avitaminosis were induced by feeding diets deficient in vitamins A, B, C and D. The effect of cod liver oil administration and treatment with ultraviolet light was also studied.

As a test of digestive efficiency there was added to the diets in successive periods definite amounts of raw potato starch and elastin or ground horn. The feces were analyzed for starch or protein and for iron and utilization calculated, a correction for metabolic nitrogen being made.

Starch digestion was in the neighborhood of 90% for all animals including controls. For protein digestion values of 51% for animals on -B diet and 60% for rachitic diets as compared with 68% for controls were the greatest variations noted. It is not believed that these differences are great enough to support the view of an early or specific impairment of digestive function in these avitaminoses. Neither did iron reduction tests[4] indicate increased intestinal bacterial activity in these conditions.

[1] McCarrison, R., *J. Am. Med. Assn.*, 1922, lxxviii, 1.
[2] Farmer, C. J., and Redenbaugh, H. E., *Am. J. Physiol.*, 1925-26, lxxv, 45.
[3] Bergeim, O., *J. Biol. Chem.*, 1923, lxx, 29.
[4] Bergeim, O., *J. Biol. Chem.*, 1924, lxii, 45.

3901

Duodenal Drainage of the Human Gall Bladder.

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During the last 5 years both the theory and the efficacy of the Meltzer-Lyon test have been frequently challenged, but as yet no adequate measurements of the amount of bile discharged from the gall bladder following the injection of $MgSO_4$ and other substances into the duodenum, seem to have been made.

In view of the consensus of opinion that $MgSO_4$ is not absorbed by the intestine and believing that evacuation of the gall bladder might be induced by mechanical stimulation, we injected air into the duodenum through a Reyfuss tube and then x-rayed the patient at short intervals—computing the volumes of the gall bladder according to the method employed in previous publications.[1] In 3 out of 4 individuals subjected to this procedure, the gall bladder showed measurable reduction in size after inflation of the duodenum (Fig.

1). In one case (the largest gall bladder we have ever seen) the reduction was considerable, from 96 down to 71 cc. (*A. R.*, Fig. 1). In 2 other cases *(E. I.* and *M. A.)* it amounted to only a few cc., and in the fourth case *(G. A. K.)*, dilation of the gall bladder ensued —a reverse effect which we interpret as a reflex inhibition of the gall bladder, due to sudden and forcible inflation of the duodenum. (*cf.* case *B. B.*, Fig. 1 of accompanying paper).[2]

In each of the 4 cases,egg yolk was subsequently injected into the duodenum in order to test the motility of the gall bladder. It is

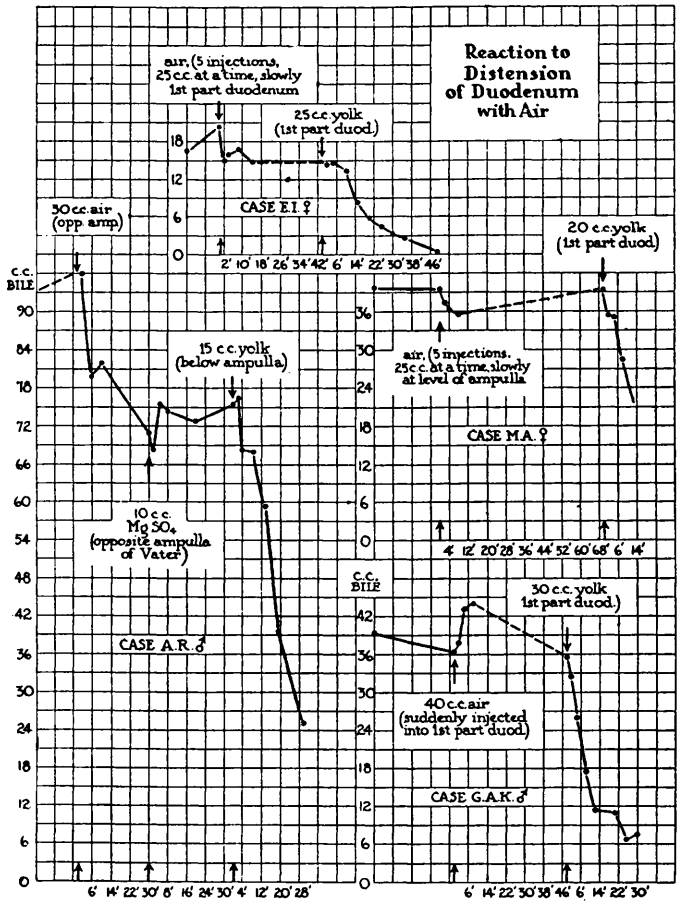

FIG. 1.

Four graphs showing reaction of human gall bladder to inflation of the duodenum through a Reyfuss tube. *cc.*, computed volumes of gall bladder; *2', 10'*, etc., minutes after injection of substances into duodenum. Case *E. I.*: epileptic, age 29, wt. 110; case *A. R.*: epileptic, age 16, wt. 165; case *M. A.*: epileptic, age 48, wt. 145; case *G. A. K.*: student, age 30, wt. 130.

interesting to note that when thus administered, this food induces as effective a phase of contraction as when taken by mouth.

Having ascertained the reaction of the gall bladder to inflation of the duodenum, concentrated $MgSO_4$ was then tried. In the first case (*A. R.*, Fig. 2) only a small amount was injected. Due to this, or possibly to the fact that it was administered after the gall bladder had just emptied a third of its contents, the drug was ineffective. In the second case, *(D. S.)* it caused a decrease in volume of about 18 cc. But in the third case (*H. A. S.*, Fig. 2) as much bile was discharged from the distended gall bladder (nearly 40 cc.) as usually occurs during the first phase of contraction following a meal of egg yolk. This was the more noticeable since the gall bladder of this individual reacted but little to previous injections of water and of dilute HCl. A study of the cholecystograms (Fig. 3) shows that within 2 minutes the broad, pear-shaped fundus of the organ markedly narrowed, and that within 15 minutes its volume had diminished from 63 to 25 cc. This rapid change in shape and volume surely indicates that we are dealing with a vigorous contraction of the gall bladder, induced by the presence of $MgSO_4$ in the intestine.

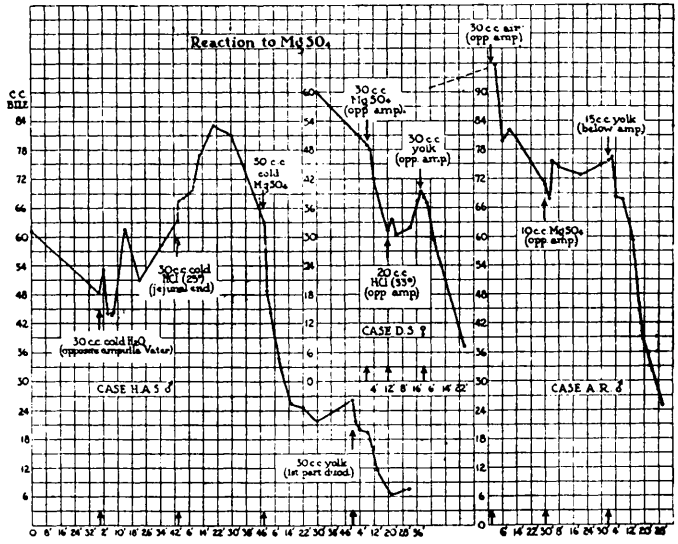

FIG. 2.

Three graphs showing reaction of human gall bladder to duodenal injection of concentrated $MgSO_4$. Case *H. A. S.:* student, age 21, wt. 155; case *D. S.:* epileptic, age 35, wt. 128; case *A. R.:* epileptic, age 16, wt. 165.

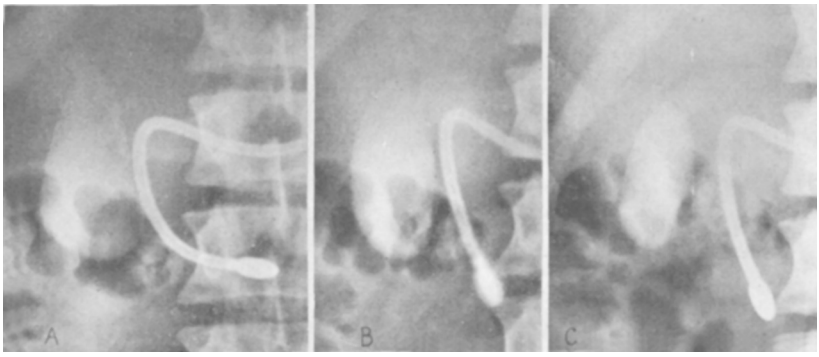

FIG. 3.

Selected cholecystograms showing contraction of human gall bladder after $MgSO_4$ (case *H. A. S.*, Fig. 2). *A*, just before $MgSO_4$: computed volume, 63 cc.; note broad fundus. *B*, 2 minutes afterwards: volume 49 cc.; fundus narrowed, Reyfuss tube forced back by injection. *C*, 15 minutes afterwards: volume 25.5 cc.

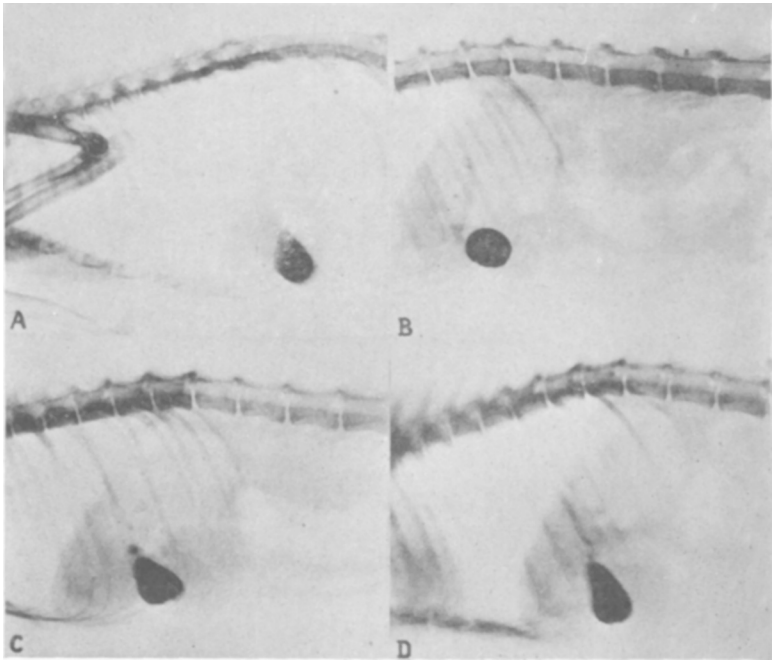

FIG. 4.

Selected X-rays of cat A II., showing reverse effects of injecting $MgSO_4$ and egg yolk into the duodenum after the common bile duct is sectioned. Gall bladder filled with iodized oil. *A*, eight hours after operation. *B*, 3 minutes after injection of a few cc. of concentrated $MgSO_4$; gall bladder relaxed. *C*, 10 minutes after injecting equal amount of egg yolk; gall bladder contracting. *D*, 15 minutes after egg yolk.

At least 3 hypotheses may be offered. *First,* the original one, that the drug paralyzes the smooth muscle of the sphincter papillae. But if it is able to pass through the epithelium of the mucosa it should be absorbed into the circulation and produce a general reaction—a circumstance which rarely occurs. *Second,* that it reacts upon the cells of the mucosa in such a way as to liberate a secretin-like hormone, which activates the musculature of the gall bladder or sphincter. To test the former hypothesis, the common duct of a cat was severed, and the gall bladder filled with iodized oil. Eight hours after the operation, $MgSO_4$ was injected into the duodenum, but the gall bladder failed to respond, although when an equal amount of egg yolk was injected it contracted vigorously (Fig. 4).

The third hypothesis is that the drug stimulates the nerve endings in the intestine, thereby setting up local or spinal reflexes which dilate the sphincter at the end of the common duct. Similarly, the contraction of the gall bladder itself may be explained in 2 ways, either that its musculature is directly activated by a spinal reflex originating in the duodenum, or that the release of pressure in the biliary duct system caused by the opening of the sphincter, stimulates the local nerve net or afferent nerve endings in the wall of the gall bladder, thereby inducing reflex contraction of its tunica muscularis. Whatever the interpretation, there can be no question of the fact that when $MgSO_4$ is injected into the duodenum it induces marked contraction of a distended gall bladder and consequent expulsion of bile.

[1] Boyden, E. A., *Anat. Rec.*, 1926, xxxiii, 201-256.

[2] Boyden, E. A., and Parmacek, L., PROC. SOC. EXP. BIOL. AND MED., 1928, xxv, 462.

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Reflex Inhibition of the Human Gall Bladder.

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In a previous publication, one of the authors reported that merely drinking a glass of water resulted in a discharge of bile from the gall bladder.[1] In extending these observations to a large number of patients (10 in all) considerable variation was found, ranging from an individual with a discharge of 24 cc. of bladder bile after