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VITAMIN C REQUIREMENTS OF NATIVE MINE LABOURERS* AN EXPERIMENTAL STUDY

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Scurvy appears occasionally among the 350,000 natives employed in the gold mines of the Witwatersrand; thus during 1939, 220 cases were reported, distributed over 73 per cent. of the larger mines. As most of these natives are housed and fed under strict supervision in compounds specially built for this purpose it was thought that conditions were particularly favourable for an investigation into the vitamin C requirements of men engaged in fairly strenuous physical activity. The following is a condensed report of an experiment the particulars of which have been published in considerable detail elsewhere (Fox, Dangerfield, Gottlich, and Jokl, 1940).

The Investigation

A mine in which scurvy had been diagnosed with rather greater frequency than the average was chosen for study. Two groups, each of approximately 1,000 natives, who had just arrived from their kraals, were selected in such a way that the ages, tribal distribution, and general physical condition were as comparable as possible. One group, referred to as the control group, was kept on the usual diet, while the other, known as the test group, received a daily additional ration of 40 mg. of ascorbic acid in the form of an orange-juice concentrate kindly provided for us by the South African Co-operative Citrus Exchange and prepared by Messrs. Tomango, Limited, of Merebank, Natal. The vitamin content of the concentrate was periodically checked, and its regular consumption was assured by administering it before the main meal of the day.

The experiment was continued for a period of seven months—from November, 1938, to May, 1939—since the records have shown that it is during our summer months that this disease is most prevalent. The diet consisted of the usual mixture of maize meal, bread, meat, vegetables, and Kaffir beer. Owing to many variations in the quantity, composition, time of cooking, and time of issue before actual consumption of the approximately 5-oz. vegetable ration it was unfortunately impossible to determine with any degree of precision what the daily intake of ascorbic acid in the diet amounted to, but from various estimates and actual tests it was considered to vary within

the limits of 12 or 15 to about 25 mg. a day. The effect of the additional ration was investigated as follows:

(a) A clinical examination of the natives was made at the beginning and the end of the experiment; (b) the incidence of the various diseases and the time spent in hospital were studied; (c) an inquiry was made into the efficiency of the natives at their various occupations; (d) several biochemical tests were applied both to healthy subjects and to those admitted to hospital; (e) their gums were examined, in many cases both at the beginning and at the close of the experiment; (f) the physical efficiency of subjects from both groups chosen at random was compared by means of certain athletic tests.

Throughout the experiment care was taken to organize the work in such a way that those carrying out the various tests were unaware of the group to which the individual being studied belonged. Moreover, no attempt was made to analyse our findings until the whole experiment was completed.

Results

After making allowances for the losses which are inevitable in experiments of this type it was found possible to compare 950 natives in each of the two groups. Analysis showed excellent, though not of course complete, agreement between the groups in respect to age, tribe, grade (that is, classification according to initial degree of physical fitness), actual number of days on the experiment (some did not complete the full seven months), nature of employment, and home conditions before joining the mine (that is, abundance or otherwise of food supplies).

General Condition.—No striking difference was noticed between the two groups at the end of the experimental period so far as general condition was concerned. The change in weight over the seven months averaged as follows:

TABLE I.—Weight Changes (1 lb. or More)

	Control Group		Test Group	
	Number	Mean Loss or Gain	Number	Mean Loss or Gain
Lost weight	304	3.4	292	3.0
Stationary	119	—	120	—
Gained weight	527	4.4	538	4.4

* Abstract of papers read on March 21, 1940, before a meeting of the Transvaal Mine Medical Officers' Association.

Working Efficiency.—Underground officials were provided at the beginning and close of the experiment with a form on which to report whether in their opinion the native specified (a) should be given lighter, the same, or heavier work, (b) whether he could be considered a lazy, medium, or hard worker, (c) whether he was stupid, average, or intelligent. It was realized that this was a very rough test, but it was thought that any *significant* improvement in general health should be reflected in general behaviour. Five hundred and ninety-nine such reports were returned, but the results did not indicate any significant difference in working efficiency between the natives in the two groups. That the working efficiency of the subjects in both groups was very high may be judged from the fact that during the whole period of the experiment no fewer than 99.1 per cent. of the possible shifts were actually worked. Shifts lost through accidents are not included.

Medical Findings.—The usual conditions for which mine natives require hospital treatment were encountered in both groups, and with the exception of scurvy it was found that both treated and untreated groups suffered from them *to the same extent*. Thus the number of cases and the number of shifts lost per case were recorded for minor ailments, influenza, colds, pneumonia, otitis media, mumps, chicken-pox, rheumatism, abscesses, and tuberculosis. There were 291 such cases in the control and 351 in the test group, the shifts lost per case averaging 4.51 and 4.94 respectively. The complete lack of success in protecting the treated group from such infections by the daily and long-continued administration of a considerable ration of ascorbic acid was one of the most striking results obtained from this investigation, particularly when the really low intake of the untreated group is considered in relation to the strenuous nature of the work upon which many of these natives were engaged.

Wounds.—Owing to the variety of the injuries sustained and the difference in situation and severity it was naturally difficult to compare the rate of healing of wounds and fractures; however, a rough division into contusions, minor and major wounds, and fractures failed to indicate any evidence of acceleration in the rate of healing amongst the patients in the test group. The shifts lost per case for the above four categories averaged 7.0, 8.4, 35.1, and 52.4 for the untreated and 6.3, 11.4, 32.5, and 57.0 for the treated natives.

However, when considering the negative findings for wound healing it is most important to state that the issue of orange-juice concentrate was deliberately stopped as soon as an individual from the test group entered hospital, since our object in this experiment was to compare the response to the change from the *previous* diet. An experiment has been started in which the response to treatment in hospital with large doses of ascorbic acid is to be studied.

Scurvy.—One mild case of scurvy occurred in the test group (diagnosed by gum condition only) and twelve cases in the control group. A statistical test indicated that it was most improbable that this difference in incidence would arise by chance, and seems to show that the amount of antiscorbutic vitamin in the basal diet must have been near the minimum protective dose. It also indicates the protective value of the concentrate used. The native contracting scurvy in the test group stoutly maintained that he regularly consumed the orange-juice concentrate. If this was really so it must be presumed that he failed to absorb the vitamin properly (McGovern, Gannon, and Wright, 1939).

Biochemical Findings

Urinary Excretion of Ascorbic Acid.—Previous experience of the very low urinary excretion of ascorbic acid by natives who appeared to be in excellent health, as well as recent literature on the subject, had so shaken our faith in the diagnostic value of this test that it was not adopted as a routine, although numerous isolated estimations were made.

Capillary Fragility.—Capillary fragility tests were carried out on a large number of subjects from both groups, including healthy and sick natives as well as patients in hospital with frank scurvy. Dalldorf's method was used with negative

pressures of 25 and, later, 50 cm. mercury. No difficulty was found in observing the results of this test, even on dark skins. *In not a single case did we obtain a reaction that could be classified even as weakly positive*, in spite of using the high negative pressure mentioned. In over 300 of these tests the amount of ascorbic acid in the plasma was also determined, and, as will be seen later, this was invariably found to be of a low order. An examination of the literature had already convinced us that this test is of doubtful value in the diagnosis of scurvy or the subscorbutic condition, but we had not expected to find such a uniform lack of response even in cases of scurvy. Our own experience with Europeans had confirmed the objection usually made to this test—namely, the number of falsely positive readings that are obtained. Further investigations into this curious lack of sensitivity shown by Bantu capillaries is being planned.

Rotter's Intradermal Test.—This test is somewhat difficult to apply to dark skins; fortunately a considerable proportion of our natives have medium- or light-coloured skins. A large series from both groups were subjected to the test, the ascorbic acid content of the plasma being determined at the same time. As reported by several other observers, and as will be seen from Table II, this test is of little or no value for the purpose for which it was suggested.

TABLE II.—Rotter's Intradermal Test

	No. of Cases	Mean Time (min.)	Range Observed (min.)	Range of Ascorbic Acid Values (mg. per 100 c.cm. Blood)
Control group ..	16	9.3	6.0–13.6	0.13–0.31
Test group ..	16	11.3	5.6–20.8	
Scurvy cases ..	18*	10.4	6.0–20.4	

* Including a few cases not in the experiment.

Ascorbic Acid Content of Blood Plasma.—The technique employed was a modification of that described in 1934 by Farmer and Abt. A series of tests carried out on Europeans gave the usual findings, with figures ranging from 0.28 to 2.4 mg. per 100 c.cm. blood, according to the previous dietary history. Table III summarizes our results in the two groups and a series of new arrivals not included in the experiment.

TABLE III.—Ascorbic Acid Content of the Blood Plasma of Native Mine Labourers

	No. Tested	Mean Value Obtained	Range Observed (mg. Ascorbic Acid per 100 c.cm. Blood)
Control Group:			
Just before leaving for home	74	0.230	0.15–0.40
Hospital cases, but excluding cases of scurvy ..	51	0.234	0.12–0.39
Test Group:			
Just before leaving for home	86	0.252	0.14–0.48
Hospital cases, but excluding case of scurvy ..	57	0.241	0.13–0.53
Cases of scurvy* ..	17	0.174	0.10–0.50
Natives just arrived from their kraals ..	43	0.185	0.10–0.63

* Including a few cases not in the experiment.

The extremely low values almost invariably obtained will at once be noted. Thus the mean value of 160 natives who had completed their contracts and were returning home was only 0.24 mg. Many of these natives had never even attended hospital during their six or seven months' stay at the mine, and were in excellent health when subjected to their final medical examination. *There was also only an insignificant difference between the values obtained for those receiving the daily ration of 40 mg. of ascorbic acid and those on the usual diet.* It was only after repeated observation that we could bring ourselves to accept this most unexpected finding. While a slightly lower mean value was obtained for the seventeen cases of scurvy, it will be noticed that there was little difference in the range observed.

Intravenous Ascorbic Acid Test.—This test, which was described in 1937 by Wright, Lilienfeld, and MacLenathen and in 1938 by Portnoy and Wilkinson, consists in injecting 1,000 mg. of ascorbic acid intravenously and then measuring

the amount excreted in the urine during the ensuing six hours. Without going into details it may be said that the test was carried out on eighteen men, eleven of whom were healthy individuals from either group and the remaining seven actually having scurvy. Although the latter excreted slightly less vitamin over the six-hour period, our experience in this somewhat limited series of extreme cases did not suggest that the test could be relied on for use with native mine labourers, who, as we have already indicated, even when in apparently robust health are so highly "unsaturated" in respect to vitamin C. This test has been criticized on the grounds that the injection of so large a quantity of vitamin at one time may give rise to a temporary excretion in spite of the fact that the tissues are heavily depleted of ascorbic acid.

Dental Findings

The original intention had been to examine a large number of natives from each group both at the beginning and at the close of the experimental period and so study the effect of a prolonged period on the two diets. Unfortunately circumstances made it impossible to carry out this programme in its entirety. However, a number of individuals, chosen at random and without the observers knowing to which group they belonged, were carefully studied. Many points of dental interest emerged, and are to be reported elsewhere; for our present purpose it will be sufficient to give our findings for the classifications "healthy" and "unhealthy." Healthy gums were defined as those entirely free from any clinical signs of inflammation. The results are given in Table IV.

TABLE IV.—Comparison of Gum Conditions in Natives from the Control and Test Groups

	No. Examined	Classified as Healthy	Percentage Healthy
Control group	159	115	72.3
Test group*	64	45	70.3

* Mean period on orange-juice concentrate at time of observation, 4.4 months.

It will be seen that in spite of the low amount of ascorbic acid in the diet of the control group and the highly depleted state of their reserves, suggested by the values obtained for the blood ascorbic acid test, the majority possessed healthy gums, and there was no significant difference between the condition of the gums in the two groups. Such results are in striking contrast to those reported for Europeans in a similar state of depletion—for example, by Weisberger, Young, and Morse (1938), Kramer (1937), and Roff and Glazebrook (1940). When the cases examined were separated into two age groups, 16–29 and 30–48 years, it was found that the percentage of healthy gums, as might be expected, was a little higher in the lower age group.

In seventy-eight cases the amount of ascorbic acid in the blood plasma was determined at the same time as the dental examination was made. The values obtained ranged from 0.10 to 0.38 mg. per 100 c.cm., the mean value being 0.22 mg. Forty-seven of these individuals were classified as possessing healthy gums. The lowest value noted for an individual with healthy gums was 0.12 mg. Among the cases in which the gums were considered to be unhealthy were four that were slightly suggestive of an early scurvy. Only one of these developed other symptoms of scurvy at a later stage of the experiment. The actual condition of the gums in individuals who suffered from clinical scurvy was also of considerable interest, for it was obvious that the picture was not one of profuse stomatitis but was rather localized to certain areas, the remainder of the gums often being apparently quite unaffected. It appeared unlikely that a more intensive study of the gums could be used for the detection of scurvy in its early stages; in other words, we have so far failed to find any indication of an intermediate stage between the healthy and the scorbutic gum in the native.

Effect on Physical Efficiency

In order to see whether the additional ration of ascorbic acid had improved physical efficiency natives chosen at random from each group were subjected to three standard performance tests—namely, putting the shot, sprinting 100 yards, and running one mile. The above three tests were chosen with a view to analysing the complex factor "physical efficiency" into its three main components—strength, skill, and endurance.

Putting the Shot.—Using a 16-lb. shot, this test was performed on sixty-one natives from the test group and 107 from the control group. No significant difference was observed between the performance in the two groups. It may be said that the general standard of efficiency shown in this test was poor, since none of the candidates achieved a throw of thirty feet, which is reached by a considerable number of untrained healthy adult Europeans.

Hundred Yards Sprint.—One hundred and four natives from the test and 130 from the control group were compared. Again no significant differences were revealed by this test, which may be considered capable of giving an insight into the co-ordinative faculties of the individuals. Considering the conditions under which the tests were conducted, and particularly the entire lack of athletic knowledge of the native runners, we adjudged the running time to be good.

Mile Race.—The running times of sixty-one natives from the test and 108 from the control group were compared. No statistical significance could be attached to the differences noted. As this test roughly indicates the candidates' power of endurance the negative result is of great physiological interest. The general standard of performance in this test, if compared with results obtained under similar circumstances for untrained Europeans, we regarded as fair.

The significance of the uniformly negative results obtained in this study can only be grasped when it is realized that the method readily demonstrates noteworthy differences when applied to other factors, such as age, weight, race, sex, puberty, and economic environment. Indeed, in the shot-put test the well-known correlation between performance and body weight was demonstrated on our experimental material.

Vitamin C Reserves in the Liver

Mention may be made here of previously unpublished work carried out by Levy and Fox in 1936 on the vitamin C content of European and native livers. A series of livers obtained from healthy European and native accident cases were analysed for vitamin C as soon as possible after death. They were sent to us as those of moderately nourished to well-nourished individuals. The average amount of reducing substance, probably mainly vitamin C, was estimated to be as follows:

TABLE V.—Total Amount of Reducing Substance in the Livers of Well-nourished European and Native Subjects (90 Cases)

	No. of Cases Examined	Mean Value as mg. Ascorbic Acid per Liver	Observed Range (mg.)
Europeans	26	320	150–640
Town natives	32	158	48–200
Mine natives	32	115	46–210

The difference between the European and native livers in the amount of vitamin C stored is most noticeable. The difference between that of the mine natives and that of the town natives may perhaps be attributed to the fact that the latter group included a number of domestic servants, such as cook-boys, etc., who may have had a more varied diet. Assuming a daily requirement of 15 mg. ascorbic acid, these reserves, if they may be regarded as such, would have lasted for only twenty-one, fifteen, and eight days respectively.

Scurvy in the Witwatersrand Gold Mines

In addition to the foregoing, information was collected concerning the cases of scurvy that have occurred since 1935 on the fifty-six mines that are members of the Transvaal Chamber of Mines. This information included the monthly incidence, the interval between joining the mine and admission to hospital, the relation between the nature of the work done and the liability to contract the disease, and the incidence amongst the various tribes. Two conclusions of more particular interest may be referred to here.

Nature of Employment and Liability to Contract Scurvy.—The actual occupation previous to contracting scurvy was classified as hard, medium, or light work, and the relative frequency in each category was found to be as in Table VI.

TABLE VI.—*Relative Frequency of Scurvy among Natives engaged in Different Types of Work*

Type of Work before Admission to Hospital	Estimated No. of Natives annually Employed in Each Grade*	Distribution expected if Incidence Uniform	Distribution found	Relative Frequency of Cases per 10,000 Natives
Hard work ..	206,083	774	768	37.3
Medium work ..	50,009	188	246	49.2
Light work ..	48,087	181	129	26.8
Totals ..	304,179	1,143	1,143	37.5

* Actual distribution not available. Estimate based on data for 1937 for one mining group employing about one-third of total labour force.

It will be seen that the hard workers have almost exactly the incidence of scurvy expected from the overall distribution, while medium workers have significantly more and light workers significantly less. It would therefore appear that the incidence of the disease is not influenced by the severity of the work undertaken. The work classified as hard includes the shovelling of rock and the pushing of trams, and is of a really strenuous nature.

Nature of Employment and Time taken to Contract Scurvy.—The mean time taken to contract scurvy by natives engaged in each type of work was also determined, and was found to be 6.59, 7.26, and 7.13 months respectively. The similarity of these three intervals lends no support to the view that scurvy develops more quickly when a native is engaged on hard work.

These conclusions as to scurvy are obviously of particular interest when considered in conjunction with the results of the physical efficiency tests.

Discussion

When considering the negative results shown by this experiment it is well to remember that they were obtained by varying the intake of a single constituent of the diet. However, a diet functions as a whole, and it is not suggested that the particular diet employed was fully adequate in respect to all its other constituents. Hence it is conceivable that some other deficiency or deficiencies may have had a limiting effect upon the response obtained with the additional ration of ascorbic acid.

Secondly, it must be remembered that these experiments have been made on Bantu subjects, and the possibility that they differ from Europeans in their requirements of the antiscorbutic vitamin cannot altogether be excluded, more especially when it is remembered that their customary diet is known to be deficient in this constituent; the peculiar results obtained with the capillary resistance test will also be recalled.

Nevertheless after making a fairly thorough and critical examination of the literature we have come to the conclusion that our own results find support from the evidence presented by other investigators during the last

few years. A few examples may be mentioned. Thus Kellie and Zilva (1939) as a result of careful laboratory experiments concluded that a daily intake of 15 mg. of ascorbic acid would be sufficient not only to protect from scurvy but to maintain normal individuals in good health. Again, an examination of the numerous papers in which the amount of ascorbic acid in the blood has been determined reveals the fact that a considerable number of apparently healthy individuals have given values as low as those found by us for Bantu mine labourers. Since such values fall below the usual figures and were often known to be associated with a low intake of vitamin in the diet they have been automatically classified as "inadequate" or "subscorbutic," although there does not appear to have been any evidence that such individuals were any the worse for their low reserves. Then with regard to the relation of vitamin C to natural resistance and immunity, while it is true that much interesting work has been done, those who have reviewed the subject recently remain unconvinced. Thus Abt and Farmer (1938) remark that the whole field "is but in its infancy, and much more experimental and clinical evidence must be accumulated before any definite claims seem justifiable." Dagulf (1939), who was more particularly concerned with tuberculosis, takes the same view, and goes so far as to say that it has not yet been established that there is any connexion between vitamin C and that disease.

The histological and clinical evidence regarding the importance of vitamin C in relation to the healing of wounds and fractures is more impressive, and in considering our negative results it must be remembered that the test-group patients did not receive additional vitamin C after they reached hospital. In this connexion, however, it may be mentioned that, although it is evident that natives as a class must often be in a most depleted state in respect to vitamin C, their general response to surgical measures and their rate of recovery are usually regarded as comparing favourably with those of Europeans, rather than otherwise.

Although it seems to be rather generally assumed that the requirements of vitamin C are increased during strenuous exercise, there is really very little reliable experimental evidence to support such a contention. The matter is discussed in an excellent paper by Rietschel and Mensching (1939). Mensching describes how fit and active he was after 100 days on a diet very deficient in vitamin C and with blood ascorbic acid values that had fallen so low that he could no longer measure them. Moreover, the absence or surprisingly low incidence of scurvy among communities whose diet is highly deficient in the antiscorbutic factor has often been commented on. A similar anomaly regarding the health of Arctic explorers has been noticed by Stefansson (1939).

The precarious nature of such minimal supplies of the vitamin is obvious enough; nevertheless it is surely unscientific to assume that general health must be greatly improved when larger amounts are made available. As a result of their work Rietschel and Mensching reach the conclusion that the healthy individual's actual requirements of vitamin C are small and that this substance most probably behaves as a metabolic catalyser, being alternately oxidized and again reduced. They also put forward the suggestion that when supplies are diminished not only is excretion also lowered but perhaps substances other than the vitamin can be utilized to some extent.

Conclusions

1. Taken as a whole the evidence presented in this study shows that the native mine labourer possesses considerable powers of adjustment to a diet low in anti-

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.