scorbutic vitamin—in fact, his daily requirement, even when engaged in strenuous physical exercise, seems to be very small indeed.

2. A net daily intake of about 15 mg. of ascorbic acid, perhaps even less, can evidently protect the majority of such individuals from scurvy. Four independent lines of investigation failed to demonstrate that further additions to the diet lead to any noticeable improvement in general health. Thus such an addition did not diminish the incidence of infectious diseases, nor did it improve dental health or physical efficiency. Alternatively, scurvy was not found to occur more frequently or more quickly amongst mine labourers engaged in the more strenuous occupations.

3. However, the precarious nature of such minimal rations in respect to the production of scurvy is also well illustrated by this experiment, since a number of cases occurred in the untreated group, whilst the disease was virtually abolished in those receiving the additional protection.

4. Attention is drawn to the singular lack of correlation obtained between the various tests available for detecting vitamin C deficiency and the clinical findings. While these tests may be useful in so far as they draw attention to the existence of low reserves of the vitamin, in our hands they failed entirely to distinguish those individuals who were any the worse for such low reserves. We are in complete agreement with Zilva and others when they deprecate the use of terms such as "subscorbutic" or "latent scurvy" for states of vitamin C depletion which have not as yet been shown to have any adverse effect upon the health or efficiency of the individual concerned.

Finally, we should like to make it quite clear that our object in drawing attention to these observations is not to minimize the importance of this vitamin in human nutrition or to advocate the use of diets that are only just capable of protecting the consumer against scurvy. We would emphasize, however, that much still remains to be learnt about the part played by ascorbic acid in the general metabolism and that many of the claims advanced cannot as yet be regarded as fully established. In the meantime the assertions so confidently made by uncritical observers should be accepted with considerable reserve.

Summary

Two groups, each of 950 mine labourers, chosen so as to be as comparable as possible in respect to tribe, age, physical condition, and occupation, were subjected to an experimental test. One group remained on the usual mine diet, which was estimated to contain from about 12 to 25 mg. of ascorbic acid, while to the other an additional daily ration of 40 mg. of ascorbic acid was administered in the form of a standardized orange-juice concentrate. The experiment was continued for seven months, and the behaviour of the two groups was studied in various ways.

Both groups maintained a high level of general health, as will be gathered from the fact that, excluding shifts lost by reason of accidents, over 99.1 per cent. of the possible shifts were actually worked, even by the untreated group.

Twelve cases of scurvy occurred in the untreated group and one mild case in the group receiving the additional ration of ascorbic acid.

Otherwise no significant difference could be detected in the behaviour of the two groups. Thus the weight changes were almost identical, and there was no evidence that the general health, physical efficiency, and resistance to infectious or dental diseases had been increased. The additional ration of vitamin C was discontinued as soon as a patient reached hospital, but there was no indication that the change in the previous diet had improved the rate of recovery from disease, or that the rate of healing of wounds and fractures had been accelerated. Nearly three-quarters of the individuals examined

by the dental surgeon in both groups were found to possess healthy gums.

Numerous tests showed that the plasma ascorbic acid values were extremely low, even in apparently healthy individuals engaged in hard work. These low values were not significantly raised by the additional daily ration of ascorbic acid.

Data concerning over 1,000 cases of scurvy occurring in the Witwatersrand gold mines over the past few years were also carefully examined from various angles. Among other conclusions it may be mentioned that there was no evidence to suggest that natives engaged on the more strenuous types of work developed scurvy either more often or more quickly than those whose metabolic resources were less severely taxed.

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SURGICAL TREATMENT OF AIR RAID CASUALTIES

WITH A REVIEW OF 12 CASES

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This report is given in a preliminary stage because of several important points brought out regarding the initial treatment of air raid casualties. The twelve cases reviewed were dealt with by one team, consisting of two surgeons, two anaesthetists, one sister, and three nurses. The injuries were caused by high-explosive bombs and many of them were multiple, there being six compound fractures, and all except three of the cases were severe. Head, chest, and abdominal wounds are not included. There have been no deaths and only one amputation. The time taken over all the operations was four hours, which averages out at forty minutes a case. With further organization this could no doubt be shortened. Two tables were used in the same theatre.

A separate history of each case is given in some detail, and these are followed by a short discussion on problems and innovations in wound treatment. There are, however, many points in the treatment which have been used as a routine and which will be detailed now to save repetition.

Routine Treatment

Shock.—The patients were put to bed with hot-water bottles and blankets, and the foot of the bed raised; morphine (if not already administered) and 2,000 units of tetanus antitoxic serum were given. One of the surgeons then went the rounds of the ward, making a list for operation. He saw that cases with tourniquets were dealt with fairly quickly and cases in the extreme stages of shock were left until they recovered. Severe injuries with a moderate degree of shock were operated on as soon as possible. As there were many in this last category the time element was important. Plasma transfusions were given to the more severely shocked cases.

The Operation.—All the patients received a general anaesthetic, ether being given by the open method. Each patient's clothes were cut off and the wound exposed; a sterile swab was then placed over the wound itself and the surrounding skin cleansed with ether soap and shaved. The surgeon now scrubbed up, removed any gross contamination from the wound with forceps, and applied first to the wound and then to the surrounding skin a solution of dettol 50% in spirit coloured with methylene-blue. The skin edges were excised and all the deeper structures that were coloured blue and were readily accessible. Deep perforating tracks which could not be opened up because of causing further injury to important structures were carefully explored for pieces of bomb casing; the whole wound, and especially these tracks, were then packed with sulphanilamide powder.

After-treatment.—Upon returning the patient to the ward the treatment for shock was continued. Sulphanilamide was given by mouth (2 tablets—15 grains—every four hours) as soon as the patients could take it, and was continued for twenty-four to forty-eight hours, according to the temperature chart. Wound dressing was avoided as far as possible, the main indication for inspection of the wound being a slight rise in temperature accompanied by a rapid rise in pulse rate. A musty smell from the dressing is an additional factor arousing suspicion of anaerobic infection.

Case Histories

Case 1: Laceration of Lower End of Forearm and Comminuted Fracture of Ulna.—A female aged 18. A fairly severe degree of shock was present; the whole of the ulnar half of the forearm had been blown away a few inches above the right wrist, the bone being shattered for two inches and the nerve, artery, tendons, and muscles severed. There was also a superficial laceration of the right leg. The wound was excised in the routine way and a closed plaster applied from the axilla to the metacarpal heads. The raw surface of the wound was separated from the plaster by a layer of vaselin gauze and sterile wool in that order. Convalescence was very quiet and comfortable. A radiograph taken on the second day showed a satisfactory position, although there was a large gap between the head of the ulna and the rest of the shaft. There were some viable fragments filling this gap, and it seemed highly probable that bony union would take place. On the fifth day the patient got up for the first time, and immediately an attack of "blue asphyxia" occurred; this lasted for a few minutes, after which there was full recovery. On the seventh day no undesirable symptoms followed a second attempt to get up. Similar attacks have occurred in cases not in this series, and it is possible that they may be the sequel to the effects of blast on the lungs. These organs on post-mortem examination may show multiple points of interstitial haemorrhage, presumably the result of the concussion.

Case 2: Perforating Wound of Forearm with Compound Fracture of Radius.—A man aged 22. This patient was fairly severely shocked and had sustained a perforating wound of the left forearm, the bomb splinter having entered on the outer side, smashed up a section of the radius, and then made its exit on the inner side. He also had a small penetrating wound of the left cheek and scalp. Wound excision was carried out in the routine manner, vaselin gauze and a thin layer of wool being applied over the wounds. The fracture was then fixed by holding the hand in ulnar adduction so as to exert extension on the radius, while a closed plaster was applied from the axilla to the metacarpal heads. The next day the temperature was 99° F. and pulse 80. The arm was comfortable. On the second day the temperature had completely settled; the arm was radiographed for the first time, and the film showed very good reduction. The plaster will probably be left undisturbed until the fracture has united.

Case 3: Perforating Wound of Sacral Region with Compound Fracture of Sacrum; Perforating Wound of Elbow

with Compound Fracture of Radius.—A man aged 36. This patient was very severely shocked and was suffering from two perforating wounds. That over his sacrum had an exit on the outer side of the left hip and there was some inability to move the left leg. The left elbow had an entry wound in the region of the head of the radius and an exit wound on the inner side of the upper arm; both radial and ulnar nerves were paralysed. Operation was delayed for over three hours, during which time plasma was given as well as routine antishock treatment. At the elbow the radial nerve could not be found, the track of the projectile having passed right across its path. The ulnar nerve was found; it appeared bruised, but was anatomically intact. The arm was put up in closed plaster. The buttock wound was excised and explored: part of the lateral mass of the sacrum was blown away, but the hip-joint was intact. Convalescence was very disturbed, the temperature rising to 101° F. and the pulse to 120 for the first three days. Windows were cut out over the elbow wounds on the second day and a thin reddish-brown fluid escaped, which showed *Cl. welchii* on examination. This, together with the general reaction, suggested the presence of gas-gangrene toxaemia, although there was no spreading area of crepitation and swelling around the wounds. In addition to the routine administration of sulphanilamide by mouth, 16,000 units of anti-gas-gangrene serum were given four-hourly for four doses. After the third day the pulse gradually settled and no drastic surgical intervention was necessary.

Case 4: Lacerated Wound of Upper Arm; Comminuted Fracture of Humerus.—A woman aged 27. The patient was extremely shocked; the local damage was extensive, the left arm being severed for over three-quarters of its substance and the humerus fragmented for the greater part of its length. The neuro-vascular bundle on the inner side of the arm and a narrow strip of skin were the only intact structures. Operation was delayed for two hours and a plasma transfusion started. As the humeral shaft was shattered at a higher level than the soft-tissue lesion and for a considerable proportion of its length, and as the soft-tissue lesion was very extensive, it was reluctantly agreed that amputation had to be performed. This was carried out at the site of the lesion, all the fragments of bone being removed. This fortunately left the proximal fragment well above the level of the skin flap, thus avoiding the formation of a conical stump. The next day the temperature was 100° F. and pulse 100; these did not settle for three days. The wound was dressed on the fifth day, when it appeared clean and culture was negative. Reamputation will probably not be required.

Case 5: Perforating Wound of Leg, with Compound Comminuted Fracture of Tibia and Fibula.—This patient, a man aged 61, was severely shocked and was suffering from a perforating wound of the left leg. The point of entry of the projectile, about as round as a sixpence, was on the outer side of the upper third of the leg, and the exit wound, 2 in. by 1 in. in size, was almost opposite, on the inner side of the leg. The track joining the two contained fragmented pieces of bone and torn muscles, at least three inches of the tibia being comminuted. In addition to the routine treatment for shock a tourniquet had been applied, so operation was not delayed. As soon as the patient was anaesthetized the tourniquet was removed, but no undue bleeding occurred. The wounds were treated in the usual manner. The fracture was then fixed by placing Steinmann pins in the tuberosity of the tibia and os calcis, and then clamping these pins to the side bars of a Thomas splint (McKee, 1940). Radiographs were not taken until the second day. Plasma was given on return to ward. Convalescence was unsettled to start with. The temperature was 100° F. and the pulse 80, but these soon subsided. On the fourth day a thin reddish-brown discharge with some bubbles in it could be expressed from the track. This had an odour of the mortuary associated with gas gangrene, and on smear and culture in sterile milk *Cl. welchii* was found. In view of the restricted local reaction and early subsidence of the general reaction the presence of gas gangrene was disregarded, and on the seventh day a snug-fitting plaster, skin-tight, was applied up to the region of the adductors. Both pins were then removed, and a window was cut out over the wound in order that the result of the *Cl. welchii* infection might be watched. There has been no

spread beyond the wound track, so the window will soon be covered in.

Case 6: Penetrating Wound of Left Ankle-joint.—A man aged 29. A moderate degree of shock was present in this case, in which there was a small penetrating wound in the inner side of the left foot just below the medial malleolus. The skin edges were excised and the track explored in the routine manner. A closed plaster was applied from toes to knee. Convalescence was undisturbed except for an initial rise of temperature to 100° F. on the first day. A radiograph on the second day showed two small fragments of bomb embedded in the substance of the os calcis. These will be removed later if they cause symptoms.

Case 7: Penetrating Wounds of Arm and Calf.—This patient, a man aged 25, was only moderately shocked, and was suffering from multiple wounds of the left upper arm and right calf. The wounds were dealt with by the usual routine, there being two large ones in the arm and six small ones in the leg. Some fragments of metal were removed, but a subsequent radiograph showed a number—some pieces very small—remaining, one of these being actually buried in the humerus. For the first few days the temperature was 99°–100° F., but this settled after the third day. All the wounds were healing well after the first week. Some fragments may require removal later if they give rise to symptoms.

Case 8: Penetrating Wounds of Right Arm and Forearm.—A man aged 42. This patient was suffering from wounds of the right upper arm and the right forearm and a laceration involving the muscles of the left forearm, but was only moderately shocked. The wounds were excised; in the right forearm a piece of metal was felt beneath the skin on the opposite side of the limb. This was removed through a counter-incision. Convalescence was completely comfortable and undisturbed.

Case 9: Small Penetrating Wounds.—A man aged 36. Only a slight degree of shock was present in this case. There were small penetrating wounds full of blackened debris on the left forearm and scalp, and from them small fragments of metal were removed. Convalescence was uneventful.

Case 10: Small Penetrating Wounds.—A man aged 31. The degree of shock was very slight in this case. There were some small penetrating wounds of the right axilla, left forearm, and left ankle region. The routine wound treatment was carried out, small pieces of metal being removed together with much blackened debris. The ankle-joint had not been penetrated. Convalescence was uneventful; there was no reaction.

Case 11: Perforating Wound of Buttock.—This patient, a man aged 39, was not badly shocked. He had a penetrating wound in the left buttock the size of a shilling and a small perforating wound in the region of the ankle which did not involve the joint. Operation consisted of the usual wound toilet and excision of the skin edges. The buttock wound was the entrance to a large cavity beneath the gluteus maximus, with passages leading in many directions. The cavity was opened up and the passages explored, but no metal fragments were found. The next day the temperature was 99° F. and the pulse 80; on the third day these had completely settled. A radiograph showed a metal fragment in the upper part of the thigh; this will probably be removed later. After a week no constitutional symptoms were present and the wound was healing well.

Case 12: Multiple Small Penetrating Wounds of Thighs.—A man aged 40. This patient was only slightly shocked. There were some twenty to thirty small penetrating wounds of both thighs, varying from 0.25 to 1.5 cm. in size. The openings of these wounds were black, as though charred. All these little wounds were excised; they contained grit, and in some of them fragments of glass were found. Convalescence was uninterrupted and undisturbed.

Points of Special Interest

Surgical Supervision of Cases.—There should be unity of control and continuity of treatment of each case so far as is possible, and while the patients remain in the one hospital this should not be difficult to organize. Each surgeon should have in his charge a unit of beds, and

should examine, operate on, and attend to the after-care of the cases.

Use of the Tourniquet.—The tourniquet had been applied as a first-aid measure in only one case, but that case did not require it. When the patient arrives in the ward the surgeon should observe the result of loosening the tourniquet, and unless the bleeding indicates that a main artery has been torn the tourniquet should be removed and the haemorrhage controlled by direct pressure with a pad and bandage.

Removal of Metallic Fragments.—A portable x-ray apparatus was not available for use with these cases, but would have been helpful in enabling the foreign bodies to be located. Films in two planes could be taken in the ward while the patients are being treated for shock; they would then be available as wet films at the operation. Extensive and prolonged operations for the removal of metallic fragments are not justified at the initial stage, but every effort should be made to remove those pieces which are readily accessible.

Treatment of Compound Fractures.—All the compound fractures of the upper limb were treated by the closed-plaster technique, except one in which severe soft-tissue damage necessitated amputation. In the case of the lower limb, however, there is a definite danger of gas gangrene occurring, and for this reason it is better to immobilize these fractures in such a way that the whole limb (and wound as well if thought necessary) is open to inspection (McKee, 1940). If this can be done without radiographic control it is a decided advantage in an emergency. After a week or so, when this danger has diminished, a snug-fitting plaster cast can be applied and correct alignment obtained without disturbing the fracture unduly and without an anaesthetic.

Type of Wound.—The wounds were of the penetrating or perforating variety and appeared to be caused by relatively small pieces of bomb casing, the term "perforating" being reserved for cases in which there was an entry-and-exit wound. The exit wound, if present, was, as is usual in these injuries, larger than the entrance wound, especially if a bone had been shattered *en route*. The edges and tracks were often blackened as though burnt, and some of the patients who had been struck by multiple splinters appeared as though peppered with little black spots.

Distribution of Wounds.—The majority of the wounds in this series were above the hips (two wounds above the hip to one below), which suggests one very important precaution—that is, to lie flat as soon as the scream of a falling bomb is heard.

Use of Sulphanilamide.—It is difficult at present to supply exact statistics by which to gauge the effectiveness of this procedure. Infection was definitely less in the cases here reported than it was in many other similar cases treated in the same hospital in which sulphanilamide was not used. Infection, however, does not appear to be particularly virulent in these bomb injuries unless the wounds are in dirty regions such as the buttock or leg. What was impressive in this series was the way proved *Cl. welchii* infection remained confined to the wound tracks. In view of past experience of compound fractures and gas gangrene this control of infection appears to be due to the administration of the sulphanilamide. In the case reported with severe toxæmia (Case 3) the combination of serum (*perfringens* antitoxin) and sulphanilamide enabled recovery to take place without any mutilating surgical procedures having to be adopted.

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