THE METABOLISM, EXCRETION, AND HUMAN REQUIREMENTS OF CALCIUM

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Until the Government decided to fortify bread with calcium in the interests of national health the metabolism of this element had been the concern only of specialists in the subject. These international investigators, many of them with years of research and clinical experience behind them, had established certain facts as beyond all question, and it was no doubt on the weight of their findings that the Government based its proposal. As so often happens in this country of free and independent thought and speech, the Government's scheme was immediately criticized in various ways, counter-measures were put forward, and for the last six months or more the whole matter has been hotly debated in the lay and medical press.

In matters of this kind only people who are familiar with the facts can form any sound judgment. Those who are not tend to be swayed by the party which is able, or takes the trouble, to make the most noise. It may be of value, therefore, to outline briefly some of the generally accepted facts about calcium metabolism, and in their light to discuss an article which has recently appeared in this *Journal* (Harris, Ireland, and James, 1941).

Storage of Calcium

Calcium is an element which is essential for life and health and which at the same time is not at all easily absorbed. There are several reasons for the latter. One is the valency of the element, divalent cations being absorbed much less readily than monovalent. Another is the tendency of the element to form salts which are insoluble in the intestinal juices. Nevertheless, the requirements of bones and teeth demand that children shall store calcium at the rate of about 2 grammes per week from the time they are born till they are 17 or 18 (Leitch, 1937). Absorption and storage are facilitated by vitamin D, but no amount of vitamin enables a child (or an adult) to dispense with calcium itself. If children are to store 2 grammes per week they should be supplied with *at least* three times this amount, because much of the calcium in the food always escapes absorption and some of the calcium which is absorbed is inevitably excreted in the urine or finds its way back into the intestine as a constituent of the digestive juices. Adults require less calcium than children because their bones and teeth are fully formed, but their needs for maintenance are just as important. If sufficient calcium is not supplied to adults their bones tend to become rarefied and therefore liable to fracture (Owen, Irving, and Lyall, 1940).

Most of this knowledge of human calcium requirements has been gained by experiments in which the intake of calcium in the food has been balanced against the output in the urine and faeces. These experiments are not easy to carry out, and considerable experience is required to make them a success, but many satisfactory ones have now been performed, and from them it is easy to see in any particular instance whether the calcium in the food has been sufficient to promote satisfactory storage or maintenance. The papers of Bauer, Albright, and Aub (1929) and of Hunscher *et al.* (1934) contain excellent examples of such work, and for a summary, review, and application of such investigations Leitch's (1937) article should be consulted. The last word has naturally not been said, but certain facts are clear. One is that the amount of calcium

retained by a normal adult over any given period of time is never more than a small percentage of the intake. Another is that normal men and women excrete 10 to 50% of their intake of calcium in the urine, 50 to 90% in the faeces.

If more calcium is absorbed than the body requires the excess is excreted in the urine. The amount so excreted is always small, and variations in it make no appreciable difference to the total osmotic work of the kidney, most of which is devoted to the excretion of urea, sodium, potassium, chlorides, and phosphates. Thus Borsook and Winegarden (1931), who set out to calculate in great detail the osmotic work performed by the kidney in producing one litre of urine, came to the conclusion that the total work amounted to 704 grammes calories and that the quota of this due to the calcium ion was only 1 grammes calorie—i.e., about 0.14%. Previous estimates of the total work of the kidney in producing a litre of urine had been of the same order (Cushny, 1926), and the principles and methods of all these authors were accepted as being substantially correct by Eggleton, Pappenheimer, and Winton (1940).

Optimum Calcium Requirement

On January 11 a paper by Harris, Ireland, and James appeared in this *Journal* entitled "Optimum Calcium Requirement." To the public and to most of the medical profession this article probably bears the stamp of having been written by experts and as such commands respect. Indeed, the views of the authors have already been given wide publicity, and it is because of this that I have ventured to write this cautionary note. To those who have made a careful study of physiology and calcium metabolism there are many features of this article to which serious exception must be taken. The section of the article headed "Calcium Balances" illustrates this. The authors give a series of balances in adults and discuss them as an integral part of the paper. A table shows the averaged intakes and excretions at different levels of intake. In every case the urinary exceeds the faecal calcium, sometimes by two to three times! Furthermore, some of the retentions of calcium amount to over 70% of the intakes. It is most unlikely that all previous investigators have been wrong on these two points and that Harris *et al.* alone are right. Yet the latter make no reference to any previous work. Surely some of it was known to them. There is no doubt that experienced investigators, finding themselves in disagreement with all previous workers, would not have published their findings without a full description of their methods and the steps they had taken to satisfy themselves that their results were the correct ones. Harris *et al.* have furnished us with none of this information.

Later in the article Harris *et al.* take up the question of the work of the kidney at various calcium intakes. They quote without reference (but with a spelling mistake) a formula for determining the work of the kidney and give some results of their own. They claim that lowering the calcium intake reduced one person's kidney work from 18.8 to 5.1 litre atmospheres/litre and another's from 14 to 0.9 litre atmospheres/litre: 14 litre atmospheres is the work equivalent of 339 grammes calories. If this figure is compared with those of Borsook, to which reference has just been made, it will be seen that it is too small to be a reasonable estimate of the total work of the kidney, and 0.9 litre atmospheres (21.8 grammes calories) is ridiculously small. One is forced to conclude that there is something radically wrong with Harris's figures. Furthermore, when it is recalled that, according to experienced authors (Borsook and Winegarden, 1931), the work done by the kidney on the calcium ion forms only 0.14% of the

total work, it is impossible to see how any physiological or pathological change in the excretion of calcium could possibly produce a significant rise or fall in the total work of the kidney.

Positive Calcium Balances

One further point. Under the heading "Positive Calcium Balances" Harris *et al.* allude to experiments on rabbits in which the animals were given diets rich in calcium, and their aortae subsequently analysed for this element. In a short table figures are given for two experimental animals and one control. The former's aortae contained 16.2 and 16.9 mg. calcium/100 grammes and the latter's 9.0 mg./100 grammes. These findings are claimed to be of significance to those interested in the aetiology of clinical arteriosclerosis, and they are employed to emphasize the dangers of high calcium diets in man. Now rabbits are animals which are well known to vary considerably among themselves. They are much less uniform than the inbred laboratory rat, and large numbers have to be used to establish differences of this kind. Yet Harris *et al.* do not give the number of animals used or their diets. They say nothing about the times for which the diets were administered, nor do they even mention the range of variations in the normal or in the experimental animals. Moreover, even if these experiments were repeated and confirmed it would not follow that the same would happen in man. Apart from the differences normally found between species, the rabbit's aorta is peculiarly liable to atheromatous degeneration when the diet is rich in cholesterol, and it may have an equally unusual calcium metabolism. So far as man is concerned there is no evidence that a high calcium diet leads to a deposition of calcium in healthy tissues. If there are degenerating areas in the body calcium phosphate may be deposited therein, whether the intake is high or low.

The results described in the article under criticism will carry no weight with the professional scientists until they have been repeated and confirmed by independent authorities. It is very much to be hoped that the public and the medical profession will take the same view.

REFERENCES

- Bauer, W., Albright, F., and Aub, J. C. (1929). *J. clin. Invest.*, **7**, 75.
 Borsook, H., and Winegarden, H. M. (1931). *Proc. nat. Acad. Sci.*, **17**, 3.
 Cushman, A. R. (1926). *The Secretion of Urine*, London.
 Eggleton, M. G., Pappenheimer, J. R., and Winton, F. R. (1940). *J. Physiol.*, **97**, 363.
 Harris, I., Ireland, J. T., and James, G. V. (1941). *British Medical Journal*, **1**, 49.
 Hunscher, H. A., Donelson, E., Erickson, B. N., and Macy, I. G. (1934). *J. Nutr.*, **8**, 341.
 Leitch, I. (1937). *Nutr. Abstr. Rev.*, **6**, 553.
 Owen, E. C., Irving, J. T., and Lyall, A. (1940). *Acta med. scand.*, **103**, 235.

It is the object of the Cicely Northcote Trust, attached to St. Thomas's Hospital, to experiment in new forms of social service and to extend the social work of the lady almoner's department from the out-patients and casualty cases to the ward patients and their families. The thirty-first annual report contains no statistics or audited accounts for the very good reason that many of the records, case papers, and books were lost in the destruction which befell parts of St. Thomas's Hospital by enemy action. The workers, however, were unharmed and the work has gone on. Throughout the year, in spite of calamity and disorganization, it has been possible to continue the systematic care of all the patients suffering from cancer. The plight of these patients during the early part of the war, when chronic wards were in many cases emptied and homes for cases of advanced disease ceased to admit, was often a desperate one. Some of these people have now been evacuated to the country, but it is stated that while a number are delighted by the peaceful surroundings, there are others who look upon the experience as one to be endured rather than enjoyed, and some who refuse to leave the part of London they know and, in addition to the sufferings entailed by their malady, face outside danger and discomfort with quite extraordinary courage.

Clinical Memoranda

Carbuncle of the Duodenum

The following case has three points of interest: (1) the difficulty in pre-operative diagnosis; (2) the unusual finding in "acute abdomen"; and (3) the satisfactory response to heroic treatment in an aged patient.

CASE REPORT

A woman aged 84 was admitted to hospital on December 5, 1940, complaining of continuous acute abdominal pain of five days' duration. The pain was generalized in the abdomen, but was most severe in the right upper quadrant. There was no complaint of nausea or vomiting. The previous history was negative for serious or relevant illness.

On admission the examination showed the patient to be well preserved for her age. There was no evidence of jaundice. The temperature was 98° F., the pulse 88, and the respiratory rate 22. Nothing abnormal was detected in the various systems beyond a degree of arteriosclerosis and a systolic murmur at the apex. The abdomen showed limited respiratory excursion and a girdle of pigmented moles at the waist-line. On palpation there was generalized tenderness, most intense in the right hypochondrium. A freely movable rounded mass about the size of a hen's egg could be felt immediately to the right of and slightly above the umbilicus. Liver dullness was normal, and localized dullness was elicited over the tumour. The remaining areas of the abdomen were uniformly tympanitic. On auscultation bowel movements could be heard. A tentative diagnosis of acute cholecystitis was made, and the patient received expectant treatment during observation.

On December 6, there being no improvement, laparotomy was performed by Mr. Richard Warren, through a right paramedian incision, under gas-oxygen-ether anaesthesia. On opening the peritoneum a mass covered by omental tags was seen in the right upper quadrant. The gall-bladder was identified and exonerated. The fundus of the stomach was traced down into the omental-covered mass, which was only slightly adherent and was easily stripped off. The lesion was then seen—a carbuncle, oval in shape, two inches by one inch, situated on the anterior surface of the first part of the duodenum. There was no macroscopic perforation into the peritoneal cavity, but six necrotic "pointing" areas were noted under the membrane. On palpation it was thought that an ulcer crater the size of a sixpence could be felt centrally in the carbuncle within the lumen of the bowel. The lesion was oversewn with a continuous catgut suture, and posterior gastro-jejunostomy performed.

Unfortunately, bacteriological investigation was inopportune, but 1 gramme of protosil soluble was given empirically, twice daily for five days by the intramuscular route. Recovery was uneventful and the patient was discharged well on December 30.

Our thanks are due to Mr. Richard Warren, honorary surgeon to the hospital, for permission to record this case.

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Note on the Treatment of Acute Bacillary Dysentery with Sulphapyridine

The treatment of acute bacillary dysentery with sulphapyridine (M & B 693) has proved with us to be highly efficient. We have treated 20 patients (dysentery Shiga, 4; Flexner-Y, 13; Strong, 1; Sonne-E, 1; Schmitz, 1) with results so uniformly good even in the severe cases that we feel justified in publishing our observations in spite of the relatively small number of cases. It should be pointed out, however, that the drug seems to have no effect whatsoever in amoebic dysentery.

All our patients were adults suffering from severe or moderately severe bacillary dysentery. Mild cases have not been