

closure of the fistula in every patient thus examined; but although it is possible in the end to say that the blood volume was shown to be increased on the average by about 15%, as the "normal" blood volume of a given individual is not known the pre-operative figure can scarcely be expected to provide evidence of a fistula.

It is much more difficult to decide where the fistula is and what vessels are involved. The loudness of the bruit is deceptive, and the determination of the point where pressure will abolish it may not be an accurate guide, because compression of the main vessel proximal to the fistula can give the same result. Arteriography, which is a great help when a main vessel is obstructed, usually fails to give a clear picture of a fistula, especially if it is large enough to allow the opaque material to diffuse rapidly into the vein. The track of the missile as shown by a through-and-through wound or a retained foreign body is often the best guide. But the decision usually has to be made by guesswork, and over and over again one has felt that the whole undertaking would have been so much simpler had one started with the information which has to be gathered in the course of the operation.

#### Treatment of Arteriovenous Fistula

We learnt that for safety it is necessary first to pass controlling tapes round the artery and vein involved as near as possible above and below the fistula without opening into it. In a bullet wound this may be comparatively simple, but as most of the wounds were caused by fragments of mortar shell or bomb, and as there had clearly been widespread haemorrhage with subsequent scarring inside and outside the vessel sheath, it was often a tedious dissection to clear the required length of the artery without damaging branches which were needed as collaterals. For the same reason it is often difficult to find healthy enough vessel wall to hold sutures, especially with varicose aneurysms, and I often felt humiliated by my lack of enterprise, for we were commonly reduced to quadruple ligation instead of carrying out the various forms of arterial reconstruction which we had hoped to attempt. On the other hand, it must be admitted that the results obtained by this "old-fashioned" method were not unsatisfactory.

We carried out lumbar ganglionectomy two to three weeks before all our operations for arteriovenous fistula in the lower extremity, with the single exception of a fistula between the peroneal artery and vein. We did this partly because our series was intended to link up with that of Lieut.-Col. A. M. Boyd, and I understood that this was also his practice; partly because, even in spite of waiting for a collateral circulation to form, damage might be done to it in the course of the dissection of the lesion, and the best possible collateral circulation therefore seemed to be desirable; and partly also because I knew that at other centres these fistulae were being treated without sympathectomy and I hoped our series might form part of an interesting controlled experiment. It may yet appear that we were unnecessarily over-cautious, but we never saw anything approaching gangrene of a toe. It would be wrong to draw conclusions from our small numbers—1 common femoral, 3 superficial femoral, 5 profunda femoris, and 7 popliteal lesions—but they all recovered with good function. The most critical was in the man who had already had his external iliac tied in continuity for a common femoral arteriovenous fistula: after a preliminary lumbar ganglionectomy I was forced to do a "triple arterial" ligation of his common, superficial, and deep femoral arteries, yet six months later he was able to walk four miles without pain, his residual disability being due to the ischaemic palsy of the external popliteal nerve, which was steadily recovering.

While quadruple ligation was in our experience the usual treatment for arteriovenous aneurysm, it may be possible to vary the procedure for aneurysmal varix. The scarring is less as a rule—no doubt the direct opening of the artery into the vein serves to limit the amount of blood extravasated into the surrounding tissues—and the dissection of the lesion is more straightforward. In two popliteal fistulae after the vein had been tied above and below the fistula it was possible to narrow down the communication till it could be safely ligated as though it were a branch of the artery, and thus the artery itself was spared.

#### Syndrome of Venous Obstruction

We were rather surprised, however, to note that these patients whose popliteal artery was preserved at the cost of the vein were less comfortable than those who had had both vessels blocked by quadruple ligation. They complained of aching pain and a bursting feeling in the lower leg, ankle, and foot produced by lowering the leg, which was more severe in the standing than in the sitting position, though sitting in one position for an hour or so may be almost intolerable. The pain may be relieved by walking for a short distance, but the quickest and most effective method of easing the pain is by lying down with the legs raised above "heart level." Swelling round the ankle may accompany the pain.

We came to recognize these symptoms of venous obstruction in many patients after injury or operation, but we also noticed that they are more marked when the arterial supply is unimpaired. Being persuaded that when ligating an artery immediately after an injury simultaneous ligation of its companion vein is advisable or is at least harmless, it took us a long time to realize that the different conditions under which ligation is undertaken at a later stage may call for different treatment. We had thought, with others, that in the treatment of an arteriovenous fistula, while immediate proximal and distal ligation of the artery would be sufficient to stop the vicious circulation, the additional ligation of the vein would be better (Maybury, 1945).

But the recognition of these symptoms as those of venous obstruction made us think again, and we were able to put the matter to the test in two fistulae—one between the profunda femoris artery and the common femoral vein, and the other between the superficial femoral artery and vein. For both of these we ligated the artery as close as possible above and below the fistula but left the vein intact. Neither of the patients complained of any of the symptoms of venous obstruction, and both had an adequate peripheral arterial supply. It is therefore our impression that the collateral circulation resulting from an arteriovenous fistula safeguards the arterial flow to the limb after ligation of the artery, and that it is a distinct advantage to preserve the vein whenever this is possible.

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## OBSERVATIONS ON CASES OF STARVATION AT BELSEN\*

BY

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Belsen was a detention and not an extermination camp—that is to say, not a camp where organized extermination was carried out. Originally devised for perhaps a few thousand people, it became progressively more overcrowded in the early part of 1945 as the Allied armies closed in from west and east and forced the Germans to evacuate other concentration camps. At its peak it is said to have contained over 66,000 persons. The majority of these were Jews of Polish or Hungarian origin, but almost all countries and religions were represented. Many of the patients had spent only short periods in Belsen, having previously been interned in other concentration camps, such as the notorious one at Auschwitz. However, the following notes, based on information given by a Hungarian woman doctor who was in Belsen for four months, convey some idea of the diet on which they had existed before the liberation of the camp.

In Jan., 1945, there was already very little food, but the quality was not so bad. Each person got one-sixth of a loaf a day (the loaf was black and weighed about 1.4 kg.), and sometimes potatoes and pieces of meat. For instance, there was occasionally a thin slice of sausage for supper and a little meat in the soup. On Sundays tinned meat was distributed; 12 persons shared one tin. By February everybody was getting

\* An abstract of a report to D.M.S. 21 Army Group.

thin and the epidemic of typhus started. From then onwards the food steadily deteriorated. For a time they received soup on three nights a week and a little margarine or jam on the other four nights (only one-twelfth of a loaf each during March and no bread at all in April). When there was no bread they were given mangel-wurzels, so that sometimes supper would consist of mangels and margarine. For the last fortnight before the camp was relieved (i.e., for the first fortnight in April) mangel-wurzels were the only food. These were distributed in a form of soup, sometimes made from flour and salt, sometimes from neither. During this final period each internee was getting about a half-litre of this soup a day and nothing else. It is evident that throughout the last weeks of the camp's existence a gruesome form of the law of the survival of the fittest was in operation. The distribution of food was arbitrary, and those that still had some strength left obtained more than their share. An idea of the general conditions prevailing during the few weeks before the arrival of the British may be gained from the official statement that 10,000 unburied corpses lay among the living when the camp was first reached by them.

The original concentration camp, where the thousands of internees lay in crowded huts, was gradually evacuated between late April and the end of May. During this time innumerable seriously ill patients had of necessity to await their turn and to remain in the huts for a further period of days or even weeks under most unfavourable conditions. The patients were first seen after they had been brought from the concentration camp, passed through the "human laundry" for disinfection, and taken to beds in the barrack rooms that formed the "hospital" accommodation. The following description of the clinical state is based on the appearance of patients in the middle of May—about four weeks after the first arrival of the British in the area.

**A Typical Clinical Picture**

The patient lay flat in bed without acute distress, yet with a miserable expression. He showed no interest in anything except his own needs, and appeared completely indifferent to the deaths that occurred so frequently. Moreover, death was a very public affair, since there were no screens and beds were crowded together. He talked with a whining voice and complained continually, usually of his severe diarrhoea. "Scheiszerei" was the commonest word. Second only to this complaint was unfavourable comment on the diet, the soup being blamed for the diarrhoea. Black bread was next in unpopularity. Patients who were a little less ill asked continually for white bread and complained that they were being starved. The truth was that there was enough food in terms of calories, but much of it was unpalatable. Although starving, they were extremely particular about their diet and very difficult to please. Most of them did not fancy sweet things, and almost all wanted solid food rather than soup. When they wanted a drink, lemonade or something sour was most often asked for. They were all sure that soup and cold food made the diarrhoea worse. Although milk was available as an alternative to the full diet, many of the patients didn't want it, and, if given it, complained that they were not getting enough to support life. Because of their poor appetite, many of them left their food untouched, and as there were insufficient nurses to feed them their state rapidly became worse. The orderly simply put the food beside the bed and left it. Later the untouched food would be collected if the patient had not secreted it in his bedding for future use. Fear of being without food was so great that even dying patients would put bread-and-butter and meat under their pillows.

All the seriously ill were incontinent of faeces, and their beds were continually soiled as there were not enough orderlies to change them, and, in any case, many of them had no sheets but simply lay on covered palliasses. Almost every patient when first seen had diarrhoea—varying from two to three loose stools a day to an almost continuous production of watery stools. In the latter cases a movement of the bowels invariably followed immediately after taking anything by mouth, so that the patient was afraid to eat or drink. The stools did not as a rule contain blood or pus. They were often light brown in colour, smelt offensive, and consisted of fluid and lumps of undigested food.

On examination the patient had an appallingly thin face. The eyes were sunken and the cheek-bones jutted out. These

extreme changes made all the patients look alike, so that it became difficult to distinguish one from another. This difficulty was accentuated by the fact that all patients had had the bulk of their hair shaved off. The skin of their arms, legs, and anterior abdominal wall was often rough, dry, and scaly. There were large bed-sores on the buttocks and the lower part of the back. The ribs stuck out, and it was difficult to use a diaphragm type of stethoscope because it simply bridged across two ribs and made no contact with the skin dipping down in between. The anterior abdominal wall was concave, falling away from the ribs above and from the anterior superior iliac spine below. The greatest muscle-wasting was around the pelvis. The ischial tuberosities stood out prominently and the posterior surface of the ilium was almost devoid of muscle. There was a depression below the anterior superior iliac spine, and the skin hung down to the thigh in a fold. The legs were fuller owing to oedema; but this was often confined to the ankles and feet, so that a common appearance was of a leg as thin as a stick with a fat swollen foot on the end of it.

The face and hands were pale. The conjunctivae were pale but otherwise normal. The sclerae were clear. The tongue was often red and smooth around the edges, but extensive changes were not seen. Koilonychia was not seen in a single case. Many patients had sore dirty mouths with gingivitis when they first arrived in the hospital area, but this condition cleared up in a few days without special treatment. Angular stomatitis was present in a small proportion of cases. The pulse was usually rapid (average approximately 100 beats a minute) and the blood pressure low, the average in 12 emaciated patients being 91/60. No abnormalities were discovered in the heart, apart from a reduced intensity of the sounds.

The average weight of 18 males who were strong enough to stand upright on scales was 44 kg. (38.7–59.7); 11 females averaged 35.3 kg. (25–45.5): i.e., males just under 7 st.; females about 5½ st. In 11 of these 29 the previous weight was known, and the loss was calculated as a percentage of the figure in health: the average loss was 38.8% (29–57%)—see Table I. The

TABLE I.—Relation between Loss of Body Weight and (1) Haematocrit and (2) Serum Protein Concentration in 11 Subjects

Case	Date	Body Weight (Kg.)			% Loss of Original Weight	Hmt. %	Serum Protein (g.-%)
		Now	Originally	Loss			
M 42	June 8	35.0	80.0	45.0	56	31.4	4.9
F 116	July 5	25.0	50.0	25.0	50	36.8	5.0
Fx 1	June 19	34.0	63.0	29.0	45	33.4	5.0
M 37	June 7	39.0	67.0	28.0	42	23.0	4.8
F 114	July 3	35.1	56.0	20.9	37	31.0	5.6
Fx 4	June 19	39.9	62.0	22.1	36	33.2	3.7
M 35	June 7	32.0	50.0	18.0	36	24.0	6.9
F 111	July 3	31.0	47.5	16.5	35	20.2	4.5
F 124	July 18	33.2	48.0	14.8	31	33.0	5.0
F 101	June 8	33.0	47.0	14.0	30	27.5	5.8
F 4	May 24	45.0	33.0	18.0	29	33.9	6.0

Average loss, all 11 cases: 38.8%.

N.B.—All above patients except M 37 and M 42 were non-tuberculous. No patient with more than a trace of oedema was included.

patients in this latter group were weighed at a comparatively late date (6 in June, 5 in July, and 1 in May), and, although all were very thin and at least one case of extreme emaciation is included (F 116), the figures do not on the whole represent the most severe cases. The thinnest patients died earlier and had been too ill to be weighed. As shown in the table, there was no correlation between percentage loss of body weight on the one hand and either haematocrit or serum protein concentration on the other.

**Pulmonary Tuberculosis**

Those who were free from pulmonary tuberculosis and had not reached the stage of extreme emaciation usually made rapid progress. They were soon able to eat almost any kind of food, and their diarrhoea diminished, although they continued to be very prone to loose stools and hurried evacuation of the bowels after meals. It was quickly realized that any patient whose progress was unsatisfactory was likely to have tuberculosis. During the last week in May it became possible to screen the chests of a few of those whose blood had been examined. Later some patients were transported to a static x-ray plant and chest films were taken. From this evidence and from post-mortem findings it was possible to say with some precision that certain

patients had tuberculosis and that certain patients were free from it. There were left some who were not x-rayed and who had no clinical signs of the disease.

Of 36 males 13 were free from tuberculosis, 7 were probably free, and 16 were affected. Of 28 females 9 were free, 8 were probably free, and 11 were affected. Thus, in all, the incidence of definite pulmonary tuberculosis in this series was at least 27 out of 64 cases, or approximately 40%, and it may have been higher. This incidence is of course in no way representative of all the victims of Belsen Concentration Camp, since many were never admitted to the hospital area. Furthermore, patients whose blood was examined were selected mainly on the grounds of being more sick than the average. On the other hand, some were selected for reasons irrelevant to their state of health—e.g., because they were doctors. All that this figure represents, therefore, is the approximate incidence of pulmonary tuberculosis among those who appeared rather more ill than the average. The incidence in those who died was probably considerably higher. Thus among 18 cases in which the cause of death was established an extensive tuberculous infection was present in 12.

crystalline haemin (81 mg. to a litre of N/10 NaOH) to make standards corresponding to 15.6 g. haemoglobin % (King *et al.*, 1937). The average density of these solutions, when checked against a standard grey screen, was found to be within 0.5% of that given by King *et al.* (3) Serum protein concentrations were deduced from specific gravities, using the copper sulphate method of Phillips *et al.* (1945). (4) Plasma volume was estimated by the dye dilution method, using Evans blue. A single blood sample was obtained 10 to 15 minutes after the injection of the dye. The dyed plasma was sometimes measured directly; in other instances the plasma was first treated to remove other pigments (methods of Crooke and Morris, 1942, or Morris, 1944).

### Findings

(The majority of the estimations were made between May 14 and June 14—that is to say, within 4 to 8 weeks of the first arrival of the British Army in Belsen.)

*Widespread Anaemia* (see Table II).—75 starvation cases (36 males, 32 females, 7 children) were tested. Many of them were chosen because they were pale or oedematous or rather more wasted

TABLE II.—Summary of Blood Findings

Group	No. in Group	R.B.C. per c.mm.	Hb (%)	Hb (g. %)	Hmt. (%)	M.C.H.C. (%)	C.I.	M.C.V. ( $\mu^3$ )	Serum Protein (g. %)
Starvation cases (males):									
<i>Non-tuberculous</i>									
Good evidence	9	3,403,000	62.2	9.7	30.9	31.4	0.91	91.4	5.6
Insufficient evidence	7	3,610,000	66.9	10.4	33.6	30.9	0.93	93.4	4.7
<i>Tuberculous</i>									
Pleural effusions only	5	3,450,000	61.4	9.6	29.8	32.2	0.89	86.6	4.8
Active pulmonary Tb.	9	3,380,000	60.1	9.4	29.8	31.8	0.90	88.6	5.4
Average	30	3,450,000	62.5	9.8	31.0	31.5	0.91	90.2	5.2
Starvation cases (females):									
<i>Non-tuberculous</i>									
Good evidence	8	3,310,000	60.2	9.4	29.3	31.7	0.91	89.0	4.3
Insufficient evidence	6	3,060,000	52.7	8.2	27.5	29.9	0.86	90.0	5.2
<i>Tuberculous</i>									
Active pulmonary Tb.	9	3,130,000	57.9	9.0	29.2	30.9	0.92	94.0	5.2
Average	23	3,180,000	57.3	8.9	28.8	31.0	0.90	91.0	4.9
Starvation cases (children)	7	3,520,000	61.2	9.6	29.9	31.9	0.87	85.5	6.0
Controls (healthy British males)	12	5,255,000	98.7	15.4	47.2	32.7	0.94	90.0	6.7

It was noted that some of the very frail patients remained afebrile despite tuberculosis—e.g., M 37, an extremely emaciated man of 50 years, whose temperature, taken twice daily for the last three weeks of his life, never exceeded 37° C., but who at necropsy was proved to have had active recent tuberculosis with cavitation. It was also frequently observed that patients coughed far less than would be expected from the extent of the pulmonary lesion, and several patients with active infection did not cough at all.

### Typhus

The typhus epidemic in Belsen apparently started in February, and cases continued to occur until about the end of May. It was very difficult to discover in any individual cases whether or not a patient had had typhus, because so many had been desperately ill and weak for some time before the liberation and could not give any exact description of the kind of illness they had had. Weil-Felix tests were carried out in 48 cases: 21 were positive in a titre of 150 or more; 27 were negative or gave titres lower than 150. Of 26 of these tests made in May, 12 were positive; and of 22 made in June or early July, 9 were positive. Of 19 patients who said they had not had typhus 10 had negative and 9 had positive Weil-Felix reactions. Of 9 patients who said they had had typhus 5 had positive and 4 had negative Weil-Felix reactions. (I am indebted to Majors Griffin, Morris, and Prior for performing these tests.)

The general conclusion reached must be that the majority of patients in Belsen had recently had typhus.

### Blood Examinations

*Notes on Methods.*—(1) All blood examinations were made on venous samples. (2) Haemoglobin was estimated as alkaline haematin; the majority of the measurements were made in a photo-electric colorimeter. Solutions were prepared from

than the average, but some included were less severe cases of starvation who later showed rapid improvement. With the exception of a few severely dehydrated patients (excluded from this series), all persons examined were found to be anaemic. Tuberculosis was evidently not the main cause of this anaemia, since there was very little difference between the Hb levels of the non-tuberculous and the tuberculous cases.

*Haemoglobin Values.*—The average haemoglobin in 30 males was 62.5%, in 23 females 57.2%, and in 7 children 61.2%. Almost all these observations were made between the middle of May and the middle of June (males, 19 in May and 11 in June—latest June 19; females, 17 in May, 2 in June, 4 in early July). One feature of the observations was the comparatively small scatter of the haemoglobin values. The following indices were calculated:

Group	No.	Mean Hb %	S.D.	Coeff. of Variation
Belsen males	30	62.5	7.3	11.6
Belsen females	23	57.3	9.3	16.6
Controls (males)	12	98.7	4.6	4.6

*Characteristics of the Anaemia: Normochromic, Normocytic.*—A striking feature was the absence of any evidence of iron deficiency. Thus the M.C.H.C. in a group of 30 males was 31.8% (lowest 29.4%), and in a group of 23 females 31.0% (lowest 26.7%). These averages do not differ materially from the average M.C.H.C. found in a group of 12 healthy British Army personnel—viz., 32.7%. Mean corpuscular volumes showed slightly larger variations than those of the control group; but average figures were normal—namely, 90.2  $\mu^3$  in a group of 30 males and 91.0  $\mu^3$  in a group of 23 females, compared with 90.0  $\mu^3$  in the control group. The examination of stained films confirmed the absence of any significant change in average cell size, though some cases showed a rather greater degree of anisocytosis than normal. The features of normocytosis and normochromia of the erythrocytes suggest a simple diminution of production rather than any abnormality of maturation. This conclusion receives support from examination of the few marrow films that were made, on which Dr. J. F. Loutit reported as follows:

"Erythropoiesis is normoblastic, and so far as one can tell there is no maturation defect." The reduced metabolic rate which is known to prevail in starvation was probably one of the chief causative factors in this diminution of production, and doubtless in many cases infection of one kind or another had also contributed to a depression of bone marrow. The lack of correlation between haemoglobin and serum protein levels (see below) suggests that protein deficiency was not the main cause of the anaemia.

**Reticulocytosis Present.**—Reticulocyte counts were made on 20 patients who had been on a normal diet for at least five weeks but had received no iron or liver or other special treatment. The average was 1.6%. In 10 non-tuberculous subjects the average was 1.9% (range 0.6-3.6%); in 10 tuberculous subjects the average was 1.3% (range 0.5-2.4%).

**Hypobilirubinaemia.**—Although serum bilirubin estimations were not made, it was repeatedly observed that the sera were pale and often almost colourless.

**Leucocyte Counts, including Differential Counts.**—Only a few leucocyte counts were made; these were within normal limits. The height of the leucocyte column in the centrifuged haematocrit was measured in all cases. The average was 0.8 in 40 males and 0.9 in 26 females. In 12 normal soldiers the average was 0.8. In 7 of the 66 cases the column was less than 0.4 of a division. However, 5 of these 7 died within four days of taking the samples. There is therefore some evidence that leucopenia was not a striking or consistent feature of these cases of starvation.

**Serum Proteins.**—Total serum proteins were estimated in 43 cases. In 18 males the average figure was 5.2 g.%. In 19 females the average was 5.0 g.%. In the oedematous cases the levels were on the average lower than in the non-oedematous, although in many individual cases there was a lack of correlation between total serum protein concentration and degree of oedema (see Table III).

TABLE III.—Relation of Serum Protein Levels to Oedema

Group	No. of Cases	Average Serum Protein Conc. (g. %)	Range of Serum Protein Conc. (g. %)
Severe oedema	4	4.0	3.6-4.4
Moderate oedema	10	4.7	3.5-6.5
Slight oedema	13	5.1	4.5-5.9
No oedema	23	5.8	4.5-7.5

N.B.—Slight oedema was defined as oedema involving only the feet and ankles. Moderate oedema was defined as oedema involving the legs as well as the feet; in some of these cases the oedema extended to the lower part of the back; in others it did not extend above the knee. The term "severe oedema" was reserved for those cases which had generalized oedema involving the face. In all these cases the urine was either completely free from protein or contained at most a trace.

**Lack of Correlation between Haemoglobin Values and Serum Protein Concentrations.**—No correlation was observed between haemoglobin levels and serum protein concentrations. It is noteworthy that the average haemoglobin level was proportionately more depressed than the average serum protein concentration—viz., average haemoglobin level about 60% of normal, average serum protein concentration about 75% of normal.

**Blood Volumes** (see Table IV).—Plasma volumes were estimated in 6 males and 10 females, and blood volumes were deduced there-

TABLE IV.—Blood Volumes

Case	Weight (kg.)	Oedema <sup>1</sup>	P.V. (litres)	Hmt. (%)	B.V. (litres)	S.Pr. (g. %)	B.V. in c.cm. kg.
M 2*	43	+	2.9	28.6	4.1	—	95
M 9*	39	+	2.5	40.2	4.3	—	110
M 23*	40	—	3.4	32.1	5.0	5.5	125
M 30*	43	+	2.7	35.0*	4.1	—	95
M 45	45	++	3.2	26.0	4.3	5.3	95 (a)
M 50	45	—	2.7	32.6	4.0	—	89
				Av. (6 cases)	4.3		
F 5	(Very wasted)	++	2.2	23.0	2.9	5.2	—
F 100	43.5	++	2.0	32.0	3.0	5.7	69
F 110	59.3	+++	2.5	28.0	3.6	4.5	61
F 111	47.0	+++	2.5	36.8	4.0	5.7	84
F 114	31.0	—	2.3	20.2	2.9	4.6	93
F 114	35.1	—	2.2	29.0	3.1	5.6	88 (b)
F 116	25.0	—	1.7	37.2	2.7	5.0	112
F 117	36.0	—	2.4	36.0	3.7	5.5	103
F 122	36.0	++	2.3	31.4	3.3	4.0	92
F 124	33.2	—	1.9	33.0	2.8	5.0	85
F 125	59.0	+++	2.7	26.5	3.7	—	63
				Av. (10 cases)	3.17		

\* In these cases the dyed serum samples were not measured directly, as they were in the others, but were first treated to remove other pigments, etc.

(a) Blood volume estimated 12 hours after a serum transfusion, which had lowered the haematocrit from 29% (before the transfusion) to 26% (at the time the blood volume was estimated).

(b) Blood volume estimated after an infusion of 500 c.cm. inulin-saline solution. The haematocrit before the infusion started was 32% and at the time of estimation of the blood volume 30%.

from, using haematocrit readings. The average figure for total blood volume was 4.30 litres in the males and 3.17 litres in the females. It is felt that the figures for females are the more reliable, as these were, with one exception, estimated by the same technique—namely, the direct measurement of the dye in serum.

In 12 of the 15 cases in which body weight was known, the relation of blood volume to body weight varied from 85 to 125 c.cm./kg., averaging 101 c.cm./kg. in 6 males and 95 c.cm./kg. in 6 females. These figures are high compared with the normals of Gibson and Evans (1937)—viz., 77.7 c.cm./kg. for males and 66.1 c.cm./kg. for females. Thus it appears that blood volume in seriously under-nourished subjects is not reduced in proportion to body weight. Three other females were found to have far lower ratios of blood volume to body weight—viz., 61, 63, and 69 c.cm./kg. respectively. These three patients all had considerable oedema. However, at least one other patient with a corresponding degree of oedema did not show this relation. All that can be said, therefore, is that, in the presence of oedema, blood volume either bore the usual relation to body weight or was relatively lower. In Case F 110 the blood volume was estimated a second time, after a considerable amount of oedema fluid had been lost; a slightly higher figure was obtained on the second occasion, although the patient had lost 12 kg. in weight. This observation is in agreement with the hypothesis that blood volume in severely oedematous cases is related to the tissue mass and is not increased in proportion to the extra weight of oedema fluid.

**Serum Urea.**—Serum urea was estimated in over 40 patients, and in some cases serial observations were made. Excluding children and five severely dehydrated adults, the average in 33 cases was 32 mg. per 100 c.cm. In the five adults the figures were 187, 70, 63, 67, and 70 mg. respectively.

**Sedimentation Rates.**—During May and June, when other haematological observations were being made, it was repeatedly observed that blood samples sedimented very rapidly. The sedimentation rate was recorded in 28 cases between June 7 and July 6 and was increased in every one, the drop varying from 22 to 60 mm. in one hour, with an average fall of 53 mm. In 12 of these patients who were radiologically free from tuberculosis the average sedimentation rate was 49 mm. in one hour, and in 7 of the 12 who had probably not had recent typhus (Weil-Felix reactions: 5 negative in all dilutions, 2 positive in 1 in 80 but not higher) the average was 45 mm. in one hour. The average haematocrit reading of the seven cases was 35.0 and the average serum protein 6.7 g.%. It appears, therefore, that a rapid sedimentation rate is characteristic of starvation cases whether or not infection is present, and that the main cause of this increase in rate is not simply the anaemia of starvation.

**Serial Blood Examinations.**—Great difficulty was encountered in following up patients, because as soon as they were well enough they were liable to be moved to other camps or to be evacuated from Belsen to their native lands. However, serial observations over periods ranging from 9 days to 45 days were made on 22 patients, and some evidence was obtained that recovery from the anaemia did not depend on the administration of liver or iron. For instance, in three patients who were closely observed, and were known to have had no medicine or injections and to have received simply the ordinary diet, the changes in the blood were as follows:

Case	Date	R.B.C.	Hb (%)	Hmt. (%)
M 2	May 14	2,790,000	57	28.3
	June 9	3,920,000	81	37.0
M 8	May 31	4,010,000	65	32.0
	July 7	4,650,000	76	43.0
M 35	May 30	2,610,000	51	24.0
	June 21	3,640,000	66	36.8

These rates of recovery were greater than those observed in many of the other cases, and some patients showed a very slow rate of improvement, with some tendency of the rate of increase in haemoglobin value to lag behind the increase in red cell count. Very few of the tuberculous patients showed any increase in values, and a few became more anaemic while under observation.

**Serial Observations on Serum Proteins.**—Between six and ten weeks after the initial liberation of the camp serial observations on serum protein concentration were made in 16 cases over periods extending from 12 to 45 days (average, 28 days). In 11 cases an increase of between 0.8 g. and 3.3 g. % was observed (average, 1.7 g. %). In 5 other cases changes from a fall of 0.2 g. % to a gain of 0.4 g. % were found. In three of these the period of observation was short (12 to 15 days), but in two the period was 37 days. These two patients were non-tuberculous; one had no diarrhoea and the other only very slight diarrhoea. The failure of the serum protein to show an appreciable increase in these two is attributed primarily to a poor intake, since both had indifferent appetites and ate but little. It is of interest that as late as seven weeks after the liberation (that is to say, the first week in June)

none of the 16 cases appeared to have reached their maximum serum protein concentration, since even cases which had by this time reached figures within the normal range showed a further increase subsequently.

**Urinary Examinations.**—In the majority of starvation cases examined no abnormalities were found in the urine. However, in the remainder two features occurred unduly frequently. First, urinary infections were found in five out of 21 cases taken at random; secondly, evidence of subacute nephritis was present in six out of 14 cases of persistent oedema examined about two months after the liberation of the camp. The most likely cause of this nephritis seems to be typhus.

### Renal Function

From the evidence of the estimations of blood urea alone it may be concluded that there is no gross disturbance of renal function in cases of starvation, except in so far as extrarenal azotaemia occurs when there is severe dehydration.

Evidence of a normal glomerular filtration rate in emaciated patients was obtained by estimating the inulin clearance in two female subjects who had lost 36% and 37% of their body weight respectively. The actual inulin clearances observed were within normal limits (see Table V), and when corrected for surface

thus appears that in at least some cases of "hunger oedema" which clear up slowly there is an impairment of renal function, although the cause of this is not known.

Inulin and diodone clearances were carried out in two patients who had been diagnosed as cases of nephritis. Very low clearances were found in both instances.

[In estimating inulin and diodone clearances the routine followed did not differ in any essential from that described by Smith (1943) and co-workers (Goldring *et al.*, 1940). Inulin was estimated by an unpublished method of Dr. S. W. Cole, and diodone by Alpert's (1941) method.]

### Summary

Observations were made on Central European subjects, of both sexes, who had survived conditions of very severe starvation. The average loss of body weight in a group which included some of the less severely affected cases was 39%, and in individual cases the loss was as great as, or slightly greater than, 50% of the original weight. The majority of the patients had recently had typhus, and in one group examined 40% had pulmonary tuberculosis.

All subjects examined were anaemic, the average Hb value in 30 males being 62.5% (9.8 g.), and in 23 females 57.3% (8.9 g.); children were similarly affected. In all cases the type of anaemia

TABLE V.—Renal Function Tests (Inulin/Diodone Clearances) in a Miscellaneous Group of Starvation Cases

Patient	Age	Weight (kg.)	Previous Weight (kg.)	Height (cm.)	Surface Area (sq. m.)	B.P. during Clearances	Plasma Clearances (c.cm./min.)				T <sub>M</sub> D mg./min.	
							Inulin		Diodone		Obs.	Corr.
							Obs.	Corr.	Obs.	Corr.		
(A) Simple Cases of Emaciation without Oedema and without Albuminuria												
Normal female*	—	—	—	—	—	—	—	117	—	594	—	—
F 124 .. ..	25	33.2	48.0	153	1.73	102/70-108/76	88	124	241	340	32.0	42.6
F 114 .. ..	21	35.1	56.0	150	1.24	88/52-88/60	102	141	501	710	—	45.3
(B) Cases of Generalized Oedema without Albuminuria												
F 110 .. ..	50	59.3	80.0	160	1.62	90/60-92/60	66	70	182	194	—	—
F 122 .. ..	50	42.0†	80.0	155	1.40	90/60	43	80	228	230	17.7	—
F 122 .. ..	50	43.9	80.0	155	1.39	90/60	43	53	228	283	—	22.0
(C) Cases of Nephritis												
F 102 .. ..	21	25.0	50.0	159	1.11	132/84	58	—	211	—	15.8	—
F 116 .. ..	23	25.0	50.0	159	1.11	74/54	41	64	135	210	—	24.7

\* From Smith (1943). † Weight after loss of most of oedema fluid.

(N.B.—Figures are based on the average of three clearance periods in those cases in which only the inulin clearance (C<sub>I</sub>) and the diodone clearance (C<sub>D</sub>) were measured. When the maximal secretory power of the tubules for diodone (T<sub>M</sub>D) was also measured, C<sub>D</sub> is based on two periods, T<sub>M</sub>D on two periods, and C<sub>I</sub> on four.)

area were slightly higher than the normal average. The renal plasma flow, as estimated by the diodone clearance, was normal in one case but reduced in the other. It is possible that in the latter case apprehension was responsible, since the patient was rather restless throughout the test. In any event, the maximum secretory power of the tubules in this case, as measured by the diodone excretion at a saturation level, was normal. In both these patients blood pressure was low, and it is of interest that renal function was still normal when, as in the first case, the pressure was approximately 88/58.

Inulin and diodone clearances were also measured in two patients with severe generalized oedema. One of these patients was of great interest from several points of view. She had a very swollen face, swollen arms, ascites, oedema of the back, and gross oedema of the legs and feet. Her urine was tested repeatedly and never contained albumin. Her blood pressure was 90/60; there was no dyspnoea or engorgement of the veins. Her serum protein concentration when she was first seen on June 29 was 4.2 g.%. Although there was thus evidence of considerable protein deficiency she had retained quite a large amount of her body fat, as was discovered when "cutting down" to expose a vein. While she was still in this very oedematous condition her renal function was estimated. The inulin clearance was only 66 c.cm./min. and the diodone clearance 182 c.cm./min. Even if these figures are corrected for surface area, using the weight to which the patient was reduced after the loss of most of the oedema fluid, they are still below normal (inulin 80 c.cm./min., diodone 230 c.cm./min.).

The second case of gross oedema with hypoproteinaemia (serum protein 4.0 g.%) but without albuminuria gave similar results. This patient died shortly afterwards, and it was thus possible to examine kidney sections. The only histological change was a slight desquamation of tubular epithelium. It

was the same—namely, normocytic and normochromic—indicating a reduction in the total output of erythrocytes from the marrow rather than any interference with maturation. There was little difference in haemoglobin values between tuberculous and non-tuberculous subjects, indicating that tuberculosis was not the chief cause of this anaemia. In uncomplicated cases, recovery from anaemia proceeded satisfactorily with ordinary feeding and without the addition of liver or iron to the diet.

Total serum proteins were reduced to an average figure of 5.1 g. per 100 c.cm. (normal British soldiers, 6.7 g. per 100 c.cm.). There was a correlation between the degree of oedema and the total serum protein levels when averages were compared, although in individual cases there was some overlap. The serum protein levels in individual cases were not correlated with Hb levels. The return of serum protein concentrations to normal was slow, and on the average was still incomplete two months after the camp was liberated.

Blood volume was reduced, but to a less extent proportionately than body weight. In oedematous subjects the blood volume tended to be lower relative to the total body weight.

There was no evidence of any interference with renal function in severely starved non-oedematous patients, apart from cases complicated by dehydration. However, two subjects with gross oedema (severe hypoproteinaemia; no albuminuria) showed considerably reduced clearances of inulin and diodone.

Starving patients are fastidious about their food, and it does not suffice to provide a diet which merely satisfies theoretical nutritional requirements.

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