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TRANSMISSION OF INFECTION DURING WITHDRAWAL OF BLOOD

BY

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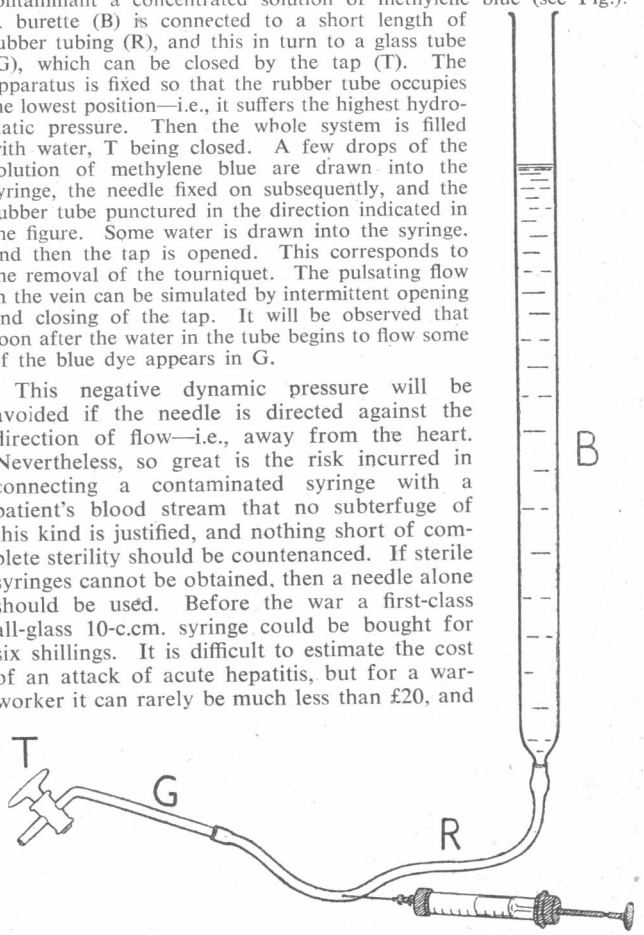
It is now generally realized that jaundice may be transmitted by syringes used for intravenous therapy if the syringes are merely rinsed with sterile water between cases and not sterilized by heat. Bigger (1943) showed that it is extremely difficult to sterilize a syringe by rinsing it even with antiseptics, and Salaman and co-workers (1944) reduced the incidence of jaundice in a V.D. clinic to vanishing-point by using properly sterilized apparatus for each individual patient. It is not so generally appreciated that there is almost equal risk of transmitting disease by syringes used for venepuncture. Sheehan (1944) attributed a long-drawn-out epidemic of jaundice in a sanatorium to transmission by the syringes used for taking blood for erythrocyte sedimentation rates, and in the present number of the *Journal* (p. 623) Droller records an outbreak of jaundice in a diabetic clinic which appears to have been in large part due to transmission by the syringes used for obtaining venous blood for estimation of blood sugar.

The orthodox method of taking a venous blood sample with a syringe consists in first placing a tourniquet on the upper arm to produce venous distension and then puncturing a vein at the bend of the elbow, inserting the needle in the direction of the heart. Blood enters the syringe under pressure from the vein, and a sample is taken by gently withdrawing the plunger. When the desired amount is collected the tourniquet is released and the needle withdrawn from the vein. Throughout the procedure direct contact with the vein is established by means of the sterile needle only, and since during the whole operation the pressure in the vein has been higher than that in the syringe it is assumed that no flow of blood can have taken place from the syringe into the vein.

In Droller's clinic the same syringe was used for all the patients bled on any one morning. It was washed out between cases and the needle was changed. It may appear strange that infection should have occurred through the syringe, though there is obviously a possibility that, unless great care is taken in changing needles, some of the contents of the wet syringe may be forced up the lumen of the needle and contaminate the point. But even if every precaution is taken in fitting the needle, some of the contents of the syringe not only can but *must* be discharged into the patient's vein during the venepuncture, and therefore material must inevitably be transmitted from one patient to another if the syringe is communal and unsterilized. This can very easily be proved by deduction or experiment.

The hydrostatic pressure of a fluid is equal to the actual pressure only if the fluid is at rest. Apart from its hydrostatic pressure, a fluid in motion exerts also a *dynamic* pressure, which depends on the speed and the direction of flow and which can have positive and negative values. In venepuncture the tourniquet must be released before the needle is withdrawn, to avoid the formation of a haematoma, and this is the determining factor in the transmission of infection. The operator ceases to exert traction on the piston of the syringe at this point, particularly if he is working single-handed. A flow of blood takes place in the vein when the tourniquet has been released, and this flow occurs in the direction in which the injection needle points—i.e., it causes a *negative* dynamic pressure in the opposite direction. As soon as this negative dynamic pressure attains a higher value than the static-pressure difference between vein and syringe, blood must flow from the syringe into the vein. In other words, the flow of blood in the vein sucks some of the contents of the syringe into the vein against the static-pressure head, very much as the contents of a throat spray are drawn up into a passing stream of air. It is clear that if the syringe was contaminated the contaminant will be drawn into the vein together with blood from the syringe.

The effect of the negative dynamic pressure can be demonstrated by substituting for the vein a tube filled with water, and for the contaminant a concentrated solution of methylene blue (see Fig.). A burette (B) is connected to a short length of rubber tubing (R), and this in turn to a glass tube (G), which can be closed by the tap (T). The apparatus is fixed so that the rubber tube occupies the lowest position—i.e., it suffers the highest hydrostatic pressure. Then the whole system is filled with water, T being closed. A few drops of the solution of methylene blue are drawn into the syringe, the needle fixed on subsequently, and the rubber tube punctured in the direction indicated in the figure. Some water is drawn into the syringe, and then the tap is opened. This corresponds to the removal of the tourniquet. The pulsating flow in the vein can be simulated by intermittent opening and closing of the tap. It will be observed that soon after the water in the tube begins to flow some of the blue dye appears in G.



This negative dynamic pressure will be avoided if the needle is directed against the direction of flow—i.e., away from the heart. Nevertheless, so great is the risk incurred in connecting a contaminated syringe with a patient's blood stream that no subterfuge of this kind is justified, and nothing short of complete sterility should be countenanced. If sterile syringes cannot be obtained, then a needle alone should be used. Before the war a first-class all-glass 10-c.cm. syringe could be bought for six shillings. It is difficult to estimate the cost of an attack of acute hepatitis, but for a war-worker it can rarely be much less than £20, and for a trained soldier it must be much more. It is therefore penny wise and pound foolish to economize in sterile syringes; but false economy of this kind is still much too prevalent in civil and military clinics and hospitals. The infecting dose of the virus of infective hepatitis is probably of the same order of size as some of the larger protein molecules, and a little contamination with this virus can go a very long way. A venepuncture, whether for taking blood or injecting drugs, is a minor operation, and there is no excuse for any lapse from the classical principles of sterility.

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Summary

When blood is taken from a vein with a syringe by the orthodox technique some of the blood is sucked back into the vein when the tourniquet is released. If, therefore, the syringe is not sterile the patient is exposed to infection.

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IRON-DEFICIENCY ANAEMIA IN NORTH-WEST INDIAN SOLDIERS

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Little work has been done on iron-deficiency anaemia in India, and that entirely on the rice-eating labourer. Although anaemia is universal in this class (Macdonald, 1939; Napier and Das Gupta, 1942), it is scarcely improved by iron (Napier and Das Gupta, 1936; Bhave and Bopaiya, 1942). Even heavy hookworm infestation does not always increase anaemia in these people, although labourers with severe anaemia, whether macrocytic or microcytic, are more commonly heavily infested than their fellows (Napier and Billimoria, 1937; Napier and Das Gupta, 1937; Napier and Majumdar, 1938; Hare, 1940). The discovery, reported in this paper, of widespread mild iron-deficiency anaemia in North-West Indian soldiers is therefore of some interest.

Material and Methods

This work was carried out in the district of Peshawar (North-West Frontier Province) from Feb. to June, 1944. Some 1,400 men from six regiments were examined. All were natives of North-West India, and included Sikhs and Mohammedans from Patiala; Mohammedans, Jats, and Hindus from Rajputana; Mohammedans, Sikhs, Jats, and Gujars from the Punjab; and Pathans. The men were unselected, and all were regarded by their units as fit for active service. All had served more than one year, and two-thirds were in their second or third year of service.

Only the capillary blood haemoglobin of most of the men was estimated, but full haematocrit determinations were done on venous blood from 341 men. These latter were selected according to their (capillary blood) haemoglobin values, with weighting of the higher and lower haemoglobin classes; but they were in all other respects representative of the whole group.

Blood, whether from finger or vein, was drawn without stasis; Wintrobe's dry oxalate mixture was used for venous blood. Haemoglobin was estimated as acid haematin; the Zeiss haemometer, which has a glass wedge standard, was used, recalibrated to a maturation time of 20 minutes. (This instrument was calibrated against van Slyke blood-oxygen-capacity determinations in London in 1939. The only comparison available in India in 1943 was with various Adams and Hellige haemoglobinometers; there was good agreement.) Adams haemoglobin pipettes were used. For red cell counts, two Zeiss-Thoma chambers were charged from the same pipette, and about 500 cells counted on each; if the totals for the two chambers differed by more than 10% a new pipette was filled and the count was repeated. Adams and Zeiss red-cell-counting pipettes were used. The packed cell determinations were done in Wintrobe haematocrits; 45 minutes' spinning at about 3,000 revolutions a minute gave a constant reading.

Stools were examined for hookworm ova by the usual gravity flotation technique, in which about 1 g. of faeces is suspended in 10 ml. saturated saline. The number of ova per microscope field (1/3-in. objective, × 6 ocular) was counted, and the infestation roughly classified as very light (1 egg per 6 or more fields), light (1 egg per 2–5 fields), moderate (1–4 ova per field), or heavy (more than 5 ova per field).

Results

The capillary blood haemoglobin distribution is shown in Table I. No significant difference was found between units,

TABLE I.—*The Distribution of Hb Values (Capillary Blood) among North-West Indian Soldiers*

	Haemoglobin (g. per 100 ml.)											Total	Mean	σ
	6–	7–	8–	9–	10–	11–	12–	13–	14–	15–	16–			
No. of cases ..	1	2	5	13	43	131	256	417	361	113	14	1,356	13·42	1·371
Per cent. ..	0·5			1	3	9·5	19	31	27	8	1			

religions, or castes. Only one-third of the men had over 14 g. haemoglobin per 100 ml.; 14% had less than 12 g., and 5% less than 11 g.

The results of the blood counts and haematocrits on venous blood are summarized in Table II. All the anaemia was

TABLE II.—*Blood Counts of North-West Indian Soldiers (Venous Blood), Grouped according to the Hb Level*

Hb Class	No. of Cases	Hb (g.) Mean	R.B.C. (M./c.mm.)		Haematocrit		M.C.V. (c.μ)		M.C.H.C. (%)	
			Mean	σ	Mean	σ	Mean	σ	Mean	σ
7–	5	7·5	3·9		31		82		24·5	
8–	4	8·3	4·5		34		80		24·5	
9–	9	9·3	4·7		36		78		25·7	
10–	17	10·6	4·9	0·67	39	2·30	82	10·5	27·2	1·57
11–	31	11·4	5·0	0·73	41	2·07	82	9·75	28·2	1·37
12–	48	12·4	4·9	0·62	43	2·45	88	8·27	29·1	1·69
13–	77	13·5	4·9	0·38	45	2·20	91	6·53	30·2	1·49
14–	82	14·4	5·2	0·32	47	2·35	90	5·46	31·0	1·47
15–	51	15·4	5·4	0·31	49	2·01	91	5·51	31·3	1·35
16–	17	16·4	5·5	0·19	51	1·90	93	4·03	32·0	1·33

hypochromic, and usually normocytic. Of bloods with less than 11 g. haemoglobin about one-third were microcytic [mean corpuscular volume (M.C.V.) less than 75 c.μ]; of those with 11–11.9 g. about one-sixth were microcytic; and all but three of the remaining bloods were normocytic. No case of macrocytic or dimorphic anaemia was found. Table II shows how little the red cell count fell with decreasing haemoglobin until values under 10 g. were reached. The disproportion between the red cell count and the haemoglobin was sometimes extreme: 5 men with haemoglobins of between 9 and 11.9 g. had red cell counts of 6 millions per c.mm. or more; their M.C.V.s were 60–70 c.μ. (Such bizarre counts were of course repeated.)

The steady fall in the haemoglobin concentration or M.C.H.C. (=mean corpuscular Hb concentration) (see Whitby and Britton's *Disorders of the Blood*, Chapter III) as anaemia increased is evident in Table II. (The correlation coefficient between haemoglobin and M.C.H.C. is 0.73, about 14 times its standard error.) The differences between the mean M.C.H.C.s in different haemoglobin classes are statistically significant, except between the 14- and 15-g. classes. The mean M.C.H.C. of the 16-g. class is, however, significantly higher than that of the 15-g. class ($D/\sigma_D = 2.0$) and the 14-g. class ($D/\sigma_D = 2.9$).

These findings suggested a widespread iron deficiency, possibly extending even to some of those with 14 and 15 g. haemoglobin per 100 ml.

The mean values in the 14–16 g. haemoglobin classes are reasonably close to those obtained by Napier and Das Gupta (1936) for 30 young well-to-do Indian males in Calcutta. (Their means and standard deviations were:—Hb, g./100 ml.: 15.7, 0.91; R.B.C., M./c.mm.: 5.53, 0.49; M.C.V., c.μ: 90.5, 7.9; M.C.H.C., %: 31.1, 1.2.)

Response to Iron Therapy

The only unequivocal proof of iron deficiency is an increase in the haemoglobin following iron therapy. A group of these soldiers was therefore given 20 gr. of ferri sulphas exsiccatus daily—58 for 21 days, and 17 for 14 days. (The object was not completely to cure anaemic men, but to observe what proportion responded to a massive dose of iron.) The powder was suspended in distilled water (10 gr. to 1/2 oz.) immediately before use, and a member of the team gave each man a dose of the mixture morning and evening, and watched him swallow it.