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Vitamin Absorption in the Elderly

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An analysis of 12 studies on elderly people in the USA living either in old people's homes or at home suggests that their vitamin status is often insufficient. This is evidenced both by dietary surveys revealing inadequate intake and by biochemical parameters. Along with what is undoubtedly the dominant factor, namely low intake, unsatisfactory vitamin and carotenoid status may also be due to increased requirement (possibly determined in part by the chronic infections that are common in the elderly) and inadequate absorption in the gastrointestinal tract [1]. Impaired absorption could be due to age-related organ involution, age-related gastrointestinal diseases, or negative influences of medications commonly used in the elderly. As demonstrated in studies on patients with extensive small intestinal and pancreatic resection, both the digestive and the absorptive organs have a very great reserve capacity. Although the pancreas starts to show degenerative changes by the age of 60, the volume of the organ halves by the age of 80, and the secretin-pancreozymin test shows a significant fall in bicarbonate and enzyme secretion with increasing age [2], the great reserve capacity of the organ ensures that absorption of fat, protein, and carbohydrates is not impaired. The frequently cited delay in stomach emptying time for both liquid and solid foods [3, 4, 5] with increasing age despite unchanged mouth-cecum transit time [5, 6, 7] probably has no effect on the absorption of orally ingested vitamins. Despite the lack of evidence – as demonstrated in particular by the normal absorption of macronutrients in the elderly – of any clinically relevant functional impairment of gastrointestinal organs as a result of the normal aging process, the fact that special gastrointestinal conditions are required for the absorption of many vitamins implies that unaltered absorption of all vitamins in the elderly cannot simply be assumed. The preconditions for optimal absorption of individual vitamins vary and in some cases are very complex.

Water-soluble vitamins

Of the water-soluble vitamins, only vitamin B_{12} and folic acid show impaired absorption in the elderly. This is due to the reduced gastric secretion commonly present in the elderly and to the use of certain medications.

Vitamin B_{12}

Protein-bound dietary vitamin B_{12} is released in the stomach by hydrochloric acid and pepsin and is bound depending on pH mostly to haptocorrin (R protein) and to a lesser extent to intrinsic factor. In the upper small intestine cobalamin is released from R protein by the action of pancreatic trypsin and is then bound to intrinsic factor and in this form absorbed in the terminal ileum mediated by specific receptors. Increasing age has a negative impact on the preconditions for optimal vitamin B_{12} absorption. Increasing age is accompanied by increasing colonization of the gastric mucosa with Helicobacter pylori, the prevalence of which in central Europe is more than 50% from the age of 50 years. This leads to the development of chronic gastritis (gastritis B) with hypochlorhydria and achlorhydria and decreased production of intrinsic factor. Long before the discovery of Helicobacter pylori it was known that both basal and histamine-stimulated gastric acid secretion decrease with increasing age [8, 9].

Gastric hypochlorhydria and achlorhydria are associated with poor absorption of protein-bound vitamin B_{12}. This is true both of the hypochlorhydria and achlorhydria of chronic gastritis and of the situation after partial gastrectomy. Whereas the absorption of 57 Co-labeled crystalline vitamin B_{12} is normal even in the presence of hydrochloric acid and pepsin deficiency, the mean absorption of vitamin B_{12} incorporated in vivo into hens' eggs is only 12% [10]. The bacterial colonization of the stomach

that regularly occurs in the presence of hypochlorhydria and achlorhydria leads both to consumption of vitamin B_{12} and to bacterial synthesis of substances that compete with the vitamin for receptors in the ileal mucosa [11]. The fasting gastric juice of persons with normal gastric acidity contains 102–105 organisms/ml, these being mostly streptococci, lactobacilli, Veillonella, and Clostridium perfringens, whereas in achlorhydric subjects the bacterial count is 106–107/ml and the flora is similar to the colonic flora, with coliforms, Bacteroides, etc. [12, 13]. Reduction of gastric pH to a plateau of 5–6 by administration of antisecretory medications leads to a bacterial count of 106–108/ml [13]. The fact that the reduction in vitamin B_{12} absorption associated with achlorhydria can be improved by administration of broad-spectrum antibiotics is evidence of the importance of bacterial colonization [14]. In elderly people H_2-receptor antagonists and proton pump inhibitors are used to reduce gastric acid secretion in the relatively common condition of reflux esophagitis. Especially with the very potent group of proton pump inhibitors, this results in a dose-dependent reduction in vitamin B_{12} absorption [11]. However, no significant fall in the serum level of vitamin B_{12} is seen until about three years after the start of such a therapy [14]. The oral antidiabetic metformin, the only biguanide still licensed for use, can also inhibit the absorption of vitamin B_{12} to such an extent as to reduce the plasma level of the vitamin [15, 16]. This finding has been confirmed in recent studies [17]. Administration of metformin has also been found to lead to a significant increase in the plasma level of homocysteine. Possible reasons for the reduction in vitamin B_{12} absorption are reduced secretion of intrinsic factor and also consumption of intrinsic factor by the altered intestinal flora that results from administration of metformin. Metformin may also interfere with the absorption of folic acid, and this indirectly may contribute to an increased plasma homocysteine concentration [17]. As biguanides are used only in type II diabetes, i.e. mostly in older patients, they may contribute to inadequate satisfaction of the vitamin B_{12} requirement in the elderly.

Folic acid

In persons with normal gastric secretion the absorption of folic acid does not decrease with increasing age [18]. Only in association with achlorhydria and hypochlorhydria is there a significant reduction in the absorption of folic acid monoglutamate as measured by the folic acid absorption test using [^{3}H]-labeled pteroylmonoglutamic acid. Thus, Russell et al. [18] found the proportion of the oral test dose absorbed to be significantly lower, at 31%, in twelve elderly subjects with atrophic gastritis than in a control group with normal gastric acid secretion. In three of the twelve subjects with atrophic gastritis folic acid absorption was reduced to less than 20%. Whereas administration of 120 ml of 0.1N HCl did not increase absorption in the subjects with normal acid secretion, it increased folic acid absorption in the subjects with atrophic gastritis to 54%, a figure within the normal range. These findings confirm the fact that a rise in pH in the jejunum, the site of folic acid absorption, reduces absorption of this vitamin [19, 20, 21]. The results of animal experiments also indicate that active absorption of folic acid is only optimal within a very narrow range of pH. The fact that folic acid absorption is markedly reduced in a high percentage of partially gastrectomized patients confirms the negative effect of a suboptimal pH range in the upper small intestine [22, 23]. Despite the reduction in folic acid absorption that occurs in association with reduced gastric acid secretion, both patients with atrophic gastritis and partially gastrectomized patients have serum folic acid levels within the normal range. This is due to increased bacterial colonization of the upper small intestine with folic acid-synthesizing organisms [18]. Recent studies have confirmed that whether due to atrophic gastritis or induced by administration of omeprazole, achlorhydria is accompanied by increased bacterial colonization of the upper small intestine. Use of a perfusion technique in which ^{3}H-paraaminobenzoic acid was instilled as a precursor for bacterial folic acid synthesis confirmed the existence both of bacterial folic acid synthesis and of absorption of the synthesized folic acid [24].

Fat-soluble vitamins and carotenoids

As stated above, despite the morphologic changes that accompany aging, exocrine pancreatic function does not diminish with age to the extent that there is any impairment of fat absorption. The most important precondition for the absorption of fat-soluble vitamins and carotenoids is thus satisfied in the elderly.

Vitamin A, vitamin E, and carotenoids

The unexpectedly higher postprandial concentrations of vitamin A esters that are found with increasing age are due to delayed plasma clearance of retinyl esters in triglyceride-rich lipoproteins rather than to increased absorption of vitamin A [25]. Nevertheless, there is also evidence suggesting that vitamin A absorption increases with increasing age, which could be explained by a reduction in the thickness of the unstirred water layer with increasing age [26]. This finding would also explain the age-related increase in the fasting plasma concentration of vitamin A

that has been found in nutritional studies such as NHANES I and II [27]. According to the available studies, absorption of the other fat-soluble vitamins, in particular vitamin E, but also beta- and alpha-carotene, zeaxanthin, lutein, and beta-cryptoxanthin, remains unchanged with increasing age. The low plasma concentrations of carotenoids and vitamin E that have been repeatedly described as occurring with increasing age may be due to inadequate dietary intake. The low lycopene concentrations that have been repeatedly found in elderly subjects and which were found even in the participants of the "nun study", who lived in very uniform conditions, are generally explained by low intake. Nevertheless, the possibility of an age-related reduction in absorption or increase in metabolism has also been discussed [28]. The results of the "nun study" show that even at an advanced age, an optimal diet without alcohol or nicotine ensures normal plasma levels of antioxidants.

Studies on α-tocopherol absorption in young (20–30 years) and older subjects (64–72 years) showed a variable pattern of postprandial vitamin E concentration in plasma. This was interpreted as a consequence of age-related changes in lipoprotein metabolism. The postprandial concentration of α-tocopherol in chylomicrons, via α-tocopherol enters the circulation after being absorbed, was found to be significantly lower in older than in younger subjects. This is due to less absorption. By contrast, the concentration α-tocopherol in non-chylomicron-lipoproteins was significantly higher in older subjects. Possible explanations for the reduced absorption are age-related changes in the intestinal lumen such as pH shifts, changes in bile salt and phospholipid concentrations, and reductions in enzyme activities. The common phenomenon, as confirmed in this study, of significantly higher fasting concentrations of α-tocopherol in the plasma of elderly subjects is regarded as being due to an age-related increase in the concentration of α-tocopherol-transporting lipoproteins and not to increased absorption [29].

Vitamin D

Optimal attainment of the vitamin D requirement is of great clinical importance for the prophylaxis of osteoporosis. Because of the known reduction in synthesis of vitamin D in the skin of the elderly, oral intake and adequate intestinal absorption are of great importance. Reports of low plasma concentrations of 25-hydroxycholecalciferol in the elderly despite adequate dietary intake go back to the 1970s. Using the [^{3}H]-cholecalciferol absorption test it was shown that as compared with subjects aged 30–58 years, subjects aged 68–94 years had significantly lower vitamin D concentrations in plasma despite a similar pattern of plasma triglycerides [30].

As a result of inadequate dietary intake of vitamin D, reduced vitamin D synthesis in the skin, and reduced absorption both of vitamin D and of calcium, the calcium and vitamin D concentrations required after the age of 65 years for optimal prophylaxis of osteoporosis are not present. Therefore, a prospective placebo-controlled study in which the diet of 176 men and 213 women all over 65 years of age was supplemented with 500 mg of calcium and 700 IU of vitamin D3 was performed in the USA. Over an observation period of three years the supplemented group showed a significant improvement in bone density and a reduction in the number of non-vertebral fractures as compared with the placebo group. The design of the study did not permit any conclusion as to the relative contributions of calcium and vitamin D3 to the observed prophylactic effect [31].

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