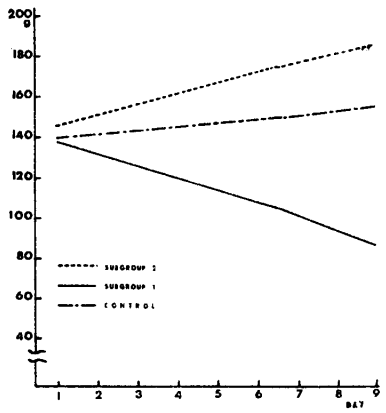

Fig. 1. Graphic illustration of the experiment.
Solid line shows the change in the average body weight of the subgroup 1 animals which were given fatty acid iron while being kept in a relatively fasting state. Dotted line shows that of the subgroup 2 animals fed on the standard solid feed along with fatty acid iron. Broken line shows that of the control animals fed on the standard solid feed only.

to the first group, the body weight increased in a straight line and it was over that of the fourth subgoup and the control, revealing marked deposits of fat on the mesentery and on the perirenal tissues showing an active absorption of fat. This fat was extracted with ether for the detection of iron but it proved to be negative. The results of Berlin blue staining of the liver and spleen sections in a marked contrast to those of the first subgroup showed no appreciable iron deposits the same as in the fourth subgroup. In the findings of H-E staining no fatty liver could be observed.

In the third subgroup given Eisenzucker (iron-sugar) while being kept in a relatively fasting state, the body weight decreased in a straight line as with the first subgroup, but just as in the second subgroup and the control no appreciable deposition of iron occurred in the liver and spleen.

Findings of the intestine stained with Berlin blue were the same as reported in the first paper in every group, but it seemed that the iron absorption decreased in the descending order of the first, second and third subgroups.

The second group: In this group given intravenous injection of colloidal fatty acid iron, the liver sections stained with Berlin blue showed hardly any iron in the parenchymal cells but it was taken up selectively by Kupffer cells in abundance. Even in the spleen marked iron deposition was observable in the splenic pulp.

SUMMARY AND DISCUSSION

In the previous report it was stated that at the time of absorption of fatty

acid iron from the intestine the iron compound is first split into iron and fatty acid and then each is absorbed by different mechanisms. After the successive administration of the iron compound in the first group of this experiment in the subgroup fed on the usual solid feed an active absorption of fat can be observed while no marked absorption of iron can be recognized. The marked iron absorption can be observed only in the subgroup given fatty acid iron while being kept in a relatively fasting state. This finding further confirms the asumption presented in the previous report that fat and iron are each absorbed by different mechanisms in the intestines.

The fact that no appreciable iron deposition could be observed in the liver and spleen of the third subgroup given Eizenzucker prepared by combining an equal amount of iron with sugar while keeping the animals in a relatively fasting state and that a marked iron deposition occurred only in the first subgroup given fatty acid iron also kept in a relatively fasting state, seems to indicate that fat plays the role of accelerating the iron absorption in the intestine. This suggests the condition where fatty acid can act as an iron carrier or the condition where a specific partner is required at the time when fatty acid is being absorbed. In other words, it indicates a possibility that iron is absorbed by being combined with fatty acid when the latter cannot find a proper partner to combine with and in the presence of a proper partner fatty acid combines with that substance rather than with iron, and thus this substance is absorbed but not iron.

Be it as it may, considering the observations of BADENOCH[3] in which he found inhibition of iron absorption in steatorrhea, it seems resonable to assume that the absorption by fatty acid iron is associated closely with the iron absorption. Moreover, the fact that a marked acceleration of iron absorption occurs in the animal fed on low protein feed[4] implies a relatively fasting state, and conversely it means that the absorption of iron is difficult to take place when fed on protein rich feed because fatty acid amino acid complex inhibits the formation of fatty acid iron. With such an interpretation it is easy to understand the experimental results of GILLMAN[5] who recognized the acceleration of iron absorption in the animals fed on the feed of low nutrition. Therefore, there is still a room for further and more precise study on fatty acid iron compound.

At the intravenous injection of colloidal fatty acid iron in the second group, however, iron entered into the reticulo-endothelial system. This indicates that, when fatty acid iron enters into blood vessel in an intact form, it is completely phagocytosed by reticulo-endothelial cells. Consequently it may be assumed that the fatty acid iron orally administered is not taken up by the intetine in the intact form of the fatty acid iron.

Plate 1.

Plate 2.

Plate 3.

EXPLANATION FOR PHOTOS

Photo Plate 1. The liver section from the animal received the oral administration of fatty acid iron with corn oil for 9 consecutive days while being kept in a relatively fasting state and sacrificed on the tenth day, stained with Berlin blue. Marked deposition of iron can be recognized in the parenchymal cells around lobules. Higher magnification in the upper right corner. Nucleus appears white and the grey cytoplasm shows the iron reaction.

Photo Plate 2. A section of the spleen stained with Berlin blue, from the same animal illustrated in Plate 1.

Photo Plate 3. A section of the liver from the animal 5 hr after the intravenous injection of colloidal fatty acid iron throuth the tail vein, stained with Berlin blue. Iron can be detected selectively in the reticulo-endothelial cells but not in the liver parenchymal cells.

CONCLUSION

1. In an attempt to see how fatty acid iron will be absorbed from the intestine, a single administration of fatty acid iron was given and when histological observations were done with lapse of time, it was found that the iron compound was first split into iron and fatty acid and each of them was then absorbed by the intestines by a different mechanism as described in the first report. The present experiment further confirmed these findings.

2. Following the first experiment, another attempt was made to determine how iron was absorbed in the animals given successive oral administration under various conditions or a single intravenous injection of colloidal fatty acid iron, and it was demonstrated that under a certain condition the presence of fat in the feed accelerates the iron absorption from the intestine but its mechanism remains unclarified.

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REFERENCES

1. AMANO, T.: Absorption of fatty acid iron from intestine, I. Absorption of iron after a single oral administration of fatty acid iron. *Acta Med. Okayama*, in press
2. Kommentar zum Deutschen Arzneibuch, 6 Ausgabe, II p. 593, 1926
3. BADENOCH, J. and CALLENDER, S. T., Iron metabolism in steatorrhea, the use of radioactive iron in studies of absorption and utilization. *Blood* 9, 123, 1954
4. WYATT, J. P. and HOWELL, J.: Experimental induction of iron overload in the rat, 1. Morphological alterations due to dietary siderosis. *Arch. of Path.* 55, 466, 1953
5. GILLMAN, T. *et al.*: Experimental dietary siderosis. *Am. J. Path.* 35, 349, 1959