VITAMIN AND PROTEIN FACTORS IN PRE-OPERATIVE AND POSTOPERATIVE CARE OF THE SURGICAL PATIENT

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THE *Romance of the Vitamins* might well be the title of the story of those accessory food factors which Gowland Hopkins, in 1909, described as being indispensable for the maintenance of growth and life, which Funk, in 1911, called "vital amines," which McCollum, in 1914, found devoid of nitrogen and therefore designated his newly discovered unidentified dietary factor as "fat-soluble A," and which now threaten by their increasing numbers to exhaust the alphabet in such designations.

The beginning of the story dates back several centuries, when scurvy lurked menacingly and diabolically in the hold of all seafaring craft, only to have it miraculously disappear the moment land was reached and fresh food was again available. As early as 1747, James Lind showed by controlled experiments that orange or lemon juice was a specific cure.

Based on the long held conviction of physicians in the tropics that beriberi was a disturbance of nutrition, Eijkman, in 1896, presented the first scientific evidence of the existence of important accessory food factors by producing experimental polyneuritis in pigeons fed on polished rice. Stirring controversies as to whether beriberi was the result of contagion or nutritional deficiency culminated in the mass experiments of Fraser and Stanton who took 300 Javanese laborers into the jungle, divided them into two groups, feeding one group a ration containing polished rice and the other the same food except for the substitution of less refined rice. Beriberi developed in the first group after 3 months, whereupon the diets were reversed and the second group developed the disease. Of supreme importance with respect to optimum nutrition was the observation in these human guinea pigs that physical impairment occurred almost as soon as the experimental diet was inaugurated, although the classical symptoms of beriberi required a depletion period of 3 to 4 months. Since this classical experiment the vistas are ever broadening, additional vital factors are still being discovered, their chemical structures accurately formulated, and their artificial syntheses successfully accomplished. Their clinical significance in surgery is just beginning to be appreciated (36, 37, 48, 64).

During the past 11 years patients on my service at the Stanford University Hospital have been prepared for operation by several days of a high-caloric, high-vitamin diet supplemented by vitamin concentrates. Although such preparation had its stimulus in the excellent researches on vitamin A by Mellanby (26, 51) of Great Britain, subsequent experimental and clinical observations have provided adequate justification for stressing all the vitamins in such pre-operative preparation. Originally administered once or twice daily as a "vitamin cocktail" in the form of 1 ounce of codliver oil in the juice of a lemon, washed down by the juice of 2 oranges, the vitamins are now given in the form of haliver oil capsules, 2 thrice daily, supplemented by the juice of 4 oranges and 2 lemons daily and the ingestion of some form of vitamin B. Preference should be given to the concentrates of the entire vitamin B complex and not to isolated fragments limited to B_1 or B_2. In operations of election, such as thoracoplasty, cholecystectomy or hernia, such preoperative preparation is begun at home 1 and 2 weeks before admission to the hospital. In emergency procedures cevitamic acid and thiamin chloride are administered parenterally just before operation and in the immediate postoperative period. It is hoped that vitamin A will soon be available for parenteral injec-

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tion in more practical form. On the third day following operation, the vitamin concentrates are resumed by mouth and continued throughout the full convalescent period.

What are the known facts substantiating the importance of stressing the nutritional preparation of the surgical patient? Is there a definite lack of vitamins in the ordinary diet? Minot observes that "borderline states of nutritional instability are much more common than is usually appreciated. There is a wide zone between optiminal nutrition and the level at which classic symptoms of recognized dietary deficient states develop." As stated editorially in 1937 (36), the submerged half of the population, which lives on overcooked stews, doughnuts, and coffee, is probably in a chronic state of vitamin deficiency. As a test of this presumption, we recently studied the vitamin C content of the blood of patients admitted on the surgical clinic wards of Lane-Stanford Hospital in San Francisco. Despite the ready and cheap availability of fruit in this California region, a surprising number of patients showed a very low concentration of vitamin C in the blood (Table I).

In their studies on the vitamin C contained in the plasma of infants, Lanman and Ingalls segregated the groups as follows:

	Plasma ascorbic acid mgm. per 100 c.cm. blood
1. Well baby clinic	1.00
2. Ward patients—good vitamin C content in diet	0.73
3. Ward patients—poor vitamin C content in diet	0.22
4. Ward patients with frank scurvy	0.08

In his studies on the urinary excretion and blood concentration of ascorbic acid in infantile scurvy, Ingalls (40) presents the following figures:

State of vitamin C nutrition	Plasma ascorbic acid mgm. per cent
Optimum	
Saturation	2.00 to 1.00
Normal	1.00 to 0.70
Low normal	0.70 to 0.50
Suboptimum	0.50 to 0.30
Deficiency	
Asymptomatic scurvy	0.30 to 0.15
Clinical scurvy	0.15 to 0.00

On this basis our studies show that approximately 44 per cent of free clinic patients, who usually fall in the low economic group, gave evidence of being on a diet poor in

TABLE I.—SHOWING AMOUNTS OF ASCORBIC ACID PRESENT IN PATIENTS' BLOOD

Case No.	Diagnosis	Ascorbic acid mgm. per 100 c.cm. blood	Case No.	Diagnosis	Ascorbic acid mgm. per 100 c.cm. blood
1	Appendicitis	.63	35	Hernia	.14
2	Carcinoma of stomach	.38	36	Appendicitis, acute	.20
3	Peptic ulcer	.20	37	Peptic ulcer	.03
4	Cord tumor	.20	38	Polyp larynx	.40
5	Case 2	1.00	39	Brain tumor	.19
6	Case 3	.48	40	Acute appendicitis	.32
7	Empyema	.70	41	Brain tumor	.14
8	Hare lip	1.20	42	Carcinoma of the rectum	.23
9	Peptic ulcer	.70	43	Inguinal hernia	.13
10	Thrombo-angitis obliterans	.48	44	Acute appendix	.17
11	Fractured arm	.48	45	Lymphopathic venera, stricture	.14
12	Thyroidectomy	.24	46	Pilonidal sinus	.16
13	Carcinoma of rectum	.15	47	Acute appendicitis	.20
14	Abdominal fecal fistula	.36	48	Chronic appendicitis	.25
15	Cholecystitis	.38	49	Goiter	.19
16	Epilepsy	.34	50	Avitaminosis	.26
17	Carcinoma cecum	.30	51	Case 30	.39
18	Varicose ulcer, cellulitis	.27	52	Brain tumor	.22
19	Fistula in ano	.40	53	Epilepsy	.22
20	Cholelithiasis	.22	54	Case 37	.20
21	Infected third degree burn	.17	55	Case 42	.31
22	Case 12	.22	56	Case 43	.25
23	Melanosarcoma	.19	57	Leg scar for skin graft	.25
24	Infected scar	.31	58	Hemorrhoids	.31
25	Colloid goiter	.50	59	Benign breast tumor	.35
26	Muscular atrophy	.30	60	Appendiceal abscess	.22
27	Berger's disease	.30	61	Inguinal hernia	.33
28	Sequestrated zygoma	.18	62	Fistula in ano	.31
29	Cervical rib	.38	63	Cholecystitis	.14
30	Observation	.38	64	Cellulitis, hand	1.5
31	Fistula in ano, tuberculous	.32	65	Fissure in ano	.80
32	Cholecystitis, chronic	.32	66	Leucemia	.26
33	Observation	.12	67	Duodenal ulcer, perforated	.70
34	Observation	.25	68	Fistula in ano	.70
			69	Carcinoma, stomach	.40

TABLE I.—SHOWING AMOUNTS OF ASCORBIC ACID PRESENT IN PATIENTS' BLOOD—Continued

Case No.	Diagnosis	Ascorbic acid mgm. per 100 c.cm. blood	Case No.	Diagnosis	Ascorbic acid mgm. per 100 c.cm. blood
70	Excision scar	.80	73	Case 45	1.8
71	Colles' fracture	.60	74	Case 35	2.0
			75	Case 21	3.4
72	Carcinoma of breast with metastasis	.40	76	Cord tumor	1.7
			77	Cholecystitis	2.0

vitamin C and 9 out of 70 patients were on the border line of scurvy. Youmans and his associates in a study of 16 presumably normal subjects found 8 to have evidence of vitamin C deficiency.

Of 34 patients admitted to a London hospital (27), 14 showed evidence of vitamin C subnormality and most of the remainder excreted not more than the minimum standard. All those above 70 years of age showed relative deficiency. Of interest to hospital authorities, responsible for the diet of their patients, was the observation that certain patients admitted for the dietetic treatment of peptic ulceration showed no deficiency in vitamin C on admission, but 4 days of the dietetic regimen produced a deficient excretion.

Ingalls and Warren (41) in a study of 20 patients with gastric and duodenal ulcers found 18 to have low ascorbic acid values in the blood and 12 had values of 0.2 milligram ascorbic acid per cent or less, as compared with a normal range from 0.6 to 2 milligrams per cent. Eight patients of the 20 had previously had gastro-intestinal hemorrhages.

This evidence from various sources speaks for itself. To find 44 per cent of our ordinary "run-of-the-mill" patients deficient in vitamin C and 13 per cent on the verge of scurvy is a startling fact when one considers the known effects of such a deficiency upon the animal organism. Wolbach (66) describes those effects as primarily an inability to produce and maintain certain intercellular substances. The intercellular substances concerned are the collagen of all fibrous tissue structures, the matrices of bone, dentin and cartilage, and all non-epithelial cement substances including that of the vascular endothelium. The failure of the cement substance in blood vessels leads to hemorrhages as in scurvy. Degeneration of skeletal and cardiac muscle may occur in long continued partial deficiency. Large regions of bone marrow become devoid of blood-forming cells, and anemia may therefore be an important secondary effect of the lack of vitamin C.

Guinea pigs maintained on a low cevitamic acid intake develop all the features of pyorrhea alveolaris, namely, loosening and wandering of the teeth and marked rarefaction of the alveolar bone with widening of the peridental membrane (9).

Of real surgical importance are Hojer's original observations that ascorbic acid is intimately concerned with the synthesis and maintenance of the intercellular supporting materials, which provide the framework of healing. These facts formed the basis of important investigations by Lanman and Ingalls later confirmed by Taffell and Harvey. They studied the healing of wounds in guinea pigs partially depleted of their vitamin C depot, and subsequently maintained at a low level of ascorbic acid supply. They considered the nutritional state of these animals to be analagous to asymptomatic scurvy, and therefore probably analagous to 13 per cent of our clinic patients. Wound healing in these partially scorbutic animals showed inferior tensile strength, a disposition of the wounds to gape before rupturing, a livid appearance and a soft consistency of the granulation tissue. As a result, the abdominal wounds of this scorbutic group ruptured at a pressure averaging about one-third of that required to rupture the wounds of normal animals.

Pertinent clinical evidence is provided by Archer and Graham who found the cause of death to be peritonitis in 16 of 51 patients who died after operations upon the stomach at St. Bartholomew's Hospital. In 12 of these, the peritoneal infections appeared to have arisen as a bacterial leakage at the site of anastomosis, following an almost complete absence of fibrous tissue response along the suture line.

The evidence for the greater need of vitamin C under certain diseased conditions is equally startling. Abassy, Harris and Ellman (1)

state that "pulmonary tuberculosis provides the most extreme example of the increased consumption of vitamin C. The daily excretion for a standardized diet falls to about one-third the controls, and the response to three days testing dose is negligible." Martin and Heise demonstrated the existence of a hypovitaminosis due to a lack of vitamin C in a large majority of tuberculous patients, and the degree of hypovitaminosis was found to parallel the extent and activity of the tuberculous process. Greene, Steiner, and Kramer showed that generalized tuberculosis developed more rapidly in animals chronically deficient in vitamin C than in non-scorbutic animals, and that chronic vitamin C deficiency combined with a tuberculous infection causes a significant shortening of the survival period. Leichentritt gave large amounts of orange juice to tuberculous guinea pigs on normal diets and found the survival period to be twice as long as that of tuberculous animals on a normal diet alone.

Similarly, Harde, Rothstein, and Ratish found a very low rate of excretion of vitamin C in pneumonia, which indicated an increased consumption of this vitamin in this disease. Vogl applies this knowledge in his treatment of pneumonias by large doses of vitamin C. As soon as pneumonia is diagnosed the patient receives 200 milligrams of ascorbic acid subcutaneously, followed by daily doses of from 200 to 500 milligrams, depending on the severity of the disease. Pulmonary abscess, chronic pneumonia, or carnification never occurred in cases treated in this manner.

In a study of 17 active cases of osteomyelitis (17 semi-cured patients, 16 healed, and 10 controls), Abassy, Harris, and Hill (2) found a diminished rate of excretion of vitamin C in the urine and a lowered response to test doses of vitamin C, indicative of an apparently increased usage of this vitamin during the infective process, greatest in the active cases, intermediate in the semi-cured, and normal in the healed.

The frequent occurrence of vitamin C deficiency suggests that other vitamins may be equally deficient. Jeans and Zentmire, using the ability to adapt to the dark as a test for detecting vitamin A adequacy, found that 26 per cent of a rural group and 53 per cent of a village group of Iowa children presented evidence of vitamin A deficiency.

Jeghers in a study of a group of medical students, who presumably should be on fairly adequate diets, found that 35 per cent were deficient in vitamin A as determined by photometric tests, and 12 per cent had clinical manifestations of the deficiency. The chief manifestations of such deficiency were night blindness, photophobia, dry skin, dry conjunctival blepharitis, and follicular hyperkeratosis. Evidence was also obtained from this study that infections were more numerous and severe among the deficient students.

Thirty-eight patients entering the Stanford-Lane Clinic for medical and surgical care were studied by the Hecht apparatus for dark adaptation, this being considered a moderately accurate indication of the degree of vitamin A sufficiency or deficiency. To our astonishment, 10 patients, or 26 per cent, showed a marked deficiency in vitamin A; 9, or 24 per cent, showed a mild deficiency; 10, or 26 per cent, were normal; and 9, or 24 per cent, showed a supersufficiency of vitamin A in their diets. In other words, one-half of the ordinary "run of the mill" patients who present themselves to a free clinic for treatment are deficient in their intake of vitamin A. Eight patients, or 20 per cent, were night blind.

The effect of such vitamin A deficiency is most pronounced on the epithelial structures (67). These undergo an atrophy, followed by a reparative proliferation of the basal cells, replacing the normal columnar cells by a stratified keratinizing epithelium. This keratinizing metaplasia involves (1) the salivary glands, including the submaxillary, parotid, and all accessory glands of the tongue, buccal cavity, and pharynx, (2) the respiratory tract, including the nares, maxillary sinuses, trachea, and bronchi, (3) the genito-urinary tract, including the renal pelves, ureters, bladder, epididymis, prostate, seminal vesicles, uterus, and vulva, and (4) the eyes and peri-ocular glands. This metaplasia results in the accumulation of keratinized cells in glands and their ducts, and in organs such as the lungs, and leads to the occlusion of bronchi, the

formation and filling up of bronchiectatic cavities with keratinized cells, and atelectasis. These changes are presumably responsible for the spontaneous infections that occur so frequently in the mouth, the salivary glands, and the genito-urinary tract of animals on vitamin A free diets (26, 39).

The importance of normally functioning epithelial surfaces in surgical patients needs no elaboration. Healthy epithelial tissue is undoubtedly a more efficient barrier to infection than epithelium whose structure has been altered by a vitamin deficiency. Parotitis, purulent bronchitis, pneumonia, and urinary infections are postoperative bugbears. To operate on patients deficient in vitamin A is inviting the development of such complications. According to Wolbach "the early effect of the deficiency on the respiratory mucosa is a satisfactory explanation of the frequency, severity and persistence of the pneumonia that has been responsible in most instances for the death of infants deficient in vitamin A."

That vitamin A deficiency may occur through faulty absorption due to hepatic or gastro-intestinal disease is suggested in isolated case reports. Among these may be mentioned night blindness in a man with a gastrocolic fistula following a gastric operation (65), xerophthalmia in a patient with hepatic cirrhosis (55), and in a patient with hepatic cirrhosis secondary to carcinoma of the liver (6). The association of chronic jaundice, night blindness, and xerophthalmia (3), though still unexplained, has led to the assumption that bile is necessary for the proper absorption of vitamin A. In experimental biliary fistulas, Greaves and Schmidt (24) found that vitamin A was absorbed only if supplied orally with bile salts. On present knowledge then, when giving vitamin A to patients with jaundice, bile salts should also be administered. The parenteral administration of vitamin A is occasionally indicated. Finkelstone et al. have administered a high concentrate (100,000 vitamin A units and 12,500 vitamin D units per cubic centimeter) to pregnant women in dosages of 1 cubic centimeter every fortnight with safety. Chu and Lin studied 3 infants and 6 adolescents who showed various degrees of xerophthalmia due to vitamin A deficiency with an associated diarrhea. An improvement of the eye condition was noted within 2 days after the intramuscular injection of avoleum, a vitamin A concentrate containing 20,000 units per gram. It was injected in divided doses of 1 and 2 cubic centimeters in different areas. The beneficial effect of a single dose of vitamin A concentrate given parenterally may last as long as 2 months.

Vitamin B deficiency is not so accurately determined, but certain qualities of the vitamin make it important in the surgical patient. Vitamin B has a stimulating action on the growth of plants. In periods of active growth there is a corresponding increase in requirements of vitamin B, i.e., infants and growing children require a much larger daily supply than adults. The polyneuritis, the weakened cardiac musculature, the atonic and weakened gastro-intestinal musculature with its associated anorexia, intestinal atony, and constipation are the more common results of vitamin B deficiency (15). Their avoidance in the surgical patient is vital. It has been stated that these symptoms of vitamin B deficiency remain latent at times and appear only with the onset of some intercurrent infection, during pregnancy, after a surgical operation, or other event which requires an increased bodily metabolism. It is significant that in the experiment on 300 Javanese, general physical impairment occurred long before the symptoms of beriberi appeared.

According to Cowgill the vitamin B requirements in man bear a direct relationship to metabolism and are increased in diuresis and diarrhea. Inasmuch as there is a very limited capacity for storage of vitamin B in human tissues, Frazier and Ravdin argued that the vitamin B requirement should be increased in hyperthyroidism. Accordingly they administered to a group of hyperthyroid patients 10 milligrams of crystalline vitamin B_1 every other day and 10 grams of brewer's yeast daily by mouth, with a demonstrable improvement in their nutritional state, a greater fall in pulse rate, and a shorter pre-operative period of preparation for the very ill patient.

Another mode of action of vitamin B may be related to an observation by Manville and

Grondahl, who found that the regeneration of red cells is possible only if yeast or some factor in yeast is included in the diet. Erythrogenesis in rats on a basal diet excluding the vitamin-B-maturation factor stopped at the megaloblastic stage. Some factor in yeast was necessary to carry the megaloblast to the normoblastic stage. The importance of this observation in the restoration of the normal blood volume immediately following severe blood loss at operation cannot be overestimated.

Of major importance in the preparation of the jaundiced patient for operation are 2 recently discovered facts: first, that the bleeding, which so easily and so frequently occurs in these patients, is due to a low level of prothrombin in the blood, and secondly, that for the formation of this prothrombin, presumably in the liver, a specific food factor designated as vitamin K is indispensable (16, 17). The vitamin is found in alfalfa, spinach, and kale, or it may even be synthesized in the lower intestine through bacterial activity. As it is a fat soluble substance, bile is necessary for its absorption. In the patient with jaundice, with a biliary fistula, with an intestinal fistula, or with prolonged duodenal syphonage as in intestinal obstruction, bile does not reach the lower intestine, vitamin K is not absorbed, the prothrombin cannot, therefore, be formed, it falls to low levels in the blood, and fatal bleeding may occur either spontaneously or following the trauma of operation (60).

In the pre-operative preparation of the jaundiced patient, not only is the administration of vitamin K imperative, but also the administration of bile salts (11). The quantity administered depends largely upon the level of the prothrombin in the blood. This is determined according to the method of Quick (57, 58). Patients with a normal prothrombin clotting time are treated prophylactically with 2000 to 6000 units of vitamin K, together with 1 to 4 grams of bile salts daily. Patients with a prolonged prothrombin clotting time, without bleeding, and those actively bleeding, receive correspondingly larger doses.

If the liver has been injured by poisons, infections, or new growth, the level of prothrombin in the blood also falls. In such instances there is, however, no vitamin deficiency but a destruction of the site where prothrombin is formed, and vitamin K will not correct the condition. The administration of this vitamin is equally useless in the bleeding of hemophilia, thrombopenia, or aplastic anemia. But the hemorrhage that occurs in jaundice, in intestinal obstruction from any cause, in intestinal or biliary fistulas, in prolonged diarrhea, or in ulcerative colitis, may be controlled by the administration of this vitamin, together with bile salts.

Additional evidence of the importance of the pre-operative nutritional preparation of the surgical patient is presented in the experimental observations of Thompson, Ravdin and Frank. In 8 out of 11 dogs operated upon in a hypoproteinemic state, the wound failed to heal and a disruption occurred. As early as 1919 Clark showed an improved repair in dogs on a high protein diet, and Harvey and Howes showed an accelerated fibroplastic proliferation on a similar high protein diet. Ravdin states that a liver high in fat and low in protein is maximally susceptible to injury. A liver low in fat and high in available protein is maximally resistant to such injury. These observations give added support to our practice of giving surgical patients a balanced diet of high caloric value in the pre- and postoperative periods. In appropriate cases, Thompson, et al., suggest restoring the serum protein to normal levels by the intravenous infusion of lyophile plasma.

As these various studies suggest, our knowledge concerning nutrition, though rapidly and phenomenally progressing, is still in its infancy. Well may we ask, how do the vitamins act? What is their fate after their ingestion? It is probable that they are not specific in their effects, although many attempts have been made to attach the attribute "anti-infective" to vitamin A. As the exact chemical structure of the vitamins unfolds, it appears that it approximates in some degree the chemical structure of the endocrine hormones. The hexuronic acid isolated by Szent Gyorgi from the adrenal cortex in considerable quantity proved to be identical in structure with vitamin C. Freeman and Glass

found a definite relationship between vitamin C level of the blood plasma before death, and the incidence of central autolysis of the adrenal glands at autopsy. If the reduced ascorbic acid value was above 0.70 milligram per cent, no central cavities were found in the adrenal glands, while on the other hand, if the value was below 0.70 milligram per cent, central cavities were invariably present. Harris, Passmore and Pagel found that guinea pigs, suffering from an acute infection with pasturella pseudotuberculosis, showed a considerable diminution in the amount of vitamin C present in their suprarenal glands as compared with controls which had received the same amount of vitamin C. The vitamin C in the liver, on the other hand, was not significantly affected. Normally the pituitary and adrenal glands are said to contain vitamin C in greater abundance per gram of gland substance than any other known substances. The liver has been credited with being a storage depot for vitamin A. In cirrhosis, Moore has found vitamin A in very low concentration.

In view of this evidence, are we not justified in assuming that in order that the liver and the all important endocrine organs may function normally, they must be properly nourished through an adequate supply of vitamins? With these organs functioning in optimum efficiency, due to optimum nutrition, one may logically infer that the patient is better able to meet the ordeal of operation, to heal the disrupted tissues more kindly, and to avoid the distressing complications of infection and delayed repair.

With the additional convincing evidence that many patients live in a chronic state of vitamin deficiency, should we not insist that whenever possible a few days be assigned before operation to the necessary nutritional preparation of the surgical patient? "Ideally, every patient should be hospitalized one or even two weeks before operation with the avowed intention of improving general nutrition and of restoring the depleted store of vitamins" (36).

In a study of the vitamin C content of human tissues, Yavorsky, et al., found a consistently diminished content in all tissues studied: adrenal, brain, pancreas, liver, spleen, kidney, lung, heart, and thymus, in those patients from 46 to 77 years of age as compared to the patients from one to 46 years of age. This suggests that the older patients require a longer period of preparation by high vitamin intake than the younger patients. Orr's observations indicate further that patients from low economic levels show correspondingly increased frequency of vitamin deficiencies.

Fortunately, the effects of vitamin lack are corrected quite promptly. Reparative changes in the metaplastic epithelium begin as early as the fifth day following the ingestion of suitable amounts of vitamin A. A low ascorbic acid content of the blood is corrected within 3 to 5 days after adequate intake. Even a few days, therefore, spent in nutritional preparation of the patient should reduce the operative hazard and diminish the length of convalescence. There is little justification for the almost universal practice of admitting the candidate for an elective operation on one day and operating upon him the next. The ordeal of operation with its attendant risks should, whenever possible, be undertaken only in patients in a state of optimum nutrition.

SUMMARY

1. Seventy patients, from low economic levels, admitted to the Stanford-Lane clinic wards for operation were studied with respect to the vitamin C content of their blood. In 44 per cent of these patients, values of 0.15 to 0.30 milligram per 100 cubic centimeter of blood were found, indicative of a low vitamin C intake. In 9 patients, values fell below 0.15 milligram per cent, indicating they were on the verge of clinical scurvy.

2. This evidence of deficiency in vitamin C is of extreme importance in surgical patients, since ascorbic acid or vitamin C is intimately concerned with the synthesis and maintenance of the intercellular supporting materials which provide the framework of healing. Experimental observations by Lanman and Ingalls showed that abdominal wounds of scorbutic animals ruptured at a pressure one-third that required to rupture the wounds of normal animals.

3. Thirty-eight patients entering Stanford-Lane Clinic for surgical and medical care were studied by means of the Hecht adaptometer. Ten patients, or 26 per cent, showed a marked deficiency in vitamin A; 9 showed a mild deficiency; 10 were normal; and 9 showed a supersufficiency of vitamin A.

4. Observations by Jeans, Zentmire, and Jeghers showed that 24 to 36 per cent of the ordinary population were deficient in vitamin A.

5. Since the effect of vitamin A is to produce metaplastic changes in epithelial structures, a deficiency in this vitamin is of real importance in patients who, following operation, are threatened with infections of such epithelial structures as the salivary glands, the bronchi, the lungs, the gastro-intestinal canal, and the genito-urinary system. Animals on diets deficient in vitamin A develop abscesses and infections in these regions.

6. Experimental observations by Thompson and Ravdin indicate that animals on a low protein diet show impaired healing and disruption of wounds in 72 per cent. Howes and Harvey found an acceleration of fibroplastic proliferation in animals on a high protein diet.

7. These observations indicate that surgical patients should, whenever possible, be prepared for operation by several days of optimum nutrition, including a well-balanced diet of high protein intake, of high caloric value, and of high vitamin content. This period of preparation should begin at home 10 to 14 days before operation.

8. This preparation should also include vitamin concentrates for 5 to 7 days before operation: 2 haliver oil capsules, thrice daily; 3 B concentrate tablets, thrice daily; juice of 4 oranges and 2 lemons daily.

9. Patients with obstructive jaundice, with biliary or intestinal fistulas, with intestinal obstruction, ulcerative colitis, or persistent diarrhea, may show a prolonged prothrombin clotting time due to a low level of prothrombin in the blood, secondary to absence or faulty absorption of vitamin K. Before operation as a prophylactic measure, or, if and when bleeding occurs, such patients should receive massive doses of vitamin K and of bile salts. The latter are indispensable in the absorption of the vitamin.

10. In emergency operations, the parenteral administration of vitamins A, B, C, and in the jaundiced patient, vitamin K, is indicated.

11. Following operation, optimum nutrition should again be instituted through a well balanced, high caloric, high vitamin diet, supplemented by vitamin concentrates throughout the full convalescent period.

12. The ordeal of operation with its attendant hazards should be undertaken, whenever possible, only in patients in a state of optimum nutrition. For the past 11 years, patients admitted to the Stanford-Lane clinic wards under my control have been prepared for operation by a high caloric, high vitamin diet, supplemented by vitamin concentrates.

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