Chapter 7

SCURVY

R.E. Hodges

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The Prevalence and Epidemiology of Scurvy

We can learn much about the epidemiology of scurvy by taking a brief look at historical records. Throughout the ages, scurvy has brought disaster to populations wherever it has appeared. It has defeated armies, paralysed navies, and ravaged civilian populations whenever regular supplies of food have been disrupted. It is for this reason that explorers and sailors have been most vulnerable to the disease, and as recently as 1912 the expedition to the South Pole led by Captain Robert Scott ended in disaster as a result of scurvy.

For many years scurvy was looked upon as a mysterious disease that appeared under conditions of poor sanitation, inadequate ventilation, exposure to dampness and cold, and many other coincidental factors. It is almost certain that a number of intelligent persons—physicians, explorers, seafarers, and others—independently discovered appropriate cures for scurvy, yet the mere collection of knowledge regarding this disease did not ensure its prevention.

Scurvy had a significant impact on British naval history. After a long history of parsimony and dietary neglect on ships, the Admiralty came to realize that any uninterrupted ocean voyage lasting more than 90 days was almost doomed to be stricken by scurvy. Whether this was true of all navies or was the result of British patterns of provisioning ships is not

entirely clear; certainly, many nations had undertaken prolonged voyages but it is not known whether scurvy was a major problem in all cases. Before his voyages to the Pacific, Captain James Cook was given a free hand to attempt to prevent scurvy by whatever means he thought fit, and it was his example, perhaps more than any other, that established the principles on which a firm understanding of the disease was eventually based. Cook demonstrated that it was possible for a ship to sail around the world for more than 4 years without a single death from scurvy. The way had been indicated by the carefully conducted study of James Lind who, in May 1747, undertook the treatment of 12 patients with scurvy on board the ship *Salisbury* at sea. These men were divided into 6 pairs, each pair receiving a different form of therapy. The two men who received 2 oranges and 1 lemon daily demonstrated "the most sudden and visible good effects, one of them being fit for duty within six days and the other was appointed nurse to the rest of the sick."

Modern concepts of scurvy are considerably more enlightened yet the disease continues to occur in sporadic form. Even the ancients, who knew little about the mechanism of the disease, recognized that there were species differences and Cook remarked that a nanny goat that accompanied him on a voyage for 2 years was undoubtedly immune to scurvy. We now view scurvy as a "genetic accident" that deprived man and a few other species (*1*) (including guineapigs, monkeys, the Indian fruit bat, and some birds, e.g., *Pycnonotus cafer*) of one or another of the enzyme systems needed to convert D-glucose through various stages to L-ascorbic acid (*2*). Whether this genetic event occurred as a sudden mutation or as a gradual evolutionary change is not known, but the result is to limit the tolerance of these species to dietary modifications.

Fortunately, the dietary habits and available food supplies of nearly every population studied throughout the world are, at least marginally, adequate in vitamin C. Surveys by the US Interdepartmental Committee on Nutrition for National Defense (ICNND)[a] (*3*) have found that substantial numbers of people throughout the world consume marginal amounts of ascorbic acid in their diet and have low levels of ascorbic acid in their serum. According to the ICNND method of classification, serum concentrations of less than 0.10 mg of ascorbic acid per 100 ml are "deficient", those between 0.10 and 0.19 are "low", and those above 0.20 are "acceptable". Similarly, dietary intakes of less than 10 mg of ascorbic daily are considered "deficient", intakes of between 10 and 29 mg per day are "low", and intakes of above 30 mg daily are "acceptable". The British Medical Research Council (*4*) and a group of American investigators (*5, 6*) are in agreement that a daily intake of 10 mg of ascorbic acid can prevent or cure scurvy

[a] Later renamed "Interdepartmental Committee on Nutrition for National Development".

under experimental conditions but they recommend somewhat larger amounts (30 mg daily). This is the amount recommended by a joint FAO/WHO expert group (*10*).

Clinical Features of Scurvy

Early descriptions of scurvy stressed "spontaneous weariness, heaviness of the body, difficulty of breathing, especially after bodily movement, rottenness of the gums, a stinking breath, frequent bleeding of the nose, difficulty walking, sometimes a swelling, sometimes a falling away of the legs, in which there are always livid, plumbeous, yellow or violet spots... The patient loves to be in a sitting or lying posture; there is pain in all the muscles as if he were overtired and when he wakes in the morning, all of his joints and muscles seem to be tired and bruised." [a] Doubtless, this form of scurvy as described included an admixture of malnutrition, infectious and parasitic diseases, exposure to the elements, and poor hygiene. Nevertheless, the principal features of experimental scurvy as seen in both the British Medical Research Council investigation and in the American studies included most of these signs. Another noteworthy feature of these two studies of scurvy in man is the difference in time between the start of the deficient diet and the onset of symptoms and signs.

Table 1. Onset of symptoms and signs of scurvy

Symptoms and signs	Sheffield (United Kingdom) study	Iowa City (USA) studies
1. No change	Up to 119 days	Up to 27 days
2. Petechial haemorrhages (not perifollicular)	–	27–102 days
3. Swollen bleeding gums	163–254 days	38– 91 days
4. Oedema	–	33– 96 days
5. Follicular hyperkeratosis	82–149 days	60– 99 days
6. Perifollicular haemorrhages	182–238 days	82–120 days
7. Dyspnea	210–228 days	63– 90 days
8. Aching of limbs	149–168 days	67– 95 days
9. Joint effusions	210–216 days	67– 98 days
10. Ocular haemorrhages	–	84– 95 days
11. Acne	114–210 days	No change
12. Neuropathy	–	70 days
13. Sicca syndrome	–	90–121 days

It should be noted that in the British study the subjects ate a diet containing small amounts of ascorbic acid, whereas the subjects in the American studies consumed a diet containing none.

Under experimental conditions, the most apparent clinical evidences of scurvy are the changes in the skin including follicular hyperkeratosis, haemorrhagic phenomena (petechial haemorrhages and ecchymoses), and

[a] *Encyclopaedia Britannica*, 1771 edition.

broken, coiled hairs (*4, 5, 6*). Aching of the extremities, swelling of the joints, and oedema of the feet and ankles occur in patients more severely afflicted. In some individuals the sicca syndrome appears. This involves loss of secretion of the lacrimal and salivary glands, loss of hair, dryness of the skin, and loss of dental fillings. One instance of severe bilateral femoral neuropathy resulted from haemorrhage into nerve sheaths (*5*). Emotional changes in scurvy are common and may represent one of the most incapacitating features. They consist primarily of loss of motivation, hydrochrondriasis, and depression.

Historically, sudden death has been described on board ship and in other epidemics of scurvy. This long remained a mystery but recent studies may offer a partial explanation. Experiments both in animals (*7*) and in scorbutic men (*8*) have shown impairment of vasocompensatory responsiveness although the mechanisms may differ between guineapigs and man. Apparently, any situation that tends to cause a profound fall in blood pressure may be life threatening in a scorbutic patient who is unable to compensate.

Infantile scurvy is still encountered sporadically in almost all parts of the world including the industrialized countries, where it is attributable to the omission of a vitamin C source in infants fed a cow's milk formula. It is seldom encountered in breast-fed infants since, unless the mother is grossly depleted, breast milk provides adequate quantities of the vitamin. Many of the clinical manifestations seen in the adult are also present in the infant, although in modified form. A prominent feature is the so-called pithed frog position assumed by the child. The ends of the long bones are "clubbed" and the joints painful to movement. The child maintains the knees in flexed position and resists movements, often crying upon anticipation of movement. Radiological examination reveals defective calcification at the epyphysis, sometimes fractures across the head of the bone and displacement, and haemorrhage encapsulated within the periosteum. Beading of the ribs, skin bruising, suborbital haemorrhage, and, if teeth have erupted, gingival changes are also seen (*9*).

Biochemical Changes

The diagnosis of scurvy is a clinical one since no single biochemical test will establish the diagnosis. The finding of "acceptable" serum concentrations of ascorbic acid virtually excludes the diagnosis and levels that approach zero do not establish the diagnosis, they merely suggest its possibility. In the course of complete deprivation of ascorbic acid man quickly ceases to excrete the vitamin in the urine, and within a few weeks the blood levels approach zero. If the concentrations of ascorbic acid in leukocytes and platelets are measured, detectable amounts are found to persist somewhat longer but estimations of body pools of ascorbic acid using ^{14}C-labelled

L-ascorbic acid indicate that more than 90% depletion usually occurs within the first 90 days of deprivation and that clinical evidence of scurvy begins to appear when the daily rate of catabolism of L-ascorbic acid falls substantially below 7.5 mg.

Despite abundant clinical evidence of haemorrhagic manifestations in scurvy there is as yet no measurable explanation for this condition. Studies of platelets, prothrombin time, fibrinogen, and the associated clotting factors, all give normal readings. Furthermore, electron microscopic examinations of vessels in the skin of scorbutic patients have failed to show abnormalities, thus casting some doubt on the "intercellular cement" theory.

Although infectious diseases were formerly rampant amongst scorbutic populations, particularly on board ship, there seems to be no impairment of antibody formation in experimental scurvy either in experimental animals or in man. Animal studies suggest that phagocyte production and function may be affected in scurvy. Protein metabolism is adversely affected by scurvy since the serum albumin falls both in man and guineapigs. In man there is a compensatory rise in the concentration of γ-globulin whereas in guineapigs the α-1-globulin rises.

Anaemia may occur in severe scurvy in both animals and man, but in both the British and American studies anaemia was not a prominent feature.

Treatment and Prevention

Treatment of scurvy consists of administering adequate amounts of L-ascorbic acid along with proper amounts of all the other essential dietary nutrients. For the critically ill patient this may mean parenteral therapy but for most patients with scurvy a proper diet supplemented by additional amounts of ascorbic acid will result in prompt and complete recovery. Indeed, cures have been achieved by the administration of daily doses of as little as 6.5 mg of ascorbic acid; however, the usual clinical approach has been to give massive daily doses in the neighborhood of 500–1 000 mg. These doses are neither necessary nor harmful. A highly satisfactory rate of repletion with ascorbic acid can be achieved by administering 100 mg of ascorbic acid orally three times daily. This, of course, assumes a proper intake of all the other essential nutrients.

In most instances, this form of therapy will result in a prompt improvement in the patient's sense of well-being and in the gradual disappearance of cutaneous abnormalities including follicular hyperkeratosis and haemorrhagic manifestations. In individuals who have severe arthralgias recovery may be somewhat slower. In the rare instance of peripheral neuropathy resulting from haemorrhage into a nerve sheath, regeneration of the nerve fibres may require several months. There are no recorded instances of permanent damage resulting from scurvy except when teeth were lost.

Prevention of scurvy is both amazingly simple and impossibly difficult. The inclusion in the daily diet of 30 mg of ascorbic acid daily should, for all practical purposes, prevent the disease. In each country of the world foods are available that contain rather high concentrations of L-ascorbic acid but there are many other foods that contain relatively small, yet very important, amounts of the vitamin. Seasonal variations in food supplies, loss of ascorbic acid content as a result of storage or methods of preparation, and economic factors all contribute to the prevalence of less than acceptable intakes of ascorbic acid. Assuming that poverty, war, or national disasters do not intervene, education of the public in the essentials of a proper diet should help to prevent not only scurvy but also most other deficiency diseases.

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